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Inventory of foraminifers and calcareous algae, biostratigraphy and paleogeography

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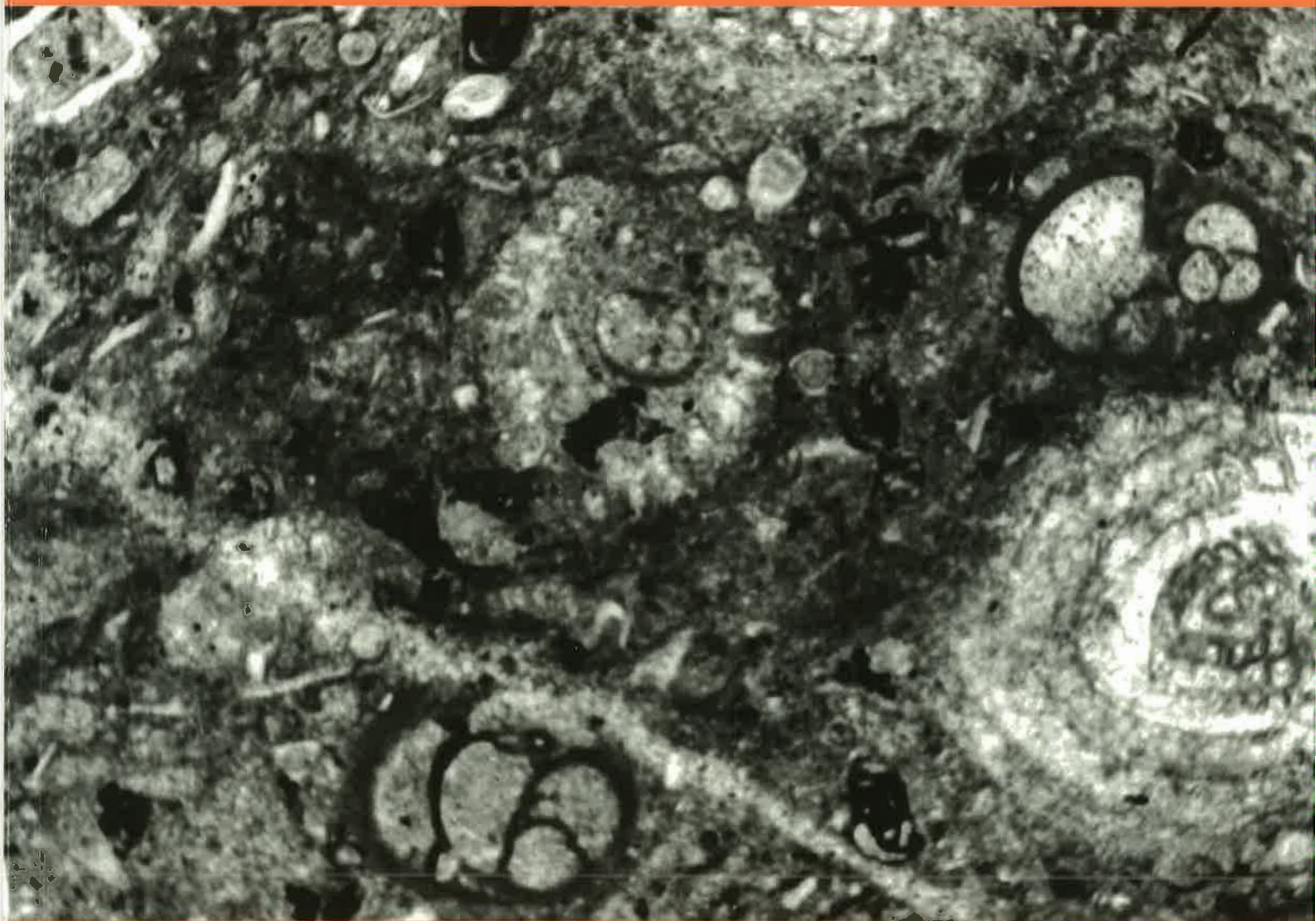

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Titre : Micropaleontology of some Permian localities in the Tethyan realm – Inventory of foraminifers and calcareous algae, biostratigraphy and paleogeography.

Page de couverture : Typical Permian microfacies from Alborz Mountains, Iran, Rudbarak section, sample CD 316.

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Micropaleontology of some Permian localities in the Tethyan realm

Inventory of foraminifers and calcareous algae, biostratigraphy and paleogeography

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et du

MUSEE
CANTONAL
DE GEOLOGIE

Mémoires de Géologie (Lausanne), No 48, 2009

To my daughters Aline et Lucie,
as example of perseverance

Contents

Preface

This inventory of Permian foraminifers and calcareous algae has been made for more than 5000 samples collected in six geographical areas (Fig.1).
Almost all of them were taken from stratigraphical sections. This important and unique collection is kept at the Geological Museum of Lausanne (Switzerland) and are available on request to any further scientific investigations*.

Several people carried out the field work. However, only one person is responsible for the determinations in genera and species of these samples. Therefore, this work method offers a good homogeny of namings and has saved a lot of discussions over nomenclature. Some colleagues may not agree with one or more of the namings and we accept their dissensions. Nevertheless we adopted this method because we are sure that the homogeny of namings vouches for best correlations in both biostratigraphical and paleogeographical investigations.

We already used with success this data set in geodynamical paleo-recontruction maps (Jenny & Stampfli, 2000) (Chapter 3) and managed the same data through the Biograph Program (Savary & Guex, 1999) (Chaper 2). This program is able to compile a lot of data to extract maximal sets of intersecting taxa ranges. The objective was to establish discrete sequences of coexistence interval of taxa and then to ensure good correlations for the different studied areas.

Catherine Jenny

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Part 1 Inventory

1.1 Introduction

The inventory is set out area by area, geographically from west to east of the present world. These areas are: the Southern Alps (six sections), Greece (eight sections), Armenia (two sections), Iran (ten sections), the Salt Range, Pakistan (two sections), South China (three sections).
The different sections are distributed as follows:

- **Southern Alps in Italy**: Tesero, Bulla, Sass de Putia, Casera Federata
- **Southern Alps in Slovenia**: Dierico, Idrijca
- **Greece** : Salamis Island (Kaki Vigla), Aegina Island (Mesagros), Chios Island (Marmara, Parpanda), Hydra Island (Cap Bisti, Lehusis, Episcopi, Cap Rigas)
- **Armenia**: Sovetachen, Vedi
- **Iran**: Alborz Mountains (Rudbarak, Dorud, Ruteh, Emarat I, II, III, Gheselghaleh) Central Iran (Sinak, Kuh e Jamal); Zagros Mountains (Dena Kuh)
- **Pakistan**: Salt Range (Nammal, Chhidru)
- **South China**: Meishan, Shangsi, Langfenya

The collection deposited at the Geological Museum of Lausanne includes, in addition, thin sections of stratigraphical sections from the Taurus Belt. Part of the turkish sections and of the inventory is published in Richoz (2006). But as the inventory of the microfauna in Turkei has been already published (mainly Lys, 1986, see also Erk, 1941; Guvenc 1966a, b; Lys & Marcoux, 1978; Altiner, 1978; 1980, Altiner et al., 1980; Altiner &Bronnimann, 1980; Zaninetti et al., 1981, Leven et Okay, 1996). data are not reworked in this present paper, but has been processed by the Biograph Program and used on the paleo-recontruction maps (Part 2 and 3).
The collection contains also thin sections and samples from Oman mountains. The sections are described with foraminifers descriptions in Pillevuit, (1993); Pillevuit et al., (1997) and Richoz (2006); for Oman mountains see also Montenat et al., (1976) and Gaillot and Vachard (2007).
The same process is valid for samples from Afghanistan, collected by Dr. Daniel Vachard. Details of this data can be consulted in Vachard (1980) and Vachard & Montenant (1981), for Afganistan see also Lys & Lapparent, (1971).
This complete collection of rocks and thin sections is regrouped and held at the Geological Museum of Lausanne (Switzerland). The collection is available on request for any scientist to consult.

1. 2 Method

For each area, we have positioned the section and/or the isolated samples on a geographical map.
Sections have been drawn showing the stratigraphical position of the samples. Except for the sections from the Alborz Mountains (Iran), no lithological desciption has been given, the reader is pleaesd to reference to the given litterature.
The micropaleontological contents (foraminifers and calcareous algae) of almost all the different sections are presented in two tables: the first one regroups the genera and species of foraminifers and calcareous algae in order of apparition, the second one gives an estimation (%) of the main present bioclasts, not only for foraminifers and calcareous algae.
This way of investigation can assist in stratigraphical recontructions of the Permian history as we have done for the Permian deposits of the Hydra Island (Greece) (Jenny & al., 2004).

In addition we have included:

- a list of all the taxa observed,
- a summary table of the main taxa in stratigraphical order,
- a range chart provided by the Biograph Program can be found in chapter 2
- some brief micropaleontological observations and remarks,
- illustrated plates.
- Regional references have been cited in each chapter.

In addition we used as more general references : Aw et al., 1977; Bensch, 1972; Bronnimann et al., 1978; Bykova, 1952; Chedjia & Davydov, 1980; Chuvasov, 1974; Colani, 1924; Cummings, 1958; Elliott, 1955; Ellis & Messina, 1940-1981; Flugel, 1979, 1994; Gargouri & Vachard, 1988; Gerke, 1959; Groves and Altiner 2005; Ishii et al., 1975; Haas et al., 1988; Jenny-Deshusses, 1983a,b; 1985;1988; 2002; Jenny-Deshusses & Baud, 1989; Jenny-Deshusses et al., 2000; Jenny-Deshusses & Guex, 2005; Johnson, 1961; 1963; Kobayashi 1996; 2003; Lange, 1925; Lee, 1933; Leven, 1967; 1975; 1981; Loebich & Tappan, 1964; 1988; Lys et al., 1980; Nakazawa & Dickins, 1985; Nakazawa et al., 1975a; Nakazawa & Kapoor, 1977; Nguyen, 1979; Okimura, 1972; Pantic, 1963; 1969; Potivskaia, 1962; Rauzer-Chernousova, 1965; Reitlinger, 1950; Riebesell et al, 2000; Rozovskaia, 1975; Sellier de Civrieux & Dessauvagie, 1965; Skinner & Wilde, 1966; 1967; Termier et al., 1977; Zaninetti, 1976; Zaninetti et al., 1979; Zaninetti & Altiner, 1981.Gaillot and Vachard, 2007 and Groves et al., 2007 are exhaustive state of the art review on Upper Permian foraminifers.

We have decided not to add a complete part for systematic nomenclature analysis as we are sure that many of the taxa of Permian foraminifers would need to be reviewed, mainly the fusulinids but also most of the other family. Conclusions of this study will highlight some observations and give evidence of some features in the main groups of foraminifers studied through this inventory.

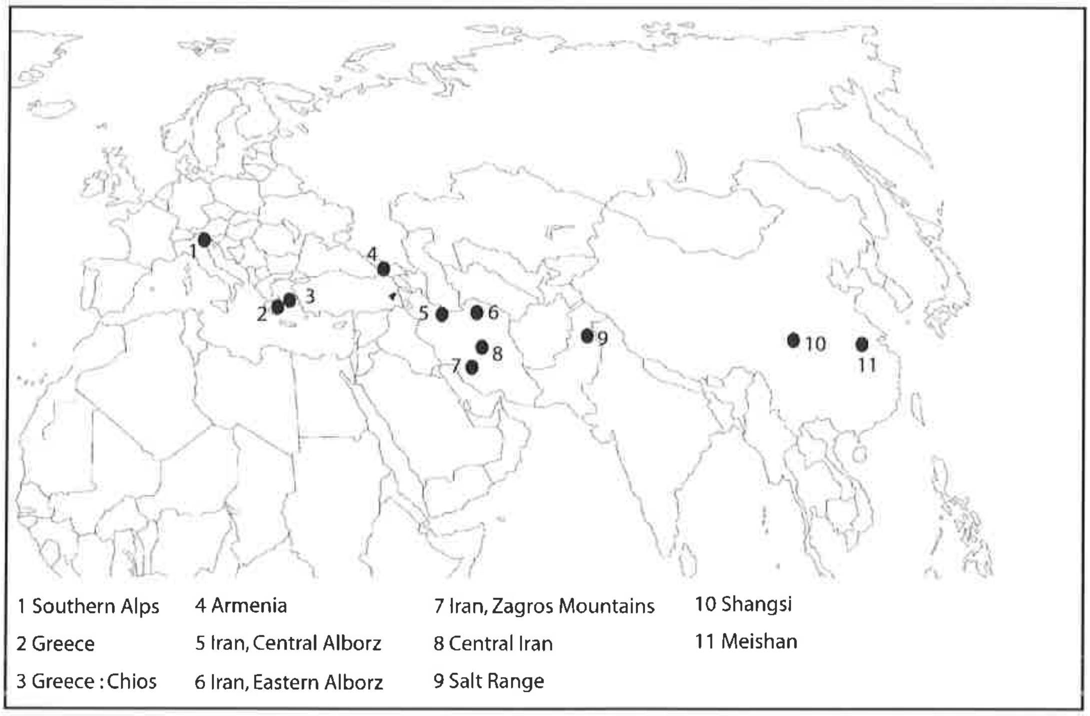

Fig 1.2 Geographic location of the studied areas (for paleogeogaphic reconstruction see chapter 3).

1. 3 Southern Alps

Introduction

Samples have been collected during a fieldtrip and conference in July 1986 (Permian and Permian- Triassic boundary in the South-Alpine segment of the Western Tethys, included in IGP Project n. 203).
These samples are issued of six lithological sections illustrating the Permo-Triassic boundary in this area (Fig.1.3.1). Regional geology and stratigraphic description can be found in Baud et al., 1989; Holzer & Schönlaub, 1991; Kochansky-Devidé 1957; 1964; 1970; 1973; 1979; Kochansky-Devidé & Herak, 1960; Noe, 1988; Panzanelli-Fratoni et al., 1987. Bulla and Tesero section have been since intenseviley studied with the last results published in Perri and Farabegoli 2003 and Farabegoli et al., 2007. A recent review of all the recent work made in Southern Alps can be found in Groves et al., 2007.

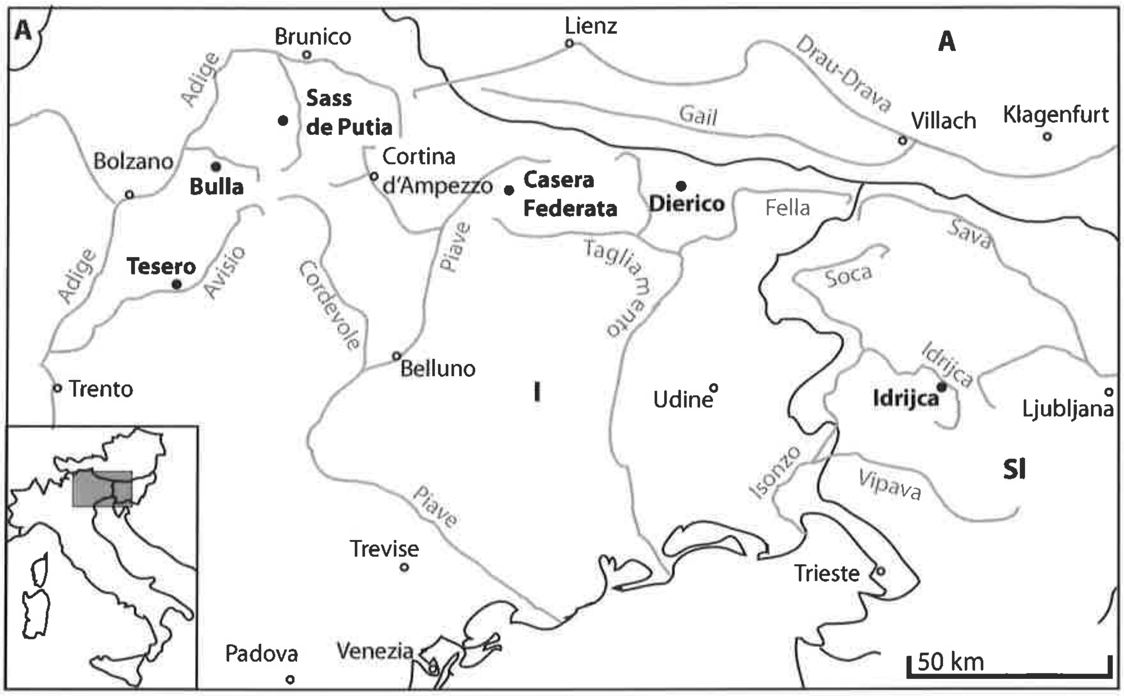

Fig. 1.3.1 General map and localization of the six stratigraphical sections.

	Series	GSSP stages	Tethyan stages	Southern Alps: fusulinids	Southern Alps: small foraminifers	Southern Alps: algae
Permian	Lopingian	Changhsingian	Dorashamian	Reichelina Codonofusiella Nankinella Staffella	Paraglobivalvulina Paradagmarita Rectostipulina Cyclogyra Dagmarita Baisalina Globivalvulina Robuloides Lasiodiscus	Atractyliopsis Mizzia Gymnocodium Permocalculus Tubiphytes
		Wuchiapingian	Djulfian			
	Guadalupian	Capitanian	Midian			
		Wordian	Murgabian			
		Roadian	Kubergandian			

Fig. 1.3.2 Faunal association table of the Southen Alps.

List of foraminifers and calcareous algae of the Southern Alps

Earlandia tintiniformis (MISIK)
Eotuberitina reitlingerae MIKLUKO-MACLAY
Tuberitina sp.
Tetrataxis conica (EHRENBERG)
Geinitzina ex.gr. *postcarbonica* (SPANDEL)
Geinitzina primitiva POTIEVSKAIA
Geinitzina reperta BYKOVA
Geinitzina uralica SULEIMANOV
Langella ocarina SELLIER de CIVRIEUX & DESSAUVAGIE
Nodosaria longissima SULEIMANOV
Pachyphloia ex. gr. *ovata* (LANGE)
Pachyphloia pedicula LANGE
Pachyphloia iranica BOZORGNIA
Robuloides gibbus REICHEL
Robuloides lens REICHEL
Frondina permica SELLIER de CIVRIEUX & DESSAUVAGIE
Ichtyolaria latilimbata SELLIER de CIVRIEUX & DESSAUVAGIE
Dagmarita chanakchiensis REITLINGER
Paradagmarita monodi LYS & MARCOUX
Globivalvulina bulloides (BRADY)
Globivalvulina vonderschmitti REICHEL
Paraglobivalvulina mira REITLINGER
Agathammina sp.
Ammovertella sp.
Baisalina pulchra REITLINGER
Calcitornella sp
Crescientia sp.
Cyclogyra mahajeri BRONNIMANN, ZANINETTI & BOZORGNIA
Glomospira sp.
Hemigordius ssp.
Hemigordius ovatus GROZDILOVA
Hemigordius padangensis (LANGE)
Lasiodiscus sp.
Pseudovermiporella nipponica (ENDO)

Codonofusiella sp.
Nankinella sp.
Reichelina sp.
Staffella sp.

Atractyliopsis sp.
Epimastopora sp.
Gymnocodium bellerophontis (ROTHPLETZ)
Permocalculus sp.
Mizzia cornuta KOCHANSKY & HERAK
Tubiphytes obscurus MASLOV

Rectostipulina quadrata JENNY- DESHUSSES

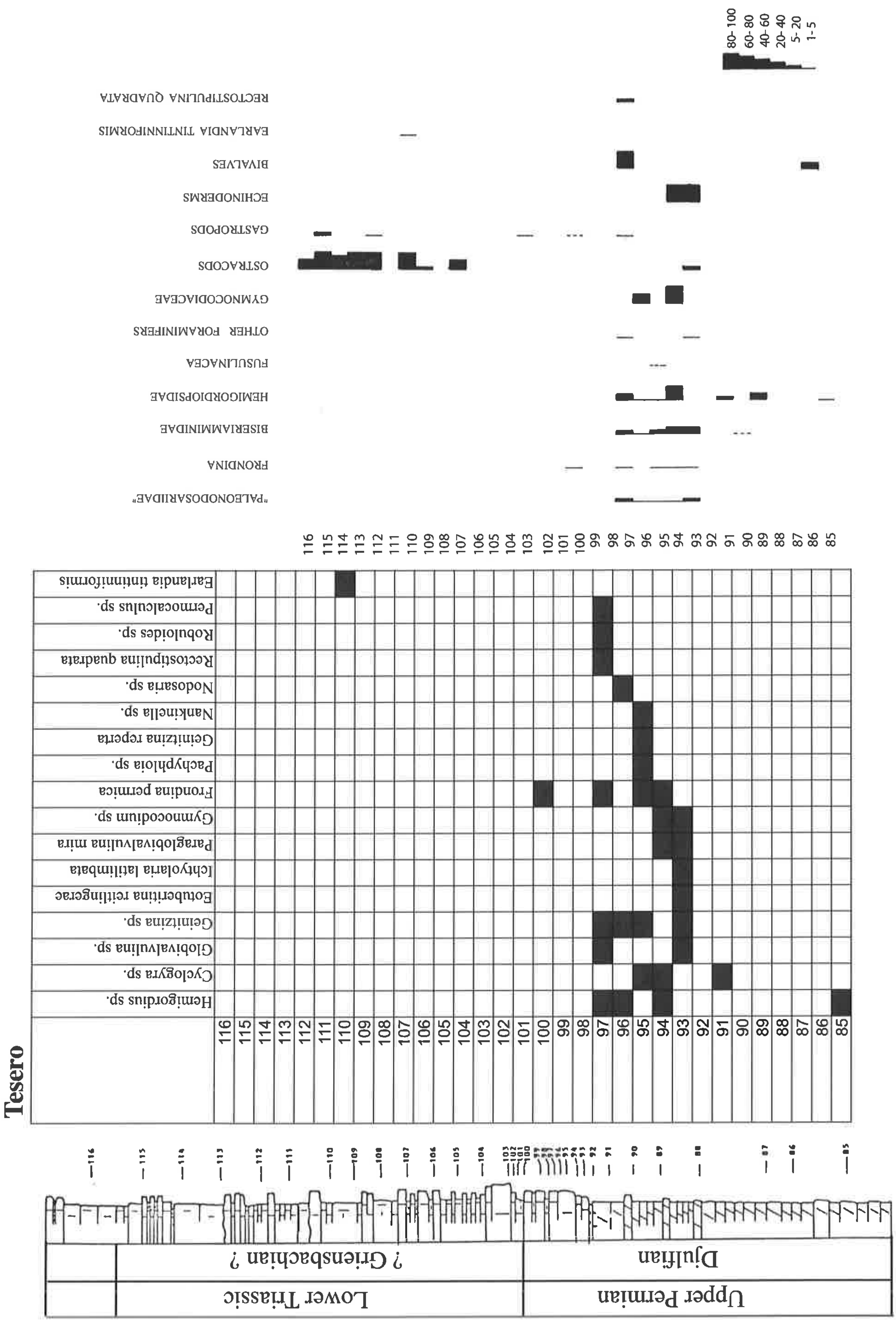

Fig. 1.3.3 Tesero section (Southern Alps). Log, inventory table of foraminifers and calcareous algae and estimation table (%) of the main bioclasts.

Bulla

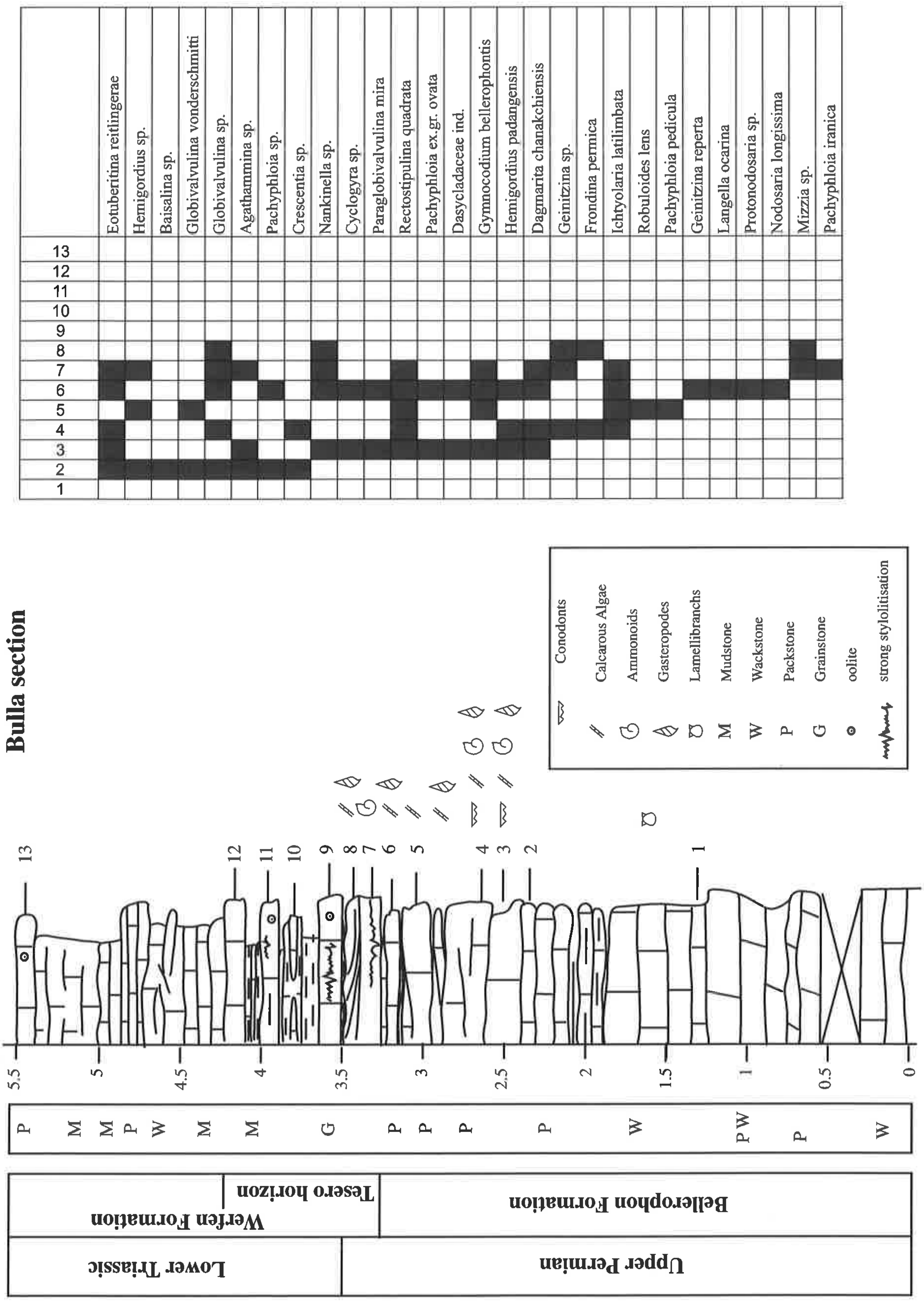

Fig.1.3.4 Bulla section. Log and inventory table of foraminifers and calcareous algae

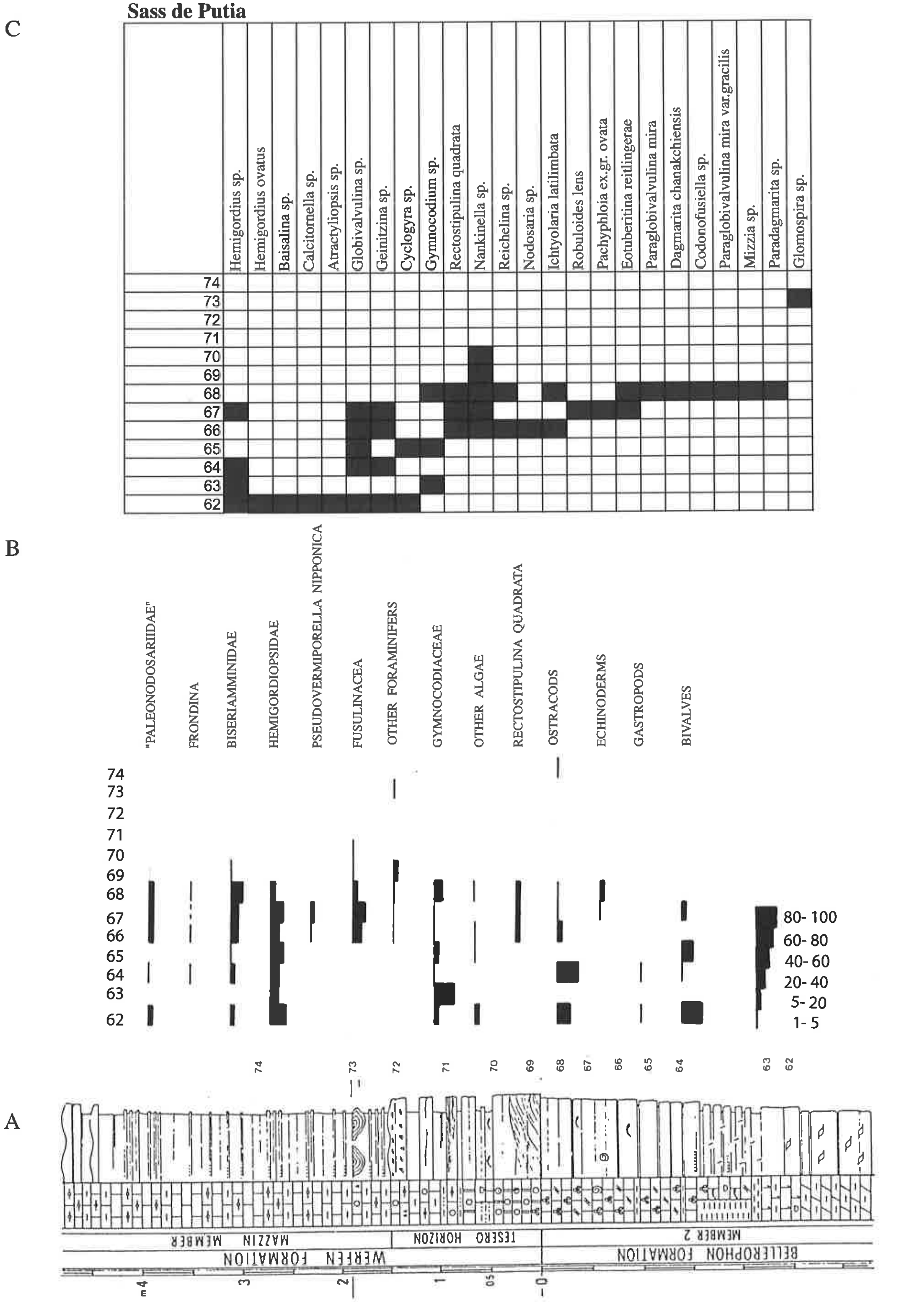

Fig. 1.3.5 Sass de Putia section. Log (A), estimation table (%) of the main bioclasts (B) and inventory table of foraminifers and calcalreous algae (C)

Casera Federata section

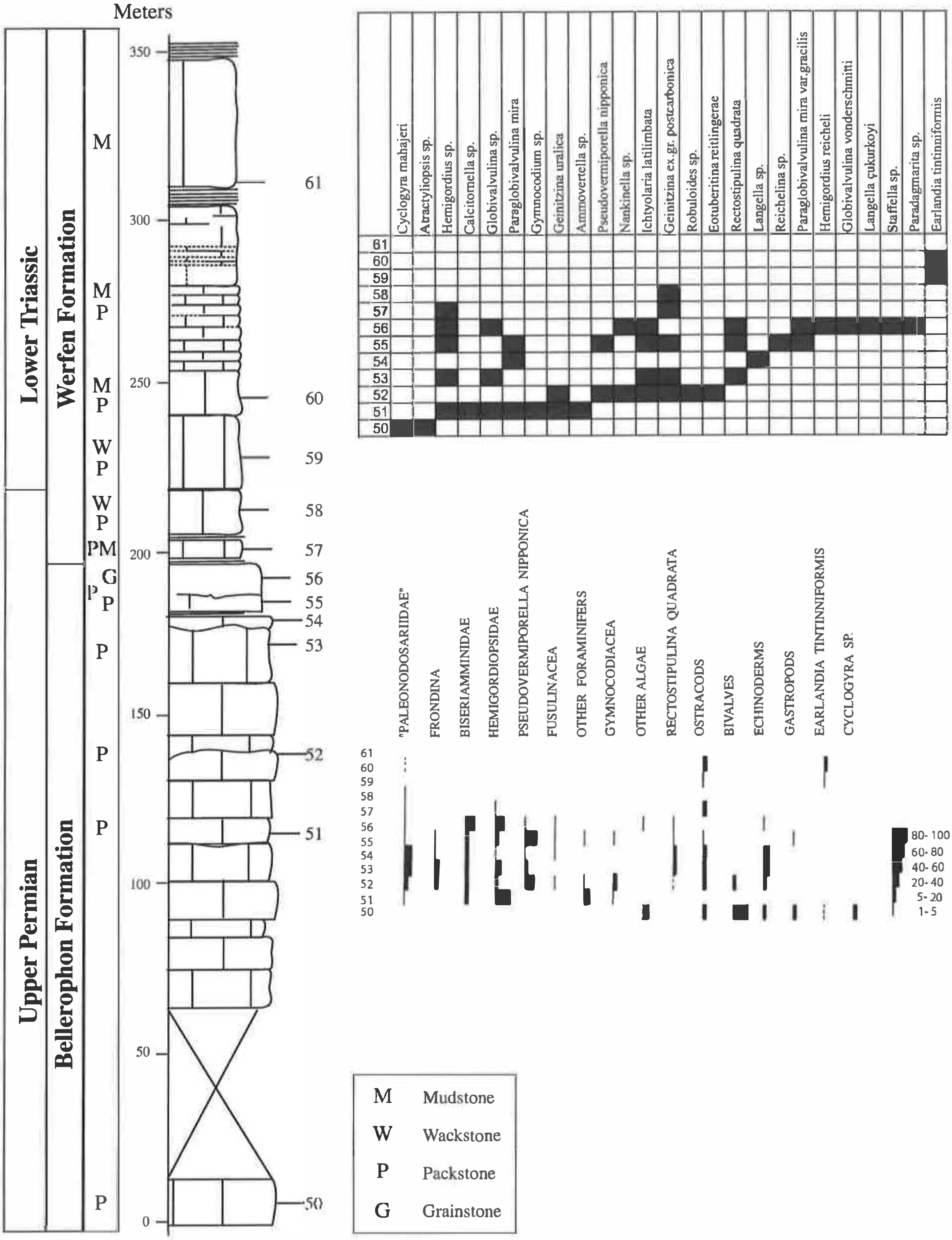

Fig. 1.3.6 Casera Federata section (Southern Alps). Log, inventory table of foraminifers and calcareous algae and estimation table (%) of the main bioclasts.

Dierico

	Eotuberitina reitlingerae	Globivalvulina vonderschmitti	Paraglobivalvulina mira	Geinitzina ex.gr. postcarbonica	Hemigordius sp.	Paraglobivalvulina mira var. gracilis	Baisalina sp.	Globivalvulina sp.	Earlandia sp.	Frondina permica	Gymnocodium bellerophontis	Geinitzina reperta	Geinitzina sp.	Staffella sp.	Cylogyra sp.	Nodosaria sp.	Rectostipulina quadrata	Tuberitina sp.	Dagmarita chanakchiensis	Ichtyolaria latilimbata	Langella ocarina	Nankinella sp.	Robuloides sp.
49																							
48																							
47																							
46					■			■														■	
45								■						■			■		■	■	■	■	■
44						■		■		■		■					■	■	■				
43					■										■	■	■						
42																							
41	■				■	■		■			■	■	■	■									
40									■	■													
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35	■	■	■	■																			

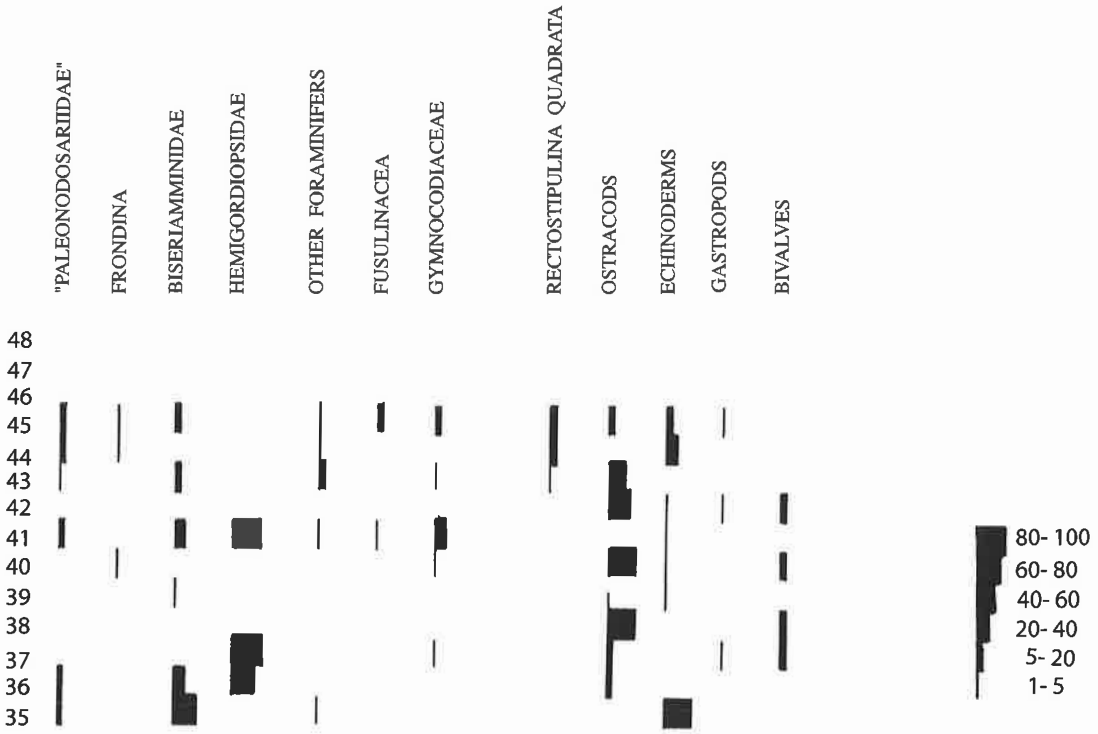

Fig.1.3.7 Dierico section (Southern Alps) : Inventory table of foraminifers and calcareous algae and estimation table (%) of the main bioclasts. Unfortunetly, no log of the Dierico section is available.

Idrijca

	Pseudovermiporella nipponica	Hemigordius sp.	Baisalina sp.	Tubiphytes obscurus	Geinitzina reperta	Geinitzina sp.	Agathammina sp.	Paraglobivalvulina mira var.gracilis	Lasiodiscus sp.	Gymnocodium sp.	Frondina permica	Globivalvulina sp.	Eotuberitina reitlingerae	Paraglobivalvulina mira	Ichtyolaria latilimbata	Geinitzina ex.gr. postcarbonica	Robuloides lens	Tetrataxis sp.	Langella sp.	Robuloides gibbus	Dagmarita chanakchiensis	Atractyliopsis sp.	Nodosaria sp.	Epimastopora sp.	Reichelina sp.	Earlandia sp.
I 24																										
I 23																										
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I 20																										
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I 14																										
I 13		■								■		■												■		
I 12																									■	
I 11						■							■	■												
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I 6					■	■								■				■	■							
I 5	■	■						■		■				■			■									
I 4	■	■				■	■							■	■		■									
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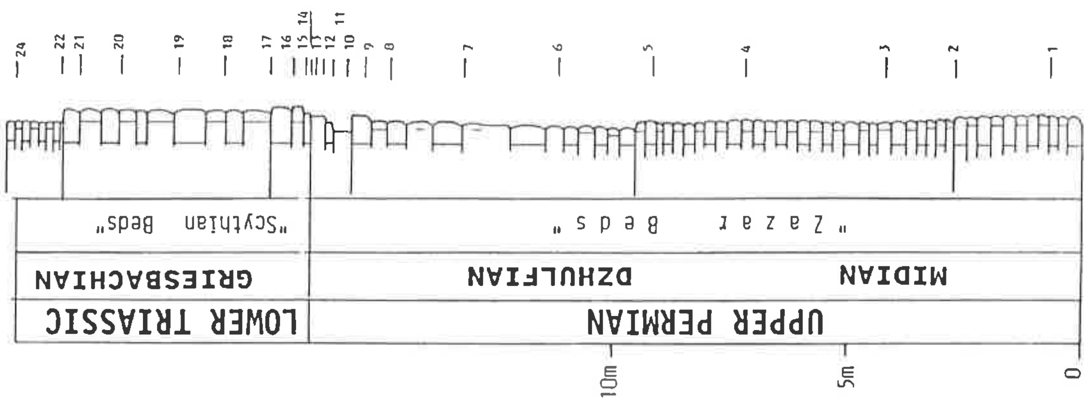

Fig. 1.3.8 Log of Idrijca section (Baud et al., 1989) and inventory table of foraminifers and calcareous algaae.

IDRIJCA SECTION

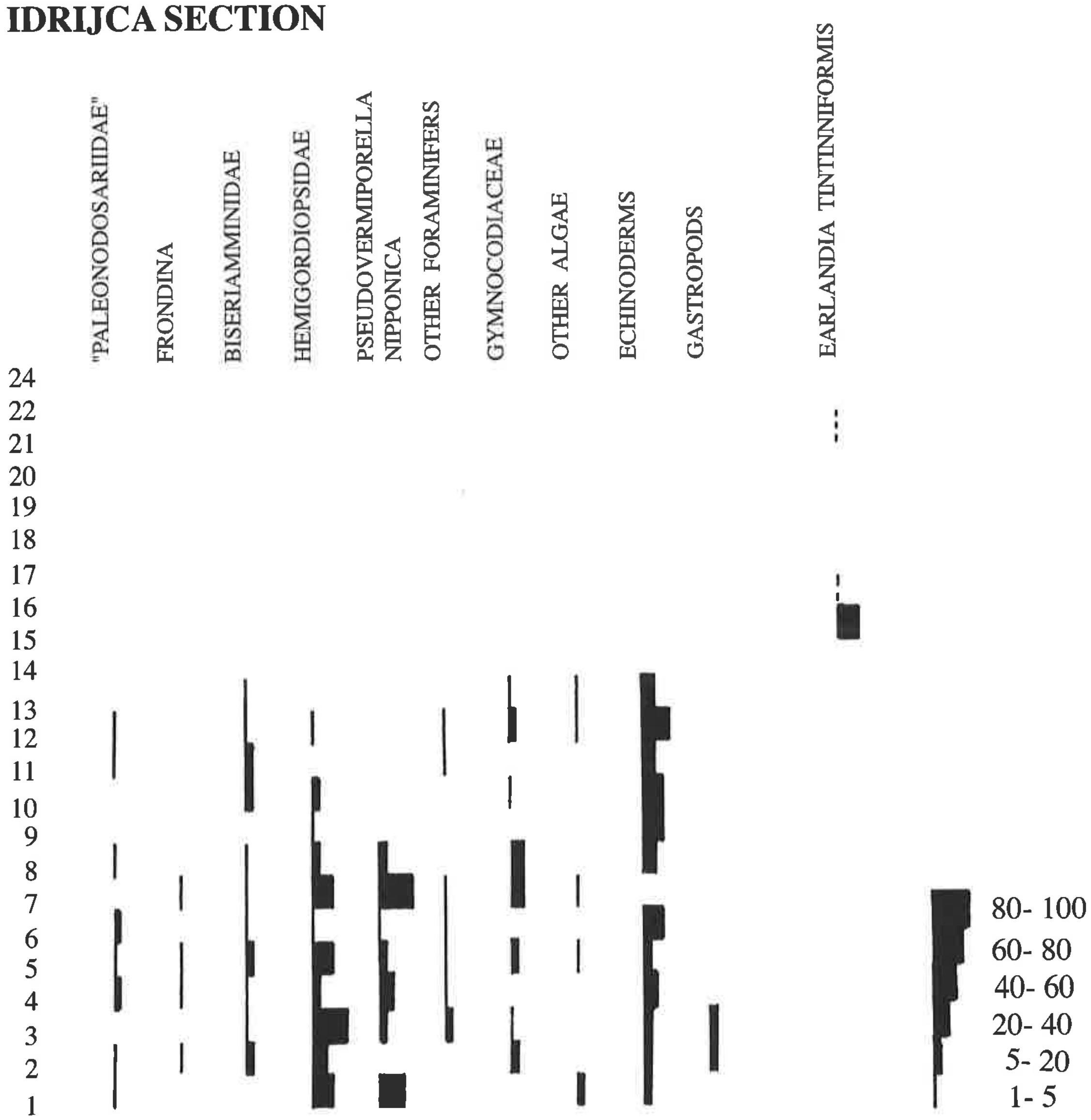

Fig. 1.3.9 Estimation table (%) of the main bioclasts in Idrijca section (Southern Alps).

Micropaleontological remarks of the Southern Alps

« Paleonodosariidae »
Robuloides gibbus REICHEL and *Robuloides lens* REICHEL for planispiral taxa, *Pachyghloia* ex. gr. *ovata* (LANGE), *Langella ocarina* S. de CIVRIEUX & DESSAUVAGIE, *Geinitzina* ex. gr. *postcarbonica* (SPANDEL), *Geinitzina primitiva* POTIEVSKAIA for uniserial taxa are the most important and representative genera for the « Paleonodosariids group ».
Frondina permica S. de C. & DESS. and *Ichtyolaria latilimbata* S. de C.& DESS. are seldom in our material.

Biseriamminidae
Biseriamminids are the most important group observed in our material from the Southern Alps, both in number of individuals and in diversity of morphology.
Initially, we interpreted this diversity of forms as a result of an anoxic environment due to the confinement in the proximal part of the marine shelf (Jenny & Stampfli, 2000). This interpretation might be correct, but further observations and comparisons with individuals from other areas of the Tethyan realm has led us to prefer the idea that these different morphologies could be aberrant forms resulting from great stress in their environment (Jenny & Guex, 2005).
In fact, the genus *Globivalvulina* presents different variations of its usual morphology in thinner wall, loss of symmetry (either for the complete individual or only at the end of coiling, illustrated by the position of the last chamber), different forms and/or sizes of the last chamber and finally in dwarf forms (Pl. 2, fig. 2 (a)).

These observations are valid for the genus *Paraglobivalvulina* and its species *P. mira* REITLINGER as well. We decided to name individuals of this taxa with as unique peculiar feature a thin wall : *Paraglobivlavulina mira* var. *gracilis*.(Pl. 1, fig. 11)
These aberrant forms exceed more than 1% of the faunal associations and coexist with normal forms (Jenny & Guex, 2005).
Furthermore recurrent species such as *Globivalvulina bulloides* (BRADY) are found in the same stratigraphical position as the more recent species *Globivalvulina vonderschmitti* REICHEL.
The biseriamminids, *Dagmarita chanakchiensis* REITLINGER (Pl. 1, fig. 13) and *Paradagmarita monodi* LYS & MARCOUX (Pl. 1, fig. 6) are present, but rare.

Hemigordiopsidae
The genus *Hemigordius* also shows important variations in the coiling of its tubular chamber. Contrary to the above observations for *Globivalvulina* and *Paraglobivalvulina*, these variations can be observed in almost all the associations where the genus *Hemigordius* is present. Therefore, we have preferred to group all these variations unter the name of *Hemigordius* ssp.
We think that this genus gives good evidence of an anoxic/disoxic environment but is less useful for age assignment.
Pseudovermiporella nipponica (ENDO) has often been observed in association with the genus *Hemigordius.*

Fusulinacea

Fusulinids are rare in our material from the Southern Alps.

We observed recrystallized individuals of *Staffella* sp. and *Nankinella* sp.; rare, poorly oriented individuals of *Reichelina* sp. as well as very few individuals of *Codonofusiella* sp., illustrating this group. This is poor evidence and does not help in precise age assignment.

Calcareous algae

The algal landscape of our material is dominated by Gymnocodiaceae (*Gymnocodium bellerophontis* ROTHPLETZ, *Permocalculus plumosus* ELIOTT). Dasycladaceae are rare ; we have observed some fragments of the thallus of *Atractyliopsis* sp.

Biofacies

Considering total assemblages of bioclasts, it is interesting to notice that the faunal assemblages are often dominated by fragments of ostracods and bivalves, especially in the Late Permian deposits (Pl. 2, fig. 3).

Although this information cannot help to determine which kind of ostracods and bivalves we observed, the estimation tables of the main bioclasts show that these bioclasts are rarely found in the presence of foraminifers: fusulinids, smaller foraminifers, especially Hemigordiopsidae. Furthermore ostracods and bivalves alternate with foraminifers.

Plate 1

Fig. 1 : *Hemigordius* sp.(a), *Globivalvulina* sp.(b), *Cyclogyra* sp.(c), C 62, Casera Federata section.

Fig. 2 : *Hemigordius* sp., P 62, Sass de Putia section.

Fig. 3 : *Atractyliopsis* sp., P 62, Sass de Putia section.

Fig. 4 : *Robuloides* sp., I 17, Idrijca. Section

Fig. 5 : *Baisalina* sp., I 5, Idrijca section.

Fig. 6 : *Paradagmarita monodi* LYS & MARCOUX, P 56, Sass de Putia section.

Fig. 7 : *Reichelina* sp., P 68, Sass de Putia section.

Fig. 8 : *Paraglobivalvulina mira* REITLINGER, P 68, Sass de Putia section.

Fig. 9 : *Frondina permica* S. de C. & DESS., P 68, , Sass de Putia section.

Fig. 10 : *Earlandia* sp., T 95, Tesero section.

Fig. 11 : *Paraglobivalvulina mira* var. *gracilis*, I 11, Idrijca section.

Fig. 12 : *Rectostipulina quadrata* JENNY- DESHUSSES, D 44, Dierico section.

Fig. 13 : *Dagmarita chanakchiensis* REITLINGER, P 68, , Sass de Putia section.

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Fig. 14 : *Ichtyolaria latilimbata* S. de C. & DESS :, P 68, , Sass de Putia section.

Fig. 15 : *Cyclogyra* sp., I 3, Idrijca section.

scale: 500 µm

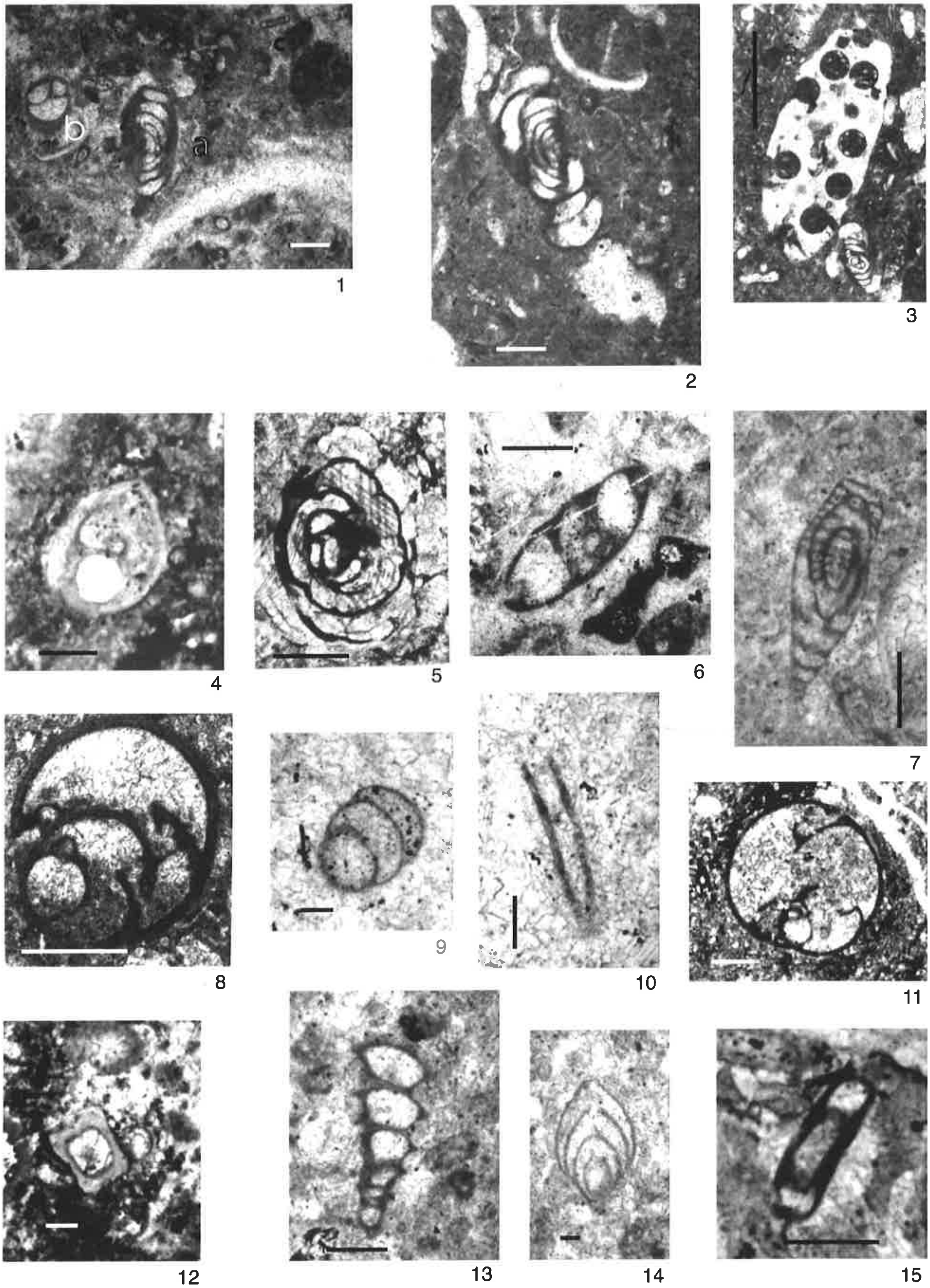

Plate 1

Plate 2

Fig. 1 : *Nankinella* sp., P 67, Sass de Putia section.

Fig. 2 : microfacies with Hemigodiopsidae C 51, Casera Federata section;
(a) *Globivalvulina* sp., aberrant form.

Fig. 3 : microfacies with bivalves, P 62, Sass de Putia section.

Fig. 4 : oolithic microfacies, T 99, Tesero section.

scale : Fig. 1, 2 = 500 µm
Fig. 3, 4 = 1 mm

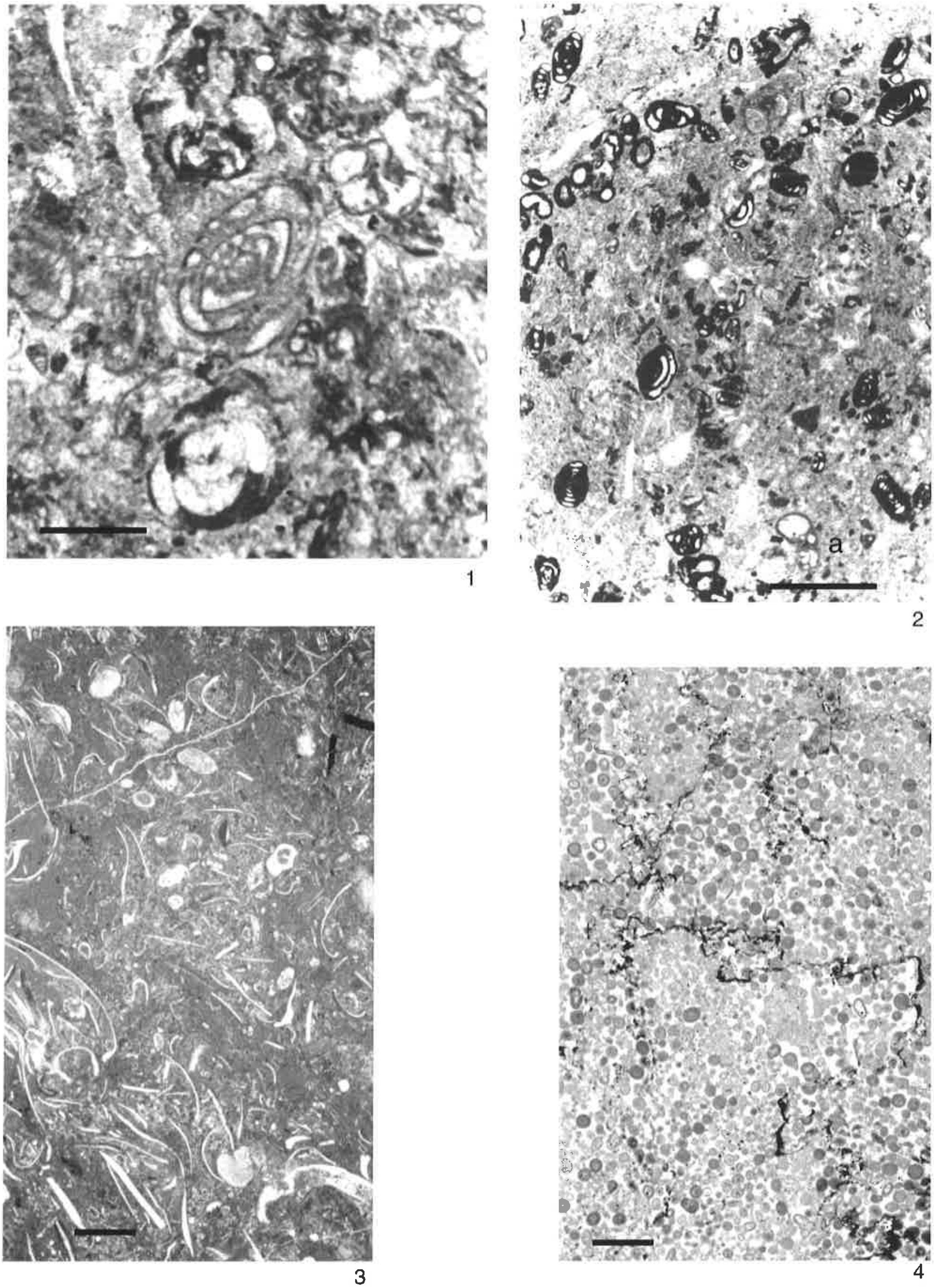

Plate 2

1.4 Greece

Introduction

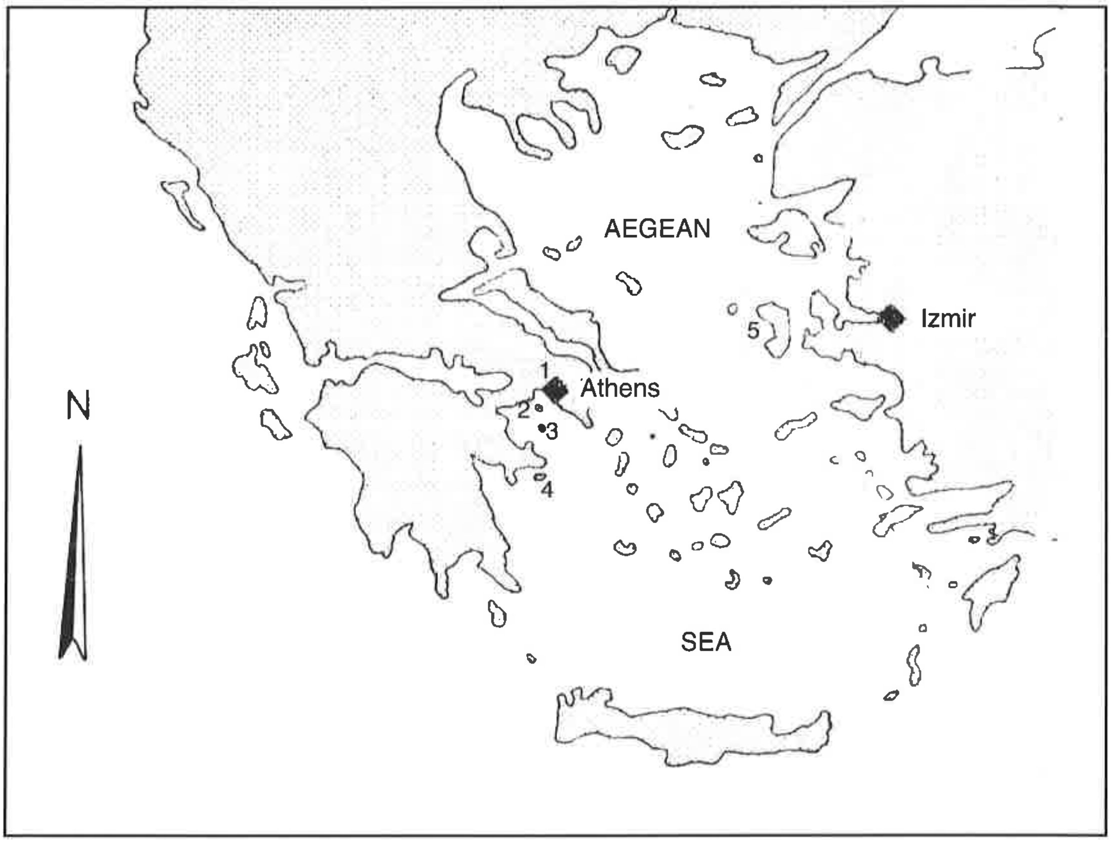

Fig.. 1.4.1 Localisation of the different outcrops and sections in Greece:
1) Attica (Mt Beletsi, Mavrinora)
2) Salamis island (Kaki Vigla section)
3) Aegina island (Mesagros section)
4) Hydra island (Cap Bisti section, Lehusis section, Episcopi sections, Cap Rigas section)
5) Chios island (Marmari section, Parpanda section)

Stratigraphical sections have been sampled in different outcrops in the islands of Hydra, Aegina, Salamis and Chios. Addition, isolated samples have been collected in Attica (Fig.1.4.1). The field work time took place in 1988 and 1989. It was supported by the Swiss National Foundation for Scientific Research (projet FNSRS n. 20-5195.86).
Since then, results have been published (Baud & al., 1991; Grant & al., 1991; Jenny & al., 2004), but the complete inventory is presented here for the first time. Regional geology, stratigraphic description and other foraminifers description of Greece can be found in Altiner and Özkan-Altiner, 1998; Clément et al., 1971; Nakazawa et al., 1975b; Nestell & Wardlaw, 1987; Reichel, 1945a,b, Vachard et al., 1993a; 1993b; 1995, 2003.

Detailed stratigraphic and micropaleontologic work on the exposures of the Permian rocks of Hydra Island, very rich in foraminifers and calcareous algae, enables a definition of the stratigraphy of the other outcrops in Aegina, Salamis, Attica and Chios. A synthetic section

illustrates these possible correlations (Fig.1.4.23).
Furthermore, the well developed stratigraphical outcrops in Hydra permitted us to propose a reconstruction of the Permian story in this island (Jenny & al., 2004), (Fig. 1.4.22).

Outcrops near Mesagros in Aegina Island and Kaki Vigla section in Salamis Island are time equivalent of the Upper Episcopi formation in Hydra (Late Wuchiapingian- Late Djulfian) with the same foraminifera *Paleofusulina- Colaniella* assemblage.
The environment is then shallow water, at proximity from the reef in Aegina, and deeper in Salamis.
The section in Salamis is stongly affected by tectonics, and even with the help of a specialist in tectonics (Prof. A. Escher) during the field work, it has been difficult to vouch for a good stratigraphical succession when collecting the samples. For this reason we do not agree with Nakazawa & al. (1975b), who proposed the Salamis Permian outcrop as a reference for Permian deposits in Greece. Nevertheless we present a table summaring foraminifers and algae associations (Fig. 1.4.3).

All the isolated samples collected in Attica can be correlated. There, data permitted correlations with the reef environmental features of Lower Permian deposits in Hydra and of the Upper Episcopi formation.
We did not collect any sample which could ascertain Middle Permian (Guadalupian) age assignment in this area (Fig.1.4.2).

	Mavrinora			**H. Mercurios**		
	algae	foraminifers	bioclasts	algae	foraminifers	bioclasts
Upper Permian	Tubiphytes Gymnocodiaceae	Paleofusulina Reichelina Colaniella Abadahella Paraglobivalvulina Paraglobivalvulinoides Agathammina Hemigordius Robuloides Pachyphloia		Tubiphytes Gymnocodiaceae Dasycladaceae	Paleofusulina Reichelina Codonofusiella Colaniella Abadahella Paraglobivalvulina Paraglobivalvulinoides Dagmarita Agathammina Pseudovermiporella Hemigordius Robuloides Pachyphloia	
Middle Permian	?	?	?	?	?	?
Lower Permian	Tubiphytes ?		?	Tubiphytes	Pseudofusulina Rugusofusulina Pseudoschwagerina Triticites Globivalvulina Deckerella Cribrogenerina Climacammina Tetrataxis	
Carboniferous	Parachaetetes	Ozawainella Bradyina Endothyra Eostaffella			Bradyina Eostaffella Climacammina	

Fig. 1.4.2 Faunal association table of Attica (Greece).

List of foraminifers and algae of Greece

Earlandia sp.
Eotuberitina reitlingerae MIKLUKO-MACLAY
Tuberitina collosa REITLINGER
Climacammina sp.
Climacammina sphaerica POTIEVSKAIA
Climacammina elegans (MOELLER)
Climacammina moelleri REITLINGER
Climacammina valvulinoides LANGE
Cribrogenerina sumatrana (VOLTZ)
Deckerella sp.
Bradyina sp.
Abadahella sp.
Abadahella coniformis OKIMURA, ISHII & NAKAZAWA
Tetrataxis sp.
Tetrataxis conica EHRENBERG
Tetrataxis planulata MOROZOVA
Neoendothyra sp.
Neoendothyra parva (LANGE)
Colaniella ex. gr. *minima* WANG
Colaniella ex. gr. *lepida* WANG
Colaniella ex. gr. *parva* (COLANI)
Cryptoseptida anatoliensis SELLIER de CIVRIEUX & DESSAUVAGIE
Geinitzina chapmani SCHUBERT
Geinitzina postcarbonica (SPANDEL)
Geinitzina primitiva POTIEVSKAIA
Geinitzina reperta BYKOVA
Geinitzina uralica SULEIMANOV
Langella çukurkoyi SELLIER de CIVRIEUX & DESSAUVAGIE
Langella ocarina SELLIER de CIVRIEUX & DESSAUVAGIE
Nodosaria longissima SULEIMANOV
Nodosaria sagitta MIKLUKO- MACLAY
Protonodosaria praecursor GERKE
Pachyphloia ovata (LANGE)
Pachyphloia pedicula LANGE
Pseudotristix sp.
Pseudotristix solida SELLIER de CIVRIEUX & DESSAUVAGIE
Robuloides lens REICHEL
Robuloides gibbus REICHEL
Frondina permica SELLIER de CIVRIEUX & DESSAUVAGIE
Ichtyolaria latilimbata SELLIER de CIVRIEUX & DESSAUVAGIE
Dagmarita chanakchiensis REITLINGER
Globivalvulina sp.
Globivalvulina kantharensis REICHEL
Globivalvulina graeca REICHEL
Globivalvulina ovata CUSHMAN & WATERS
Globivalvulina vonderschmitti REICHEL
Paraglobivalvulina mira REITLINGER
Paraglobivalvulina mira var. *gracilis* (ZANINETTI & ALTINER)
Paraglobivalvulinoides septulifera ZANINETTI & ALTINER
Agathammina sp.
Agathammina pusilla (GEINITZ)
Baisalina pulchra REITLINGER
Cyclogyra sp.
Hemigordius ssp.
Hemigordius ovatus GROZDILOVA
Hemigordius permicus GROZDILOVA

Hemigordius padangensis (LANGE)
Hemigordiopsis renzi REICHEL
Lasiodiscus sp.
Meandrospira sp.
Planinvoluta sp.
Pseudovermiporella nipponica (ENDO)

Boultonia
Codonofusiella sp.
Codonofusiella schubertelloides SHENG
Minojapanella sp.
Nanlingella sp.
Paleofusulina sp.
Paleofusulina sinensis SHENG
Paradoxiella sp.
Schubertella sp.
Neofusulinella sp.
Pseudoreichelina sp.
Reichelina sp.
Reichelina changhsiengensis
Reichelina criptoseptida ERK
Reichelina media MIKLUKO- MACLAY
Reichelina tenuissima MIKLULO- MACLAY
Nankinella sp.
Staffella sp.
Staffella sphaerica (ABICH)
Staffella zisonghzengensis (SHENG)
Triticites stuckenbergi RAUSER- TCHERNOUSOVA
Pseudofusulina sp.
Pseudofusulina tchernyschewi SCHELLWIEN
Rugosofusulina directa BENSCH
Parafusulina sp.
Quasifusulina sp.
Schwagerina sp.
Pseudoschwagerina sp.
Neoschwagerina sp.
Neoschwagerina schuberti KOCHANSKY- DEVIDE
Neoschwagerina margaritae DEPRAT
Kahlerina sp.
Pseudodoliolina sp.

Gymnocodium sp.
Gymnocodium bellerophontis (ROTHPLETZ)
Permocalculus sp.
Permocalculus plumosus ELIOTT
Atractyliopsis sp.
Mizzia sp.
Mizzia velebitana SCHUBERT
Epimastopora sp.
Tubiphytes obscurus MASLOV
Undgarella uralica

Rectostipulina quadrata JENNY- DESHUSSES

Kaki Vigla (Salamis island)

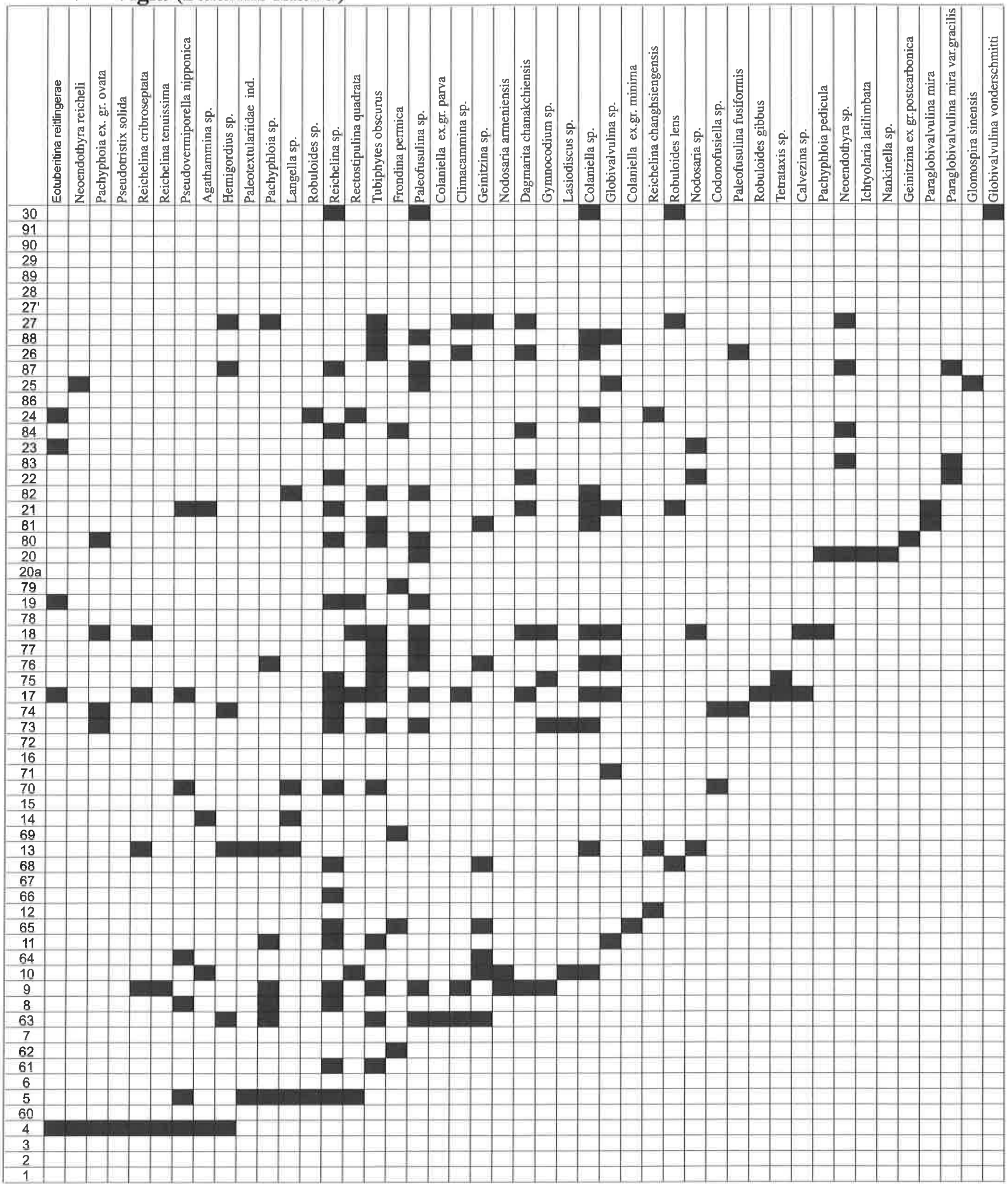

Fig. 1.4.3 Inventory table of foraminifers and calcareous algae of Kaki Vigla section (Salamis Island, Greece), For a section description see also Baud et al., 1989.

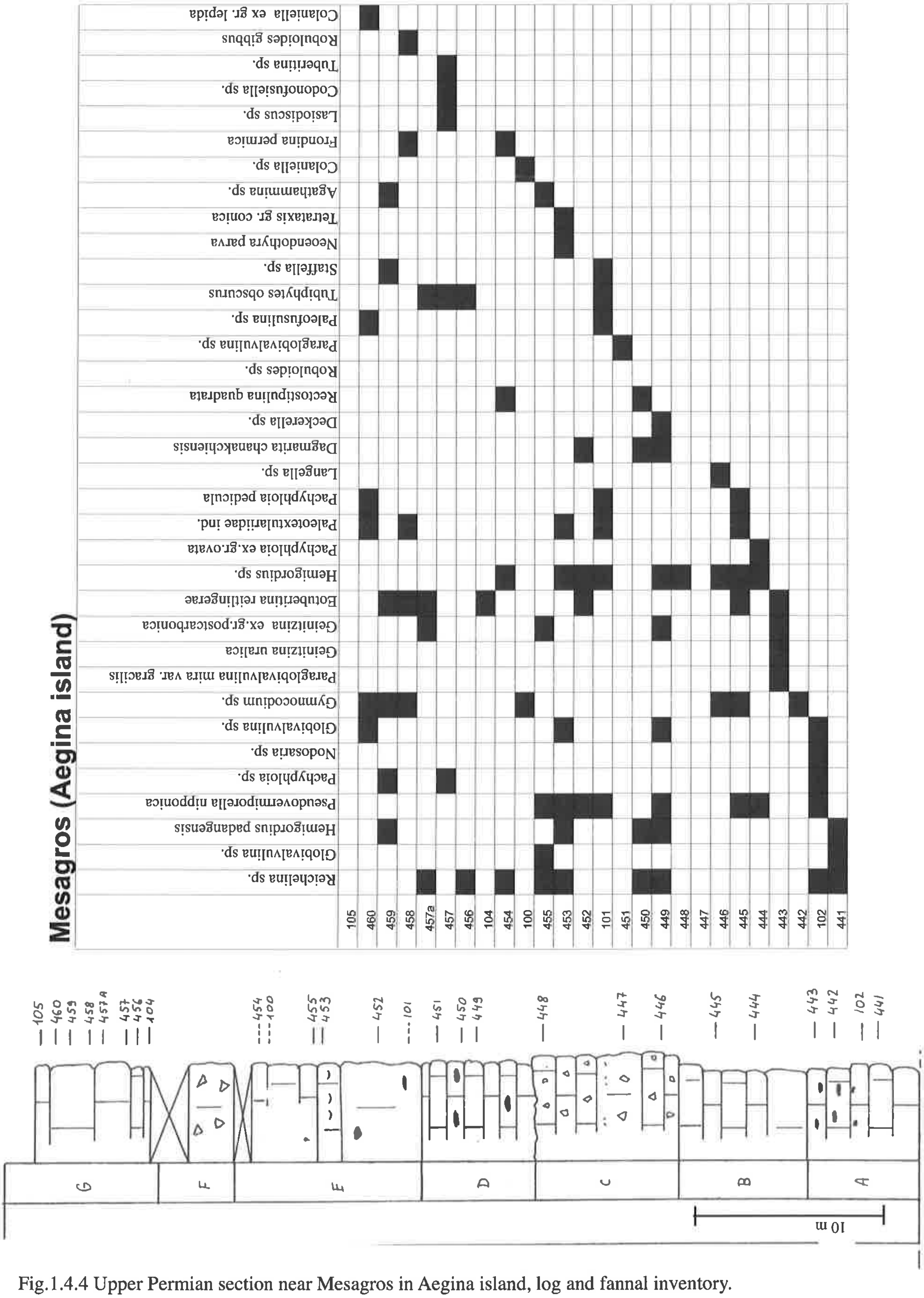

Fig.1.4.4 Upper Permian section near Mesagros in Aegina island, log and fannal inventory.

MESAGROS SECTION (Aegina island, Greece)

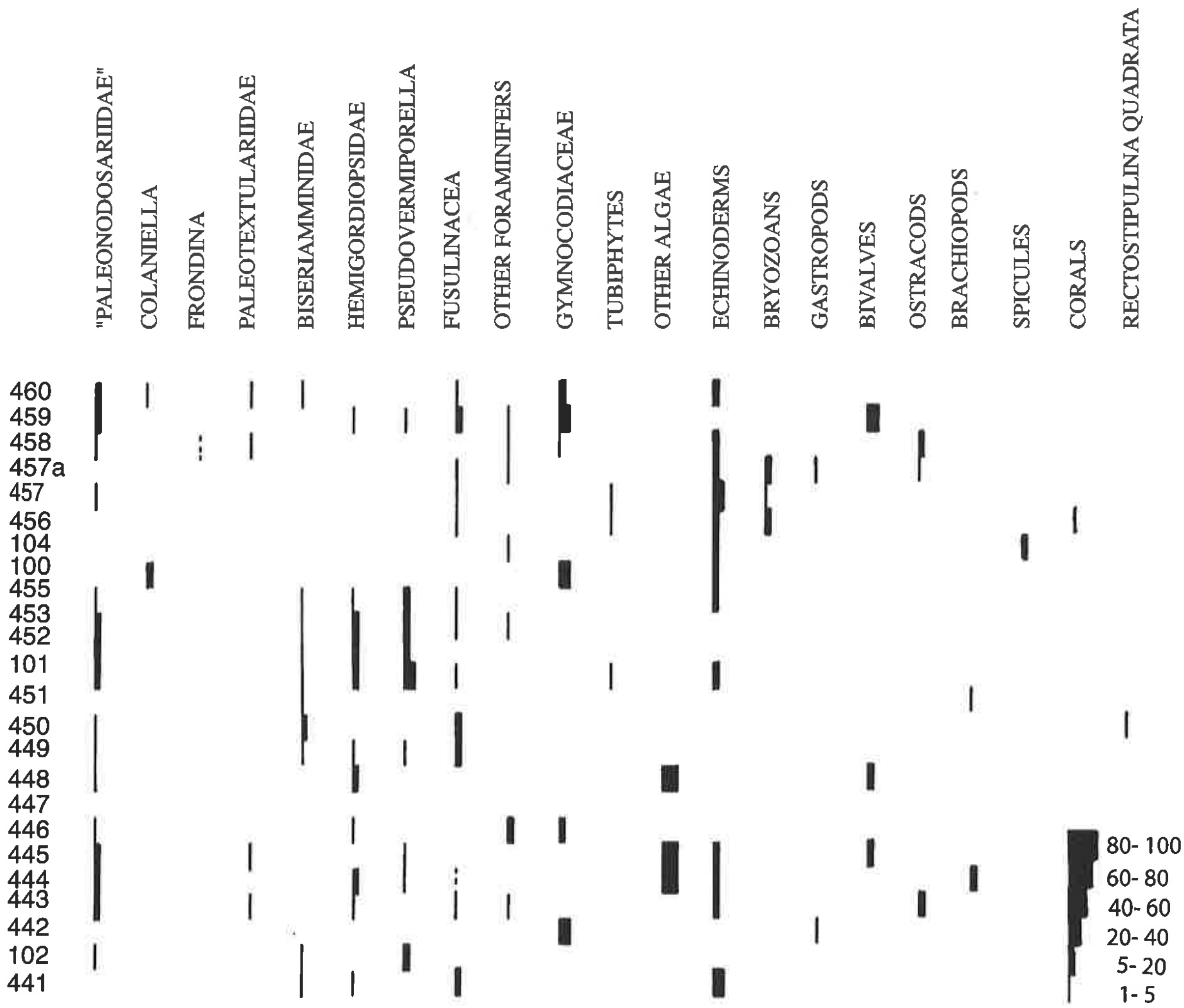

Fig.1.4.5 Estimation table (%) of the main bioclasts in Mesagros section (Aegina island, Greece).

Parpanda (Chios)

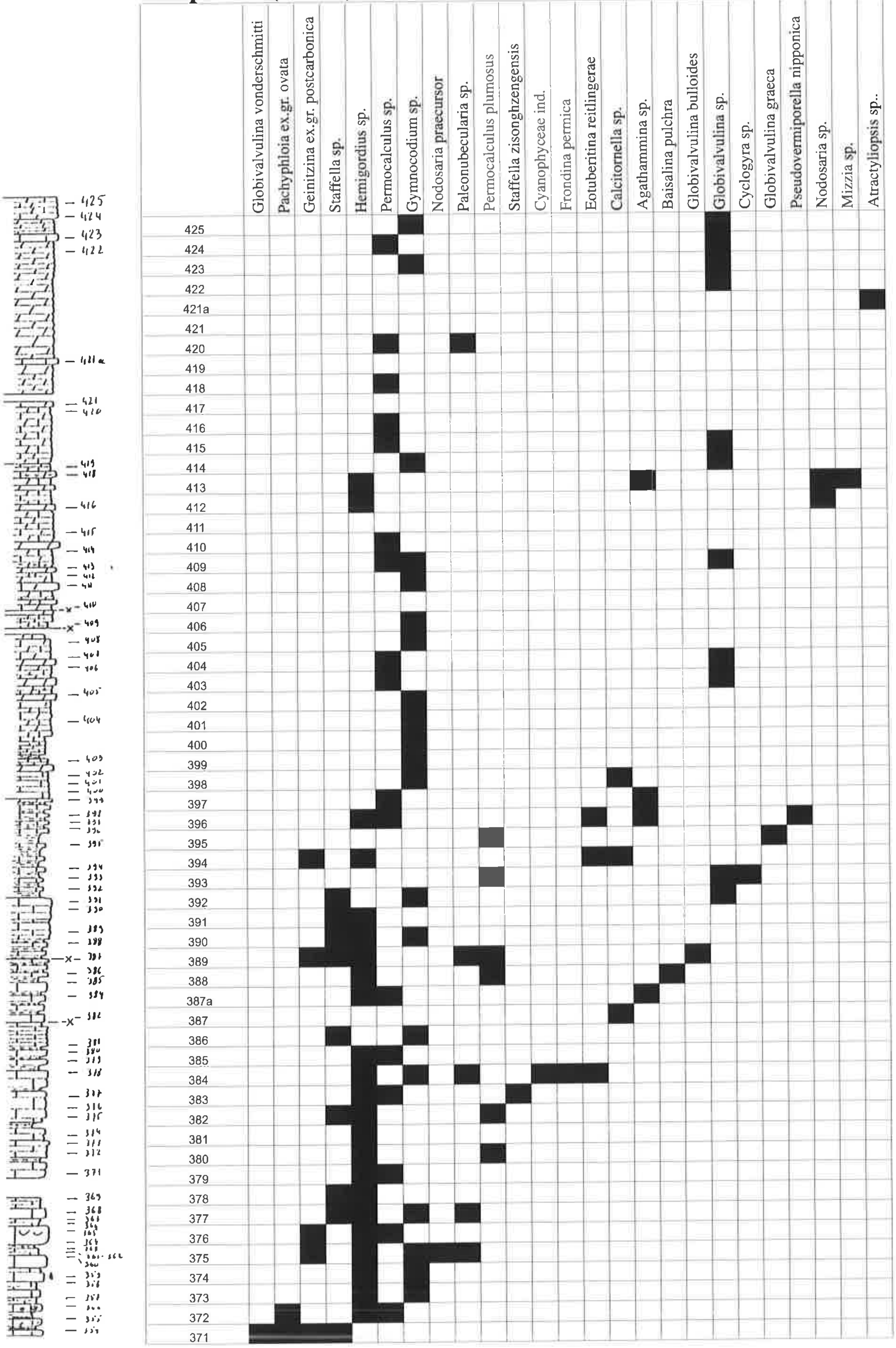

Fig. 1.4.6 Log and inventory table of foraminifers and calcareous algae of Parpanda section (Chios Island, Greece).

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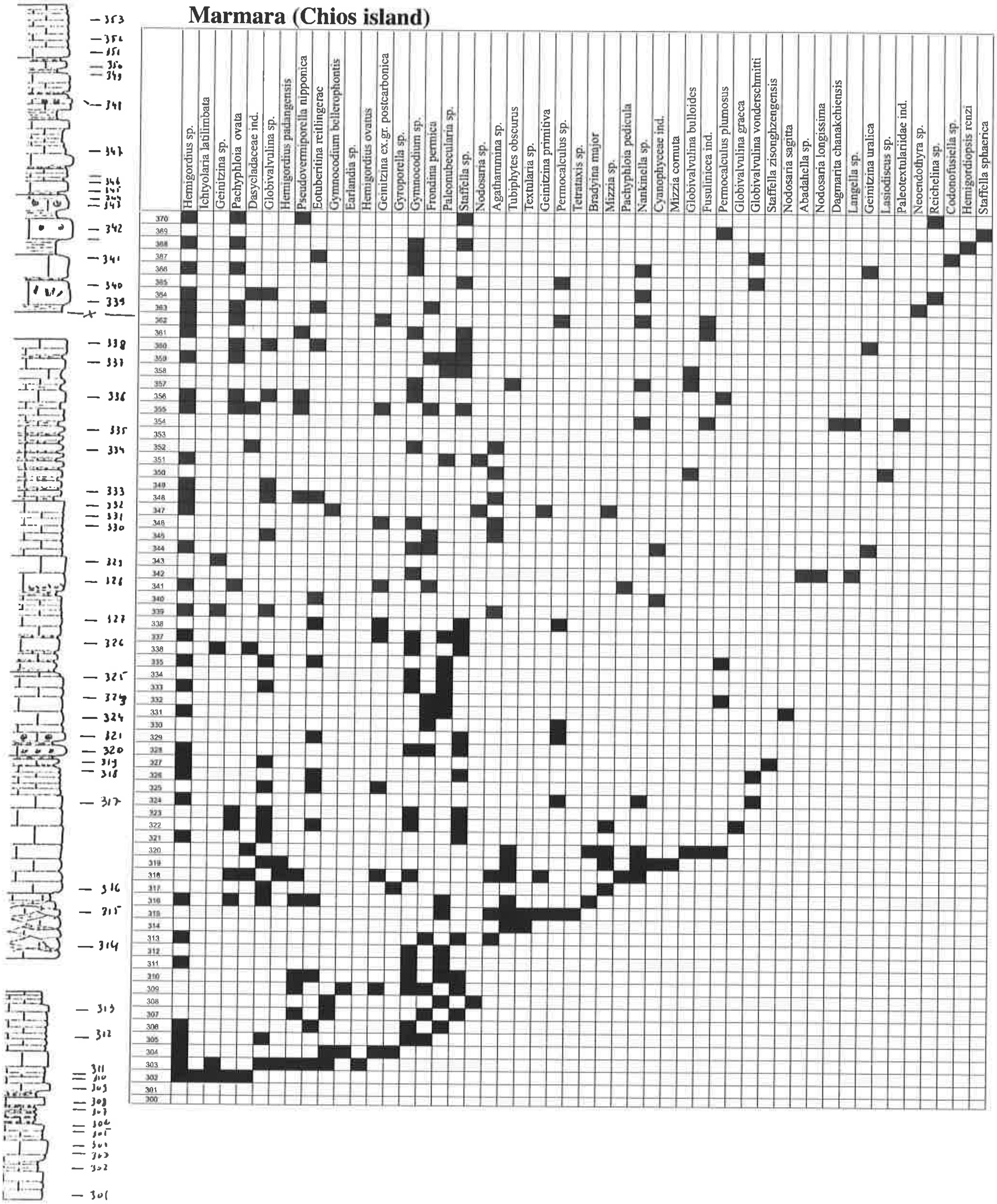


Fig. 1.4.7 Log and inventory table of foraminifers and calcareous algae of Marmara section (Chios Island, Greece).

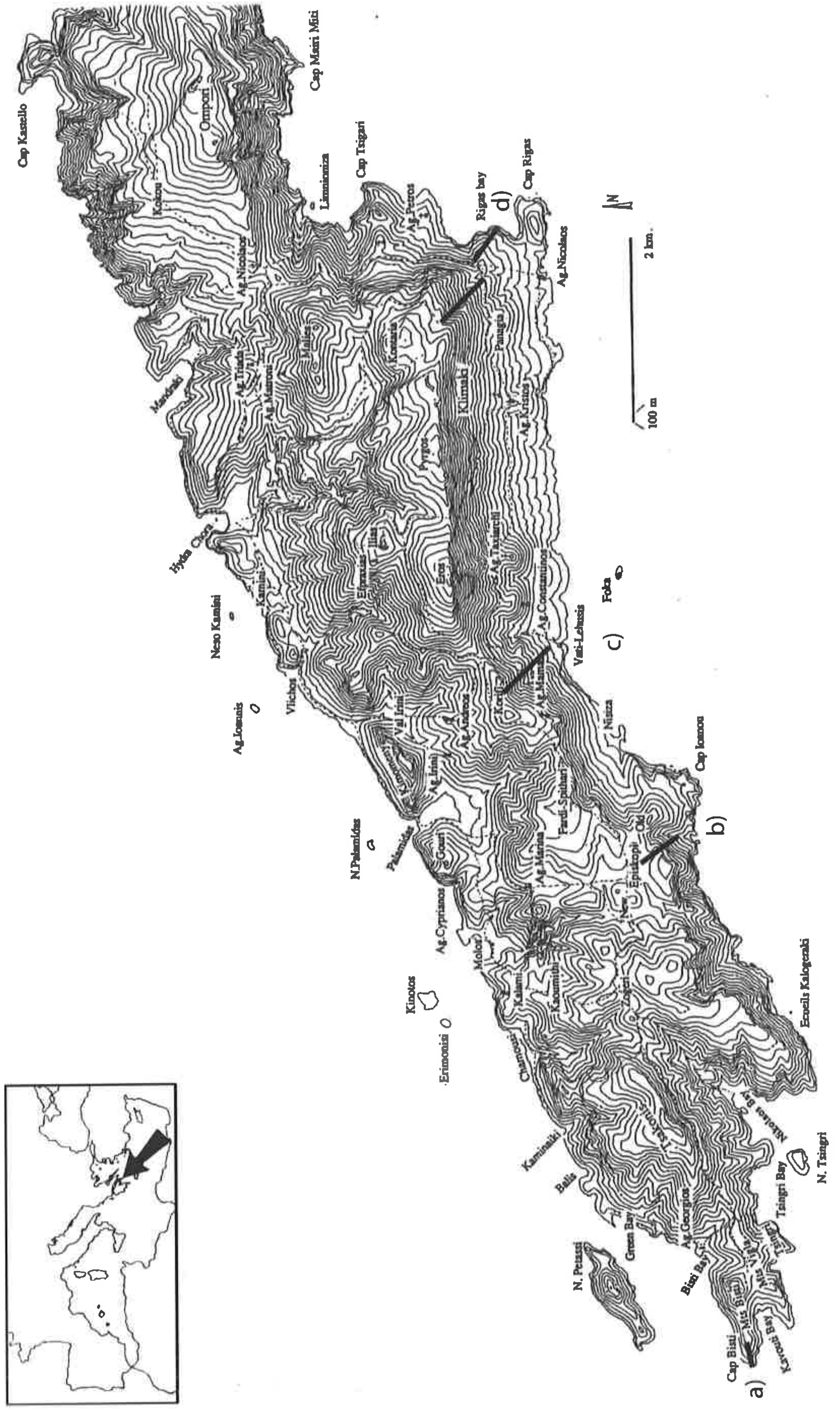
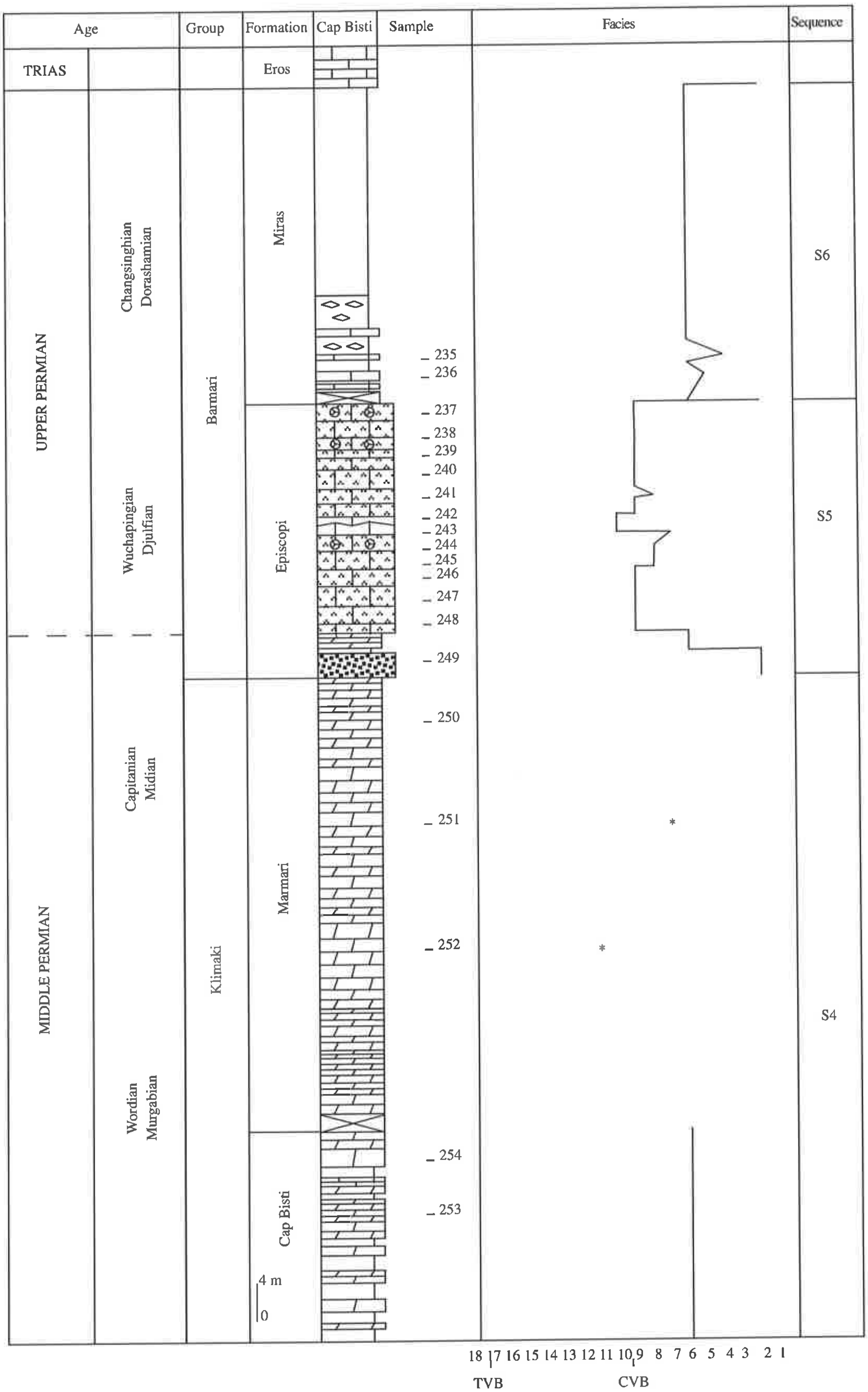


Fig. 1.4.8 : Localisation of the section in Hydra Island (Greece): a) Cap Bisti b) Episcopi c) Lehusis d) Cap Rigas

System	Series	stages GSSP	Tethyan stages	Greece (Hydra): fusulinids	Greece (Hydra): small foraminifers	Greece (Hydra): algae
Permian	Lopingian	Changhsingian	Dorashamian	Paradoxiella Paleofusulina Reichelina Staffella Codonofusiella	Colaniella Paraglobivalvulinoides Paraglobivalvulina Abadahella Hemigordiopsis Rectostipulina Dagmarita Globivalvulina Robuloides	Mizzia Gymnocodium Permocalculus Tubiphytes
		Wuchiapingian	Djulfian			
	Guadalupian	Capitanian	Midian	Reichelina Neoschwagerina Staffella Nankinella	Dagmarita Pseudovermiporella Hemigordius Globivalvulina	Gymnocodium Permocalculus
		Wordian	Murgabian			
		Roadian	Kubergandian			
	Cisuralien	Kungurian	Bolorian			
		Artinskian	Artinskian	Rugosofusulina Minojapanella	Pseudovermiporella	Tubiphytes
		Sakmarian	Sakmarian	Pseudofusulina Pseudoreichelina Schwagerina Neofusulinella	Globivalvulina Tetrataxis	Tubiphytes
		Asselian	Asselian	Trticites		Tubiphytes

Fig. 1.4.9 Faunal association table of Hydra island (Greece).



Legend			
Calcirudite	Limestone	Coral	TVB : Limit of storm wave action
Limestone with algae	Dolomite	Silex	CVB : Limit of wave action by calm weather
	Shale	Lime nodule	

Fig 1.4.10 Lithostratigraphic profile and sedimentary sequences Cap Bisti section (Hydra Island, Greece)

CAP BISTI SECTION (Hydra Island, Greece)

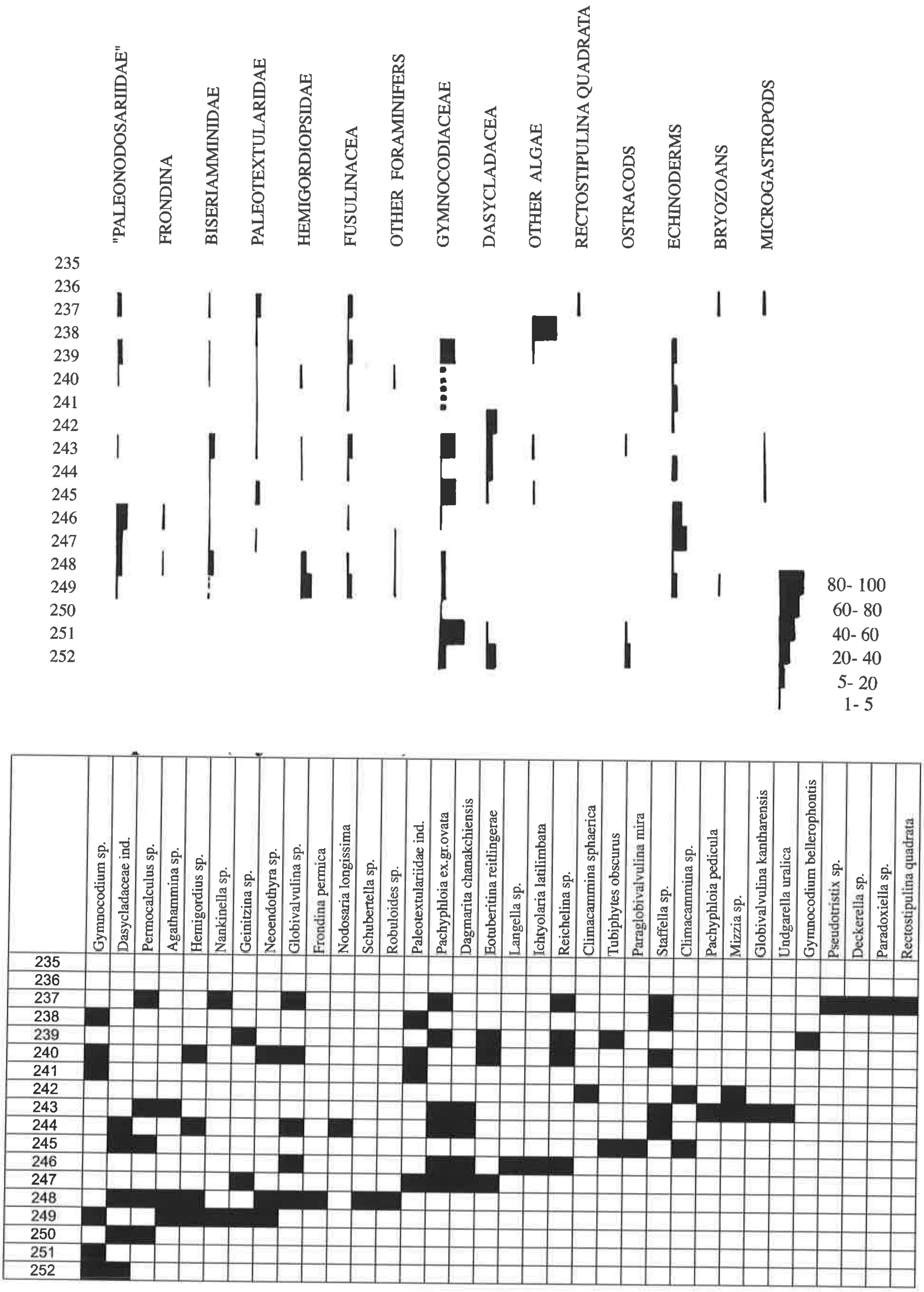


Fig. 1.4.11 Estimation table (%) of the main bioclasts and inventory table of foraminifers and calcareous algae in Cap Bisti section.

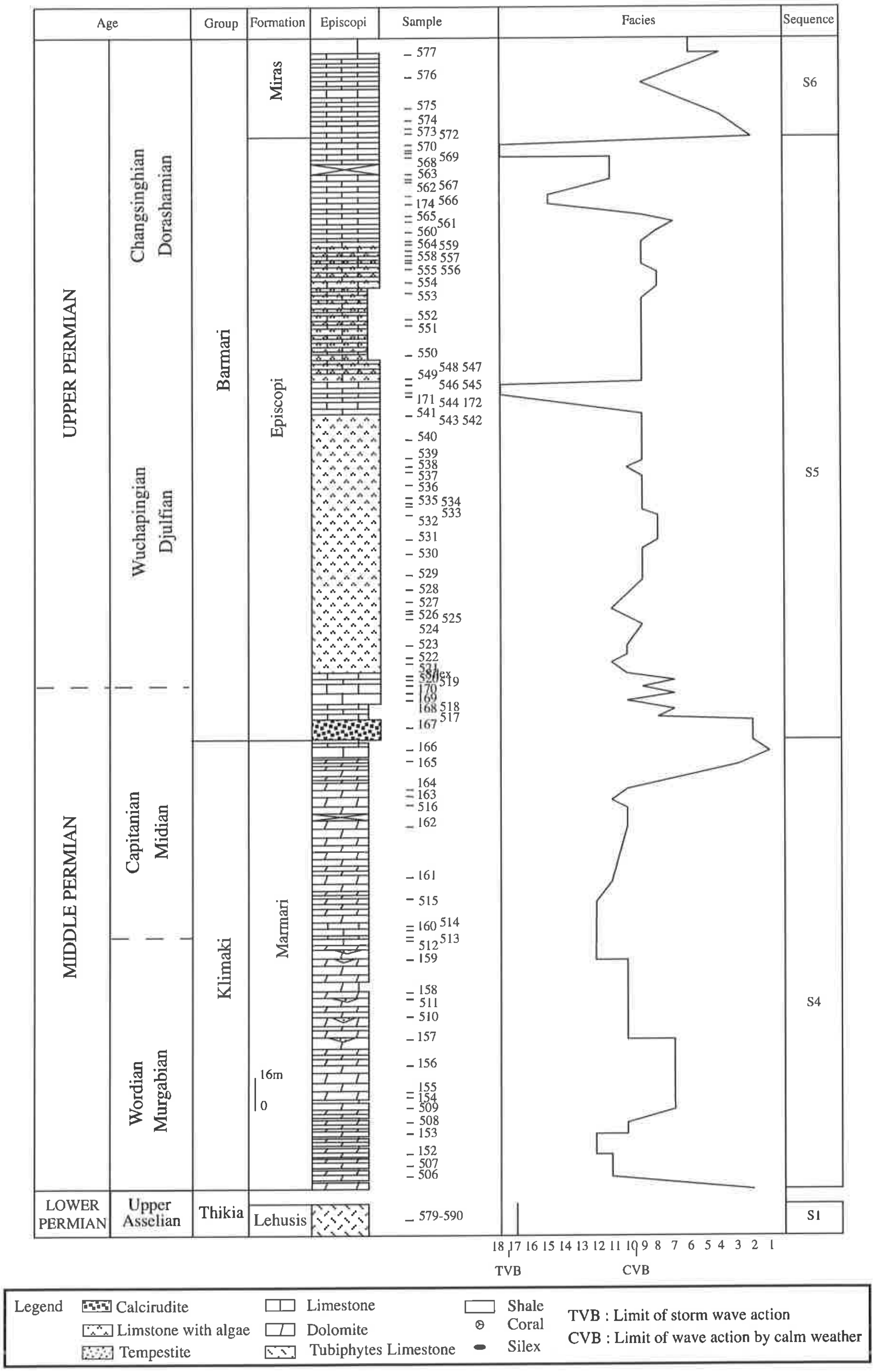


Fig. 1.4.12 Lithostratigraphic profile and sedimentary sequences of Episcopi section (Hydra Island, Greece).

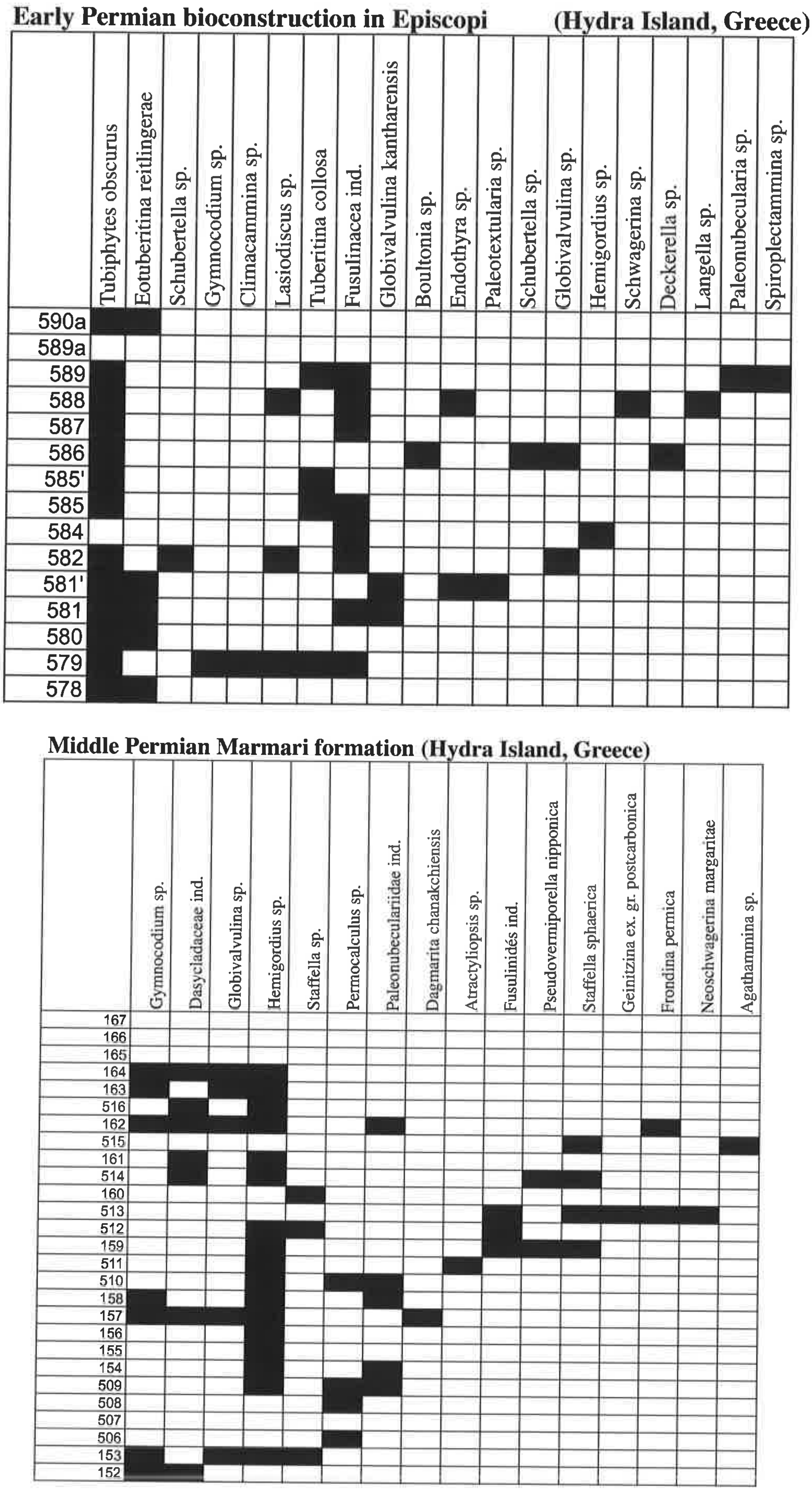


Fig. 1.4.13 Inventory table of foraminifers and calcareous algae of Lower Permian bioconstruction and Middle Permian Marmari Formation (Episcopi section, Hydra Island, Greece).

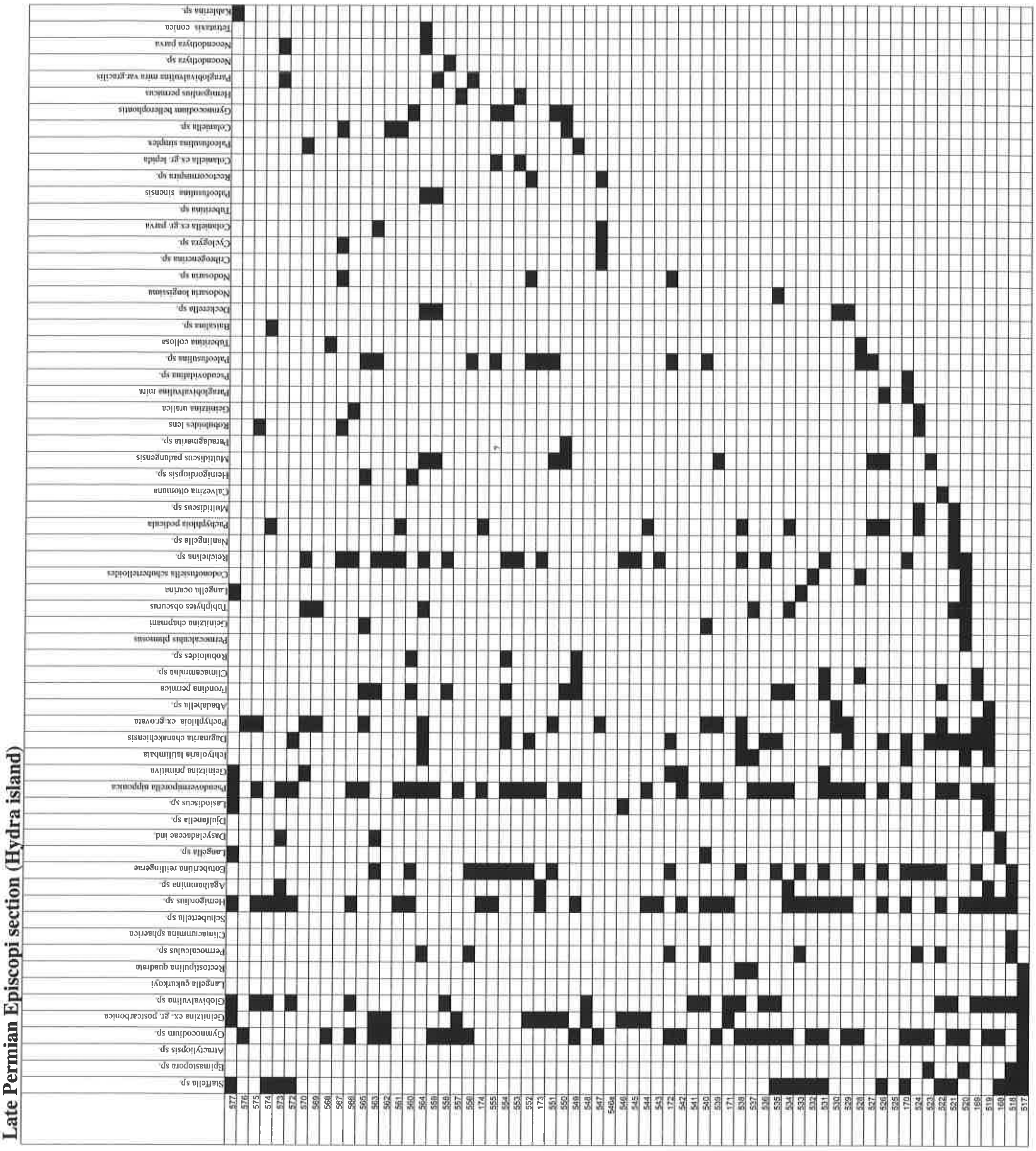


Fig. 1.4.14 Inventory table of foraminifers and calcareous algae of Episcopi section (Hydra Island, Greece).

EPISCOPI SECTION (Hydra island, Greece)

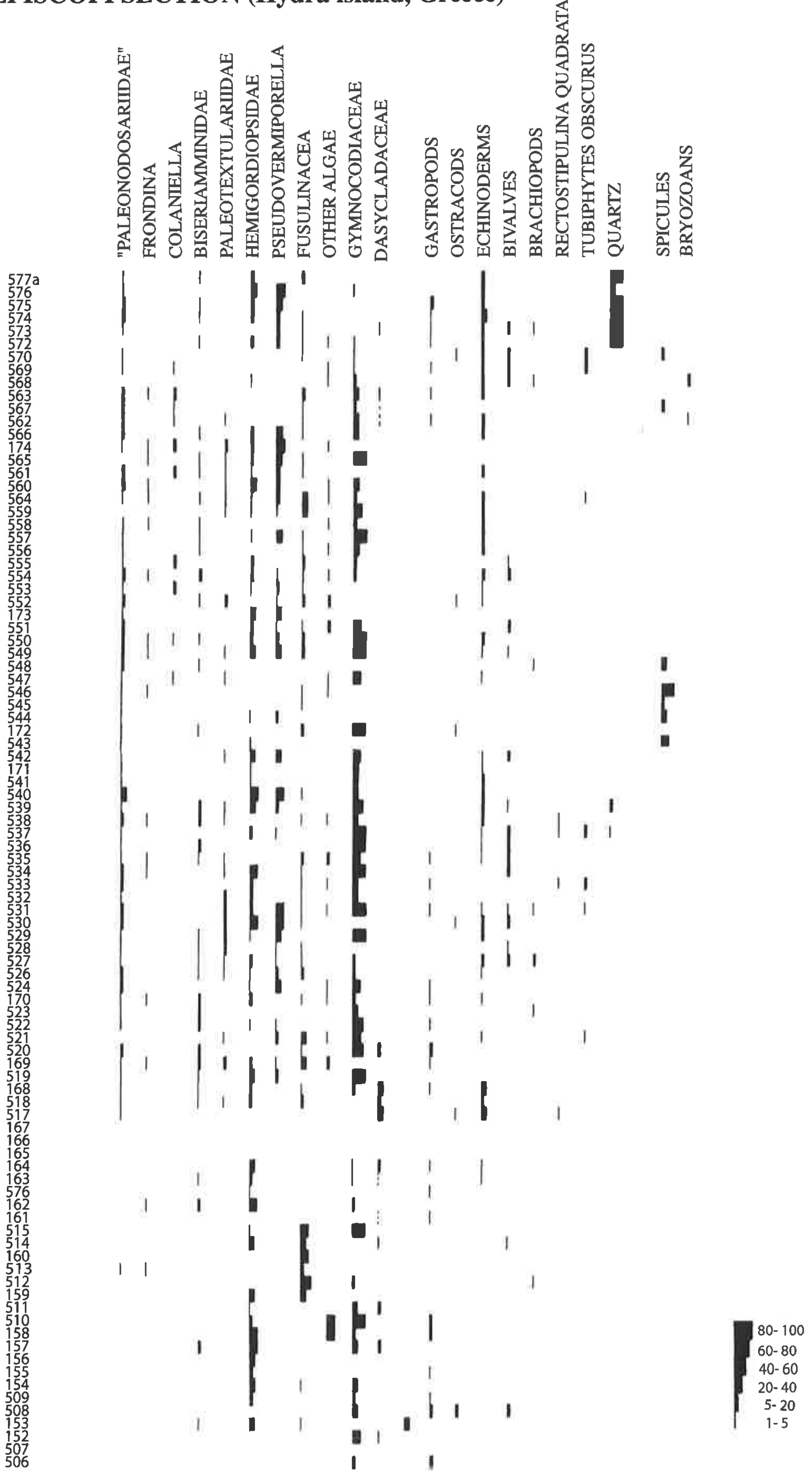


Fig. 1.4.15 Estimation table (%) of the main bioclasts in Episcopi sections (Marmari and Episcopi Formations).

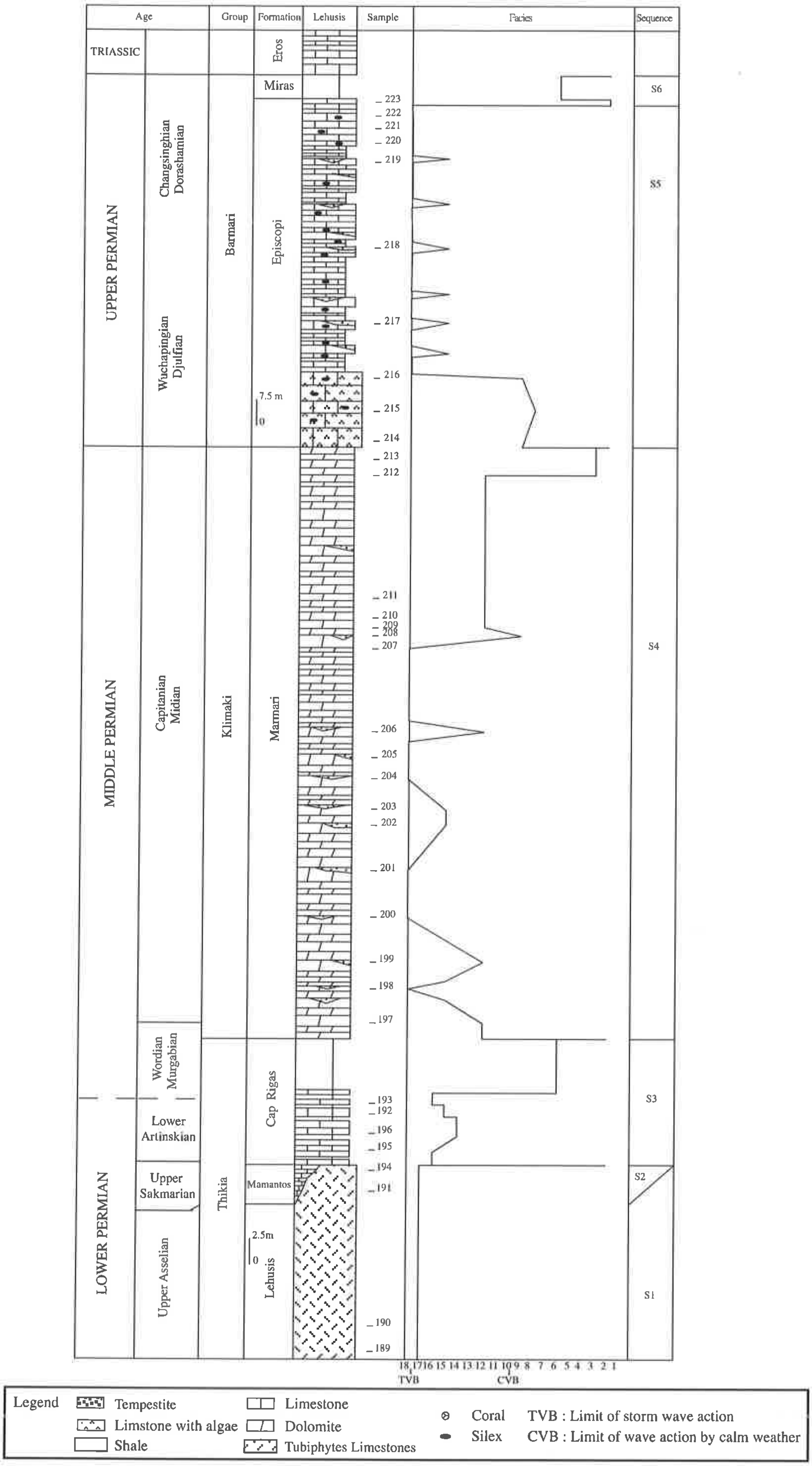


Fig. 1.4.16 Lithostratigraphic profile and sedimentary sequences of Lehusis section (Hydra Island, Greece).

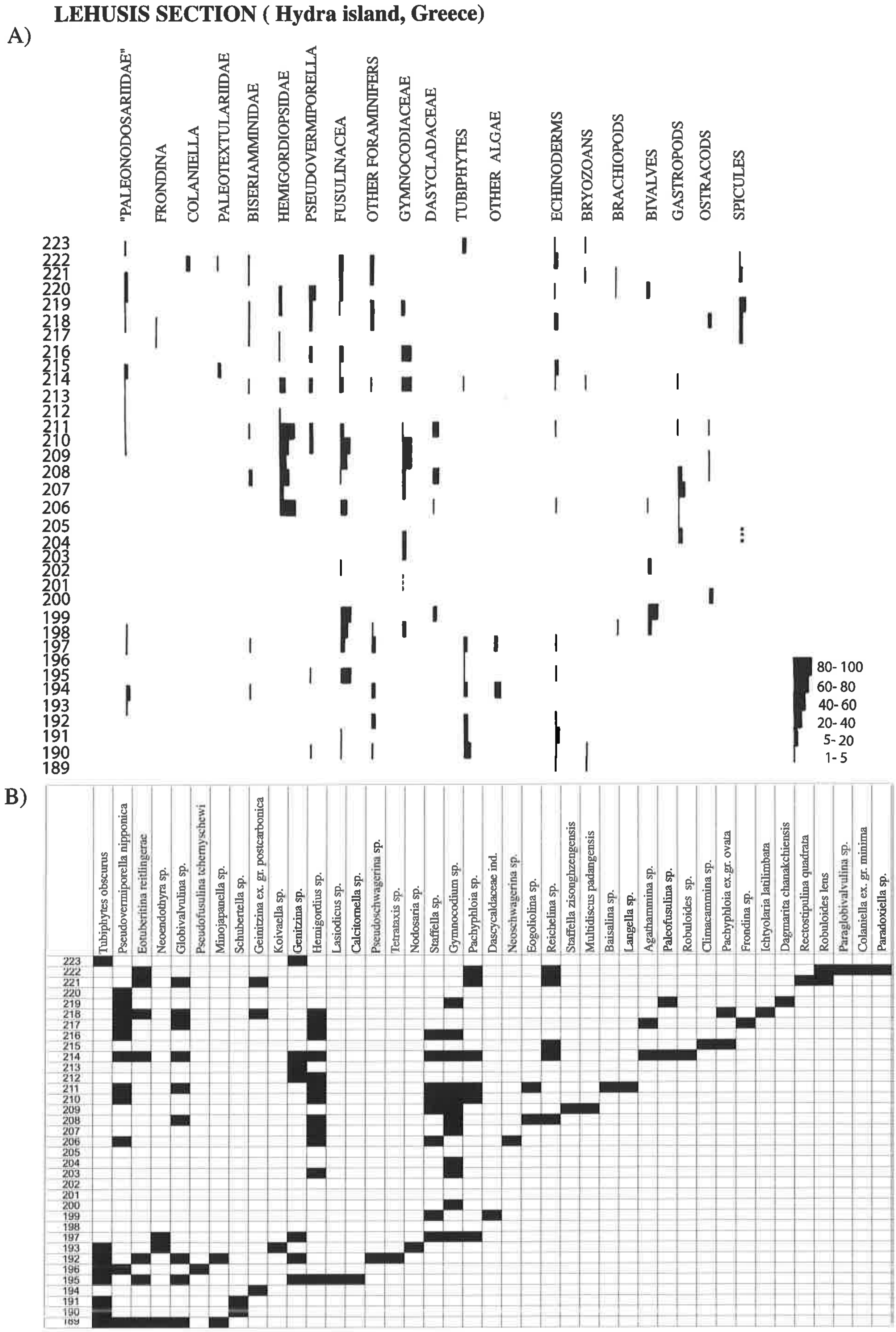


Fig. 1.4.17 Estimation table (%) of the main bioclasts (A) and inventory table of foraminifers and calcareous algae (B) of Lehusis section (Hydra Island, Greece).

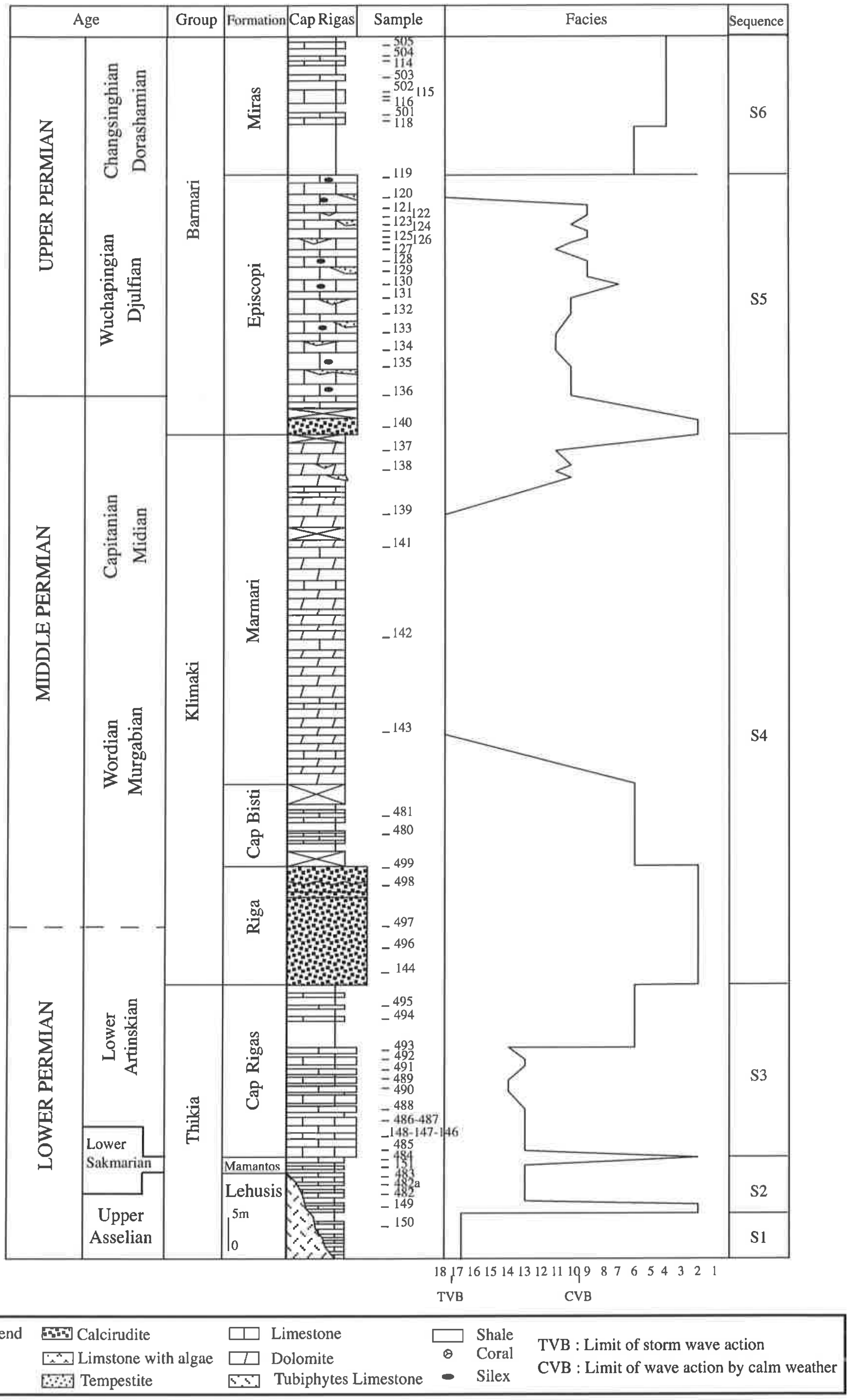


Fig. 14.1.18 Lithostratigraphic profile and sedimentary sequences of Cap Riga section (Hydra Island, Greece).

CAP RIGAS SECTION (Hydra island, Greece)

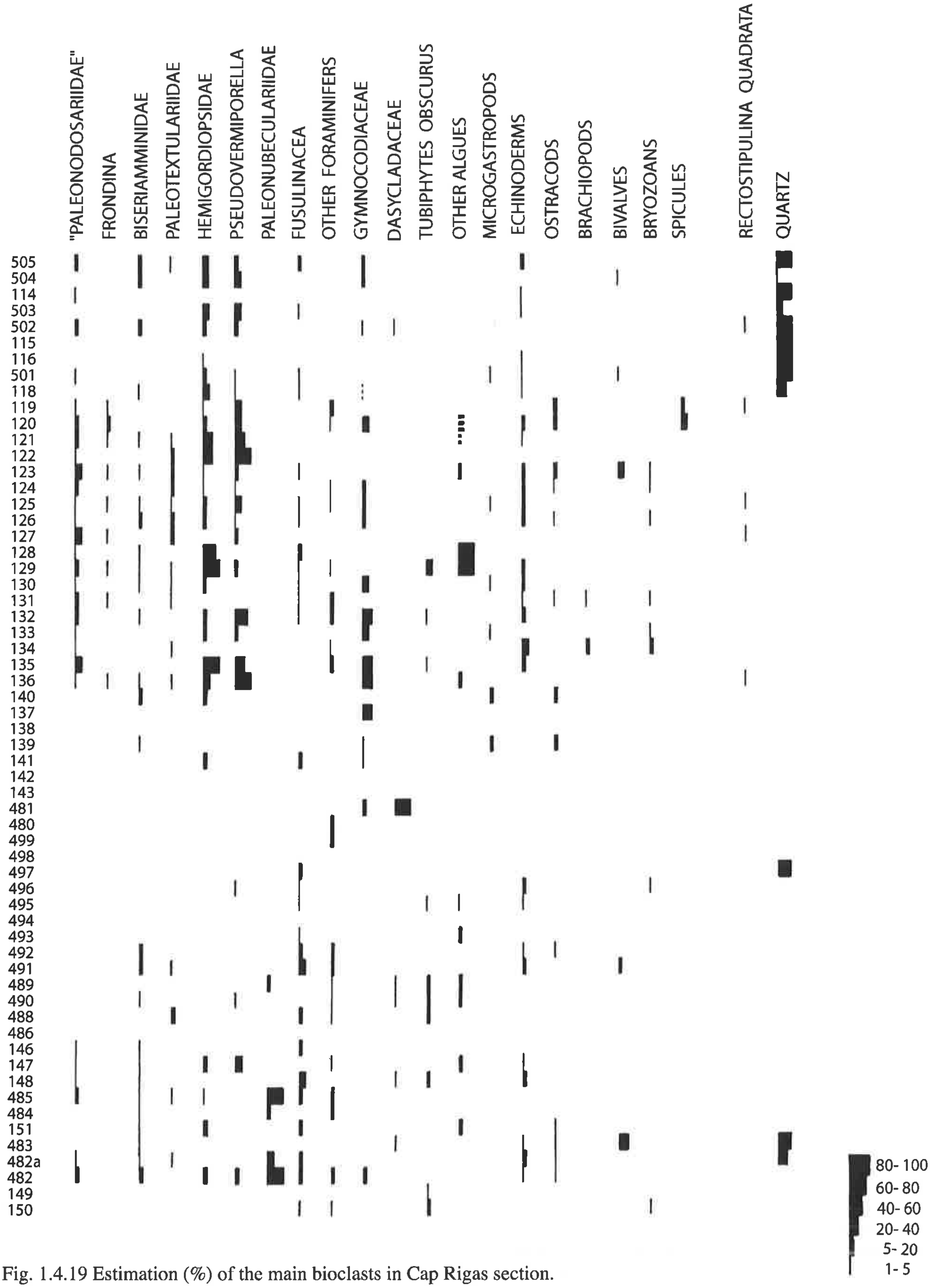


Fig. 1.4.19 Estimation (%) of the main bioclasts in Cap Rigas section.

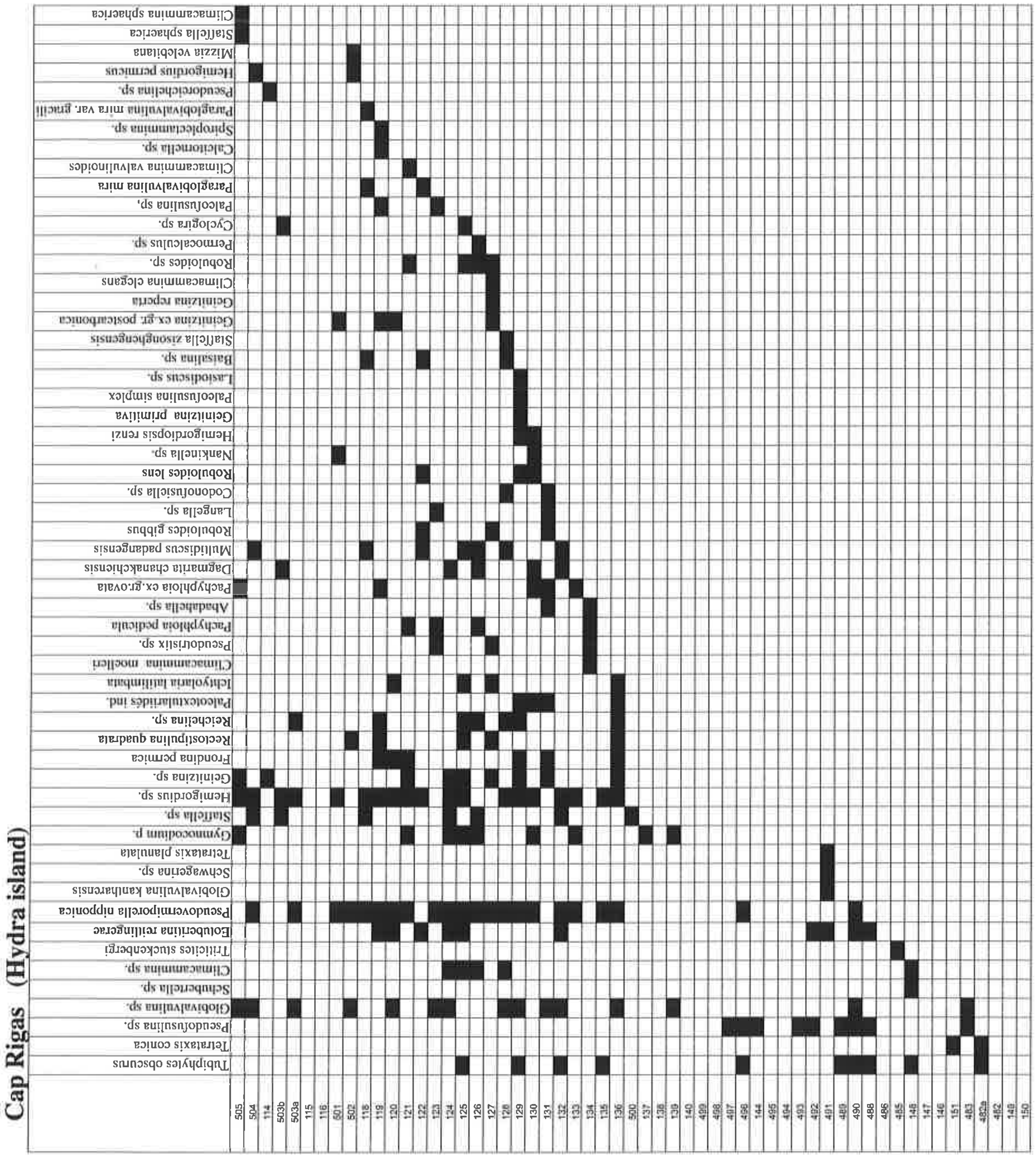


Fig. 1.4.20 Inventory table of foraminifers and calcareous algae of Cap Rigas section (Hydra Island, Greece).

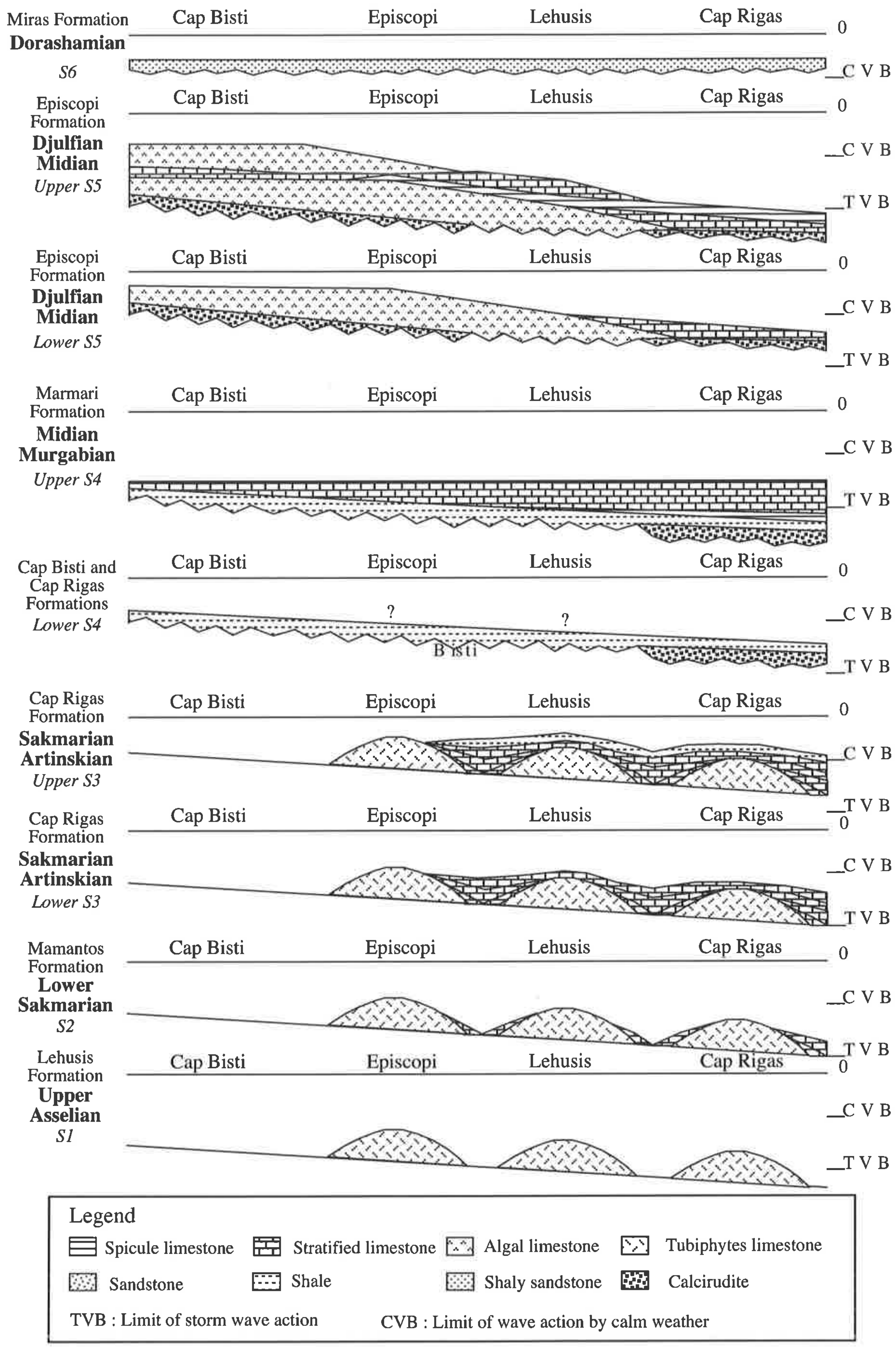


Fig. 1.4.21 Stratigraphic reconstruction of Permian deposits in Hydra Island, (Greece), from Jenny & al., 2004

Hydra Island

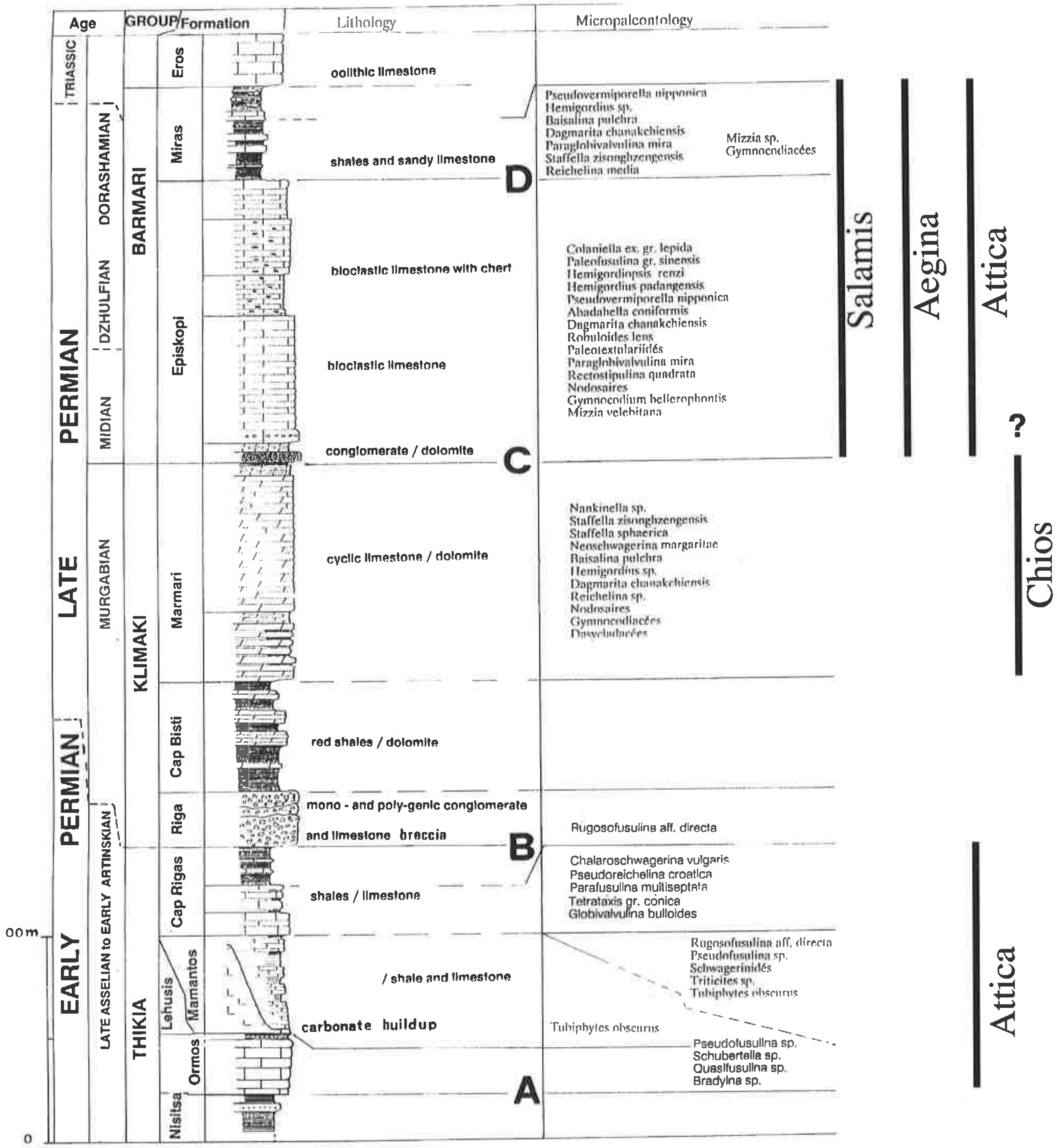


Fig. 1.4.22 Synthetic log of the Permian deposits in Hydra Island and comparison with the extension of other studied areas in Greece (Baud et al., 1991)

Micropaleontological remarks on Permian deposits in Greece

« Paleonodosariidae »
Individuals of this group are present in every locality in Greece, and range from Lower to Late Permian.
The most frequent species are *Genitzina* ex. gr. *postcarbonica* (SPANDEL) and *Pachyphloia* ex. gr. *ovata* (LANGE). Other species of this group are also present. Individuals of these genera show dwarf forms below the Permo-Triassic Boundary (PTB).
Colaniella ex. gr. *parva* (COLANI) is present in isolated samples in Attica (Pl. 3, fig. 2) and in Late Permian deposits in different sections in Hydra (Pl. 3, fig. 6) and Salamis; furthermore *Colaniella* ex. gr. *minima* WANG and *Colaniella* ex. gr. *lepida* WANG (Pl. 3, fig. 4) have also been unmistakably observed in Hydra and Aegina.
Robuloides lens REICHEL and *Robuloides gibbus* REICHEL are also well recognizable in all Upper Permian deposits in Greece (Pl. 3, fig. 3).
The same is true for *Frondina permica* S. de CIVRIEUX & DESSAUVAGIE. *Ichtyolaria latilmbata* S.de C. & DESS. is missing in Aegina, but present in the other localities.

Paleotextulariidae
Species assignment for individuals of this group is not always easy. For this reason, we sometimes call doubtful individuals: "Paleonodosariids ind." in the tables. Nevertheless the list of foraminifers from the deposits of Greece present five species for this group. Individuals of this group are found in Lower to Late Permian. They are present in every locality in Greece.

Biseriamminidae
We observed many characteristic species of this group in every locality in Greece, from Lower to Late Permian. We especially noticed the presence of *Paraglobivalvulinoides septulifer* ZANINETTI & ALTINER in Attica (Pl. 6, fig. 3) and in Hydra Island. *Paradagmarita* LYS & MARCOUX made exception with only one section, too doubtful to be assigned to this genus.

Hemigordiopsidae
This group of foraminifers is well represented in every locality in Greece. They even characterize a biofacies of the Middle Permian Marmari Formation in Hydra and Chios, in association with Staffellids (Pl. 4, fig. 9). They show many types of coiling of their locular chambers. They also develop dwarf forms below the PTB.
Hemigordiopsis sp. is present only in the Upper Permian Episcopi Formation in the section of Episcopi in Hydra Island.

Fusulinacea
The different plates and tables contain a lot of information on the different taxa for this main group of foraminifers.
It is nevertheless important to notice the presence of *Paleofususlina* in every locality where Late Permian deposits were collected.
Each faunal association of the Permian in Greece can be characterized by one or more taxa of this group of foraminifers, from Lower to Late Permian (Figs.1.4.2; 1.4.10).

Incertae sedis
As often in the Upper Permian deposits in the Tethyan realm, the well recognizable and regular taxa *Rectostipulina quadrata* JENNY-DESHUSSES has been observed in all Upper Permian deposits in Greece.

Biofacies
Jenny & al. (2004) proposed successive associations for the Permian, defined in the sections of Hydra Island. These associations include not only foraminifers and calcareous algae, but also other bioclasts. Tables of estimation of the different bioclasts greatly help to establish the proposed Permian history of Hydra (Fig.1.4.23).

In conclusion, the great faunal diversity in species and individuals of foraminifers and calcareous algae of the Permian deposits in Greece, especially in Hydra Island have to be rised.
In this large area, the *Paleofusulina-Colaniella* association is present but rarely observable in the Upper Permian deposits. This is their most western well-documented occurrence in the Tethys realm.

Plate 3

Fig. 1 : *Baisalina* sp., G 389, Chios Island, Parpanda section.

Fig. 2 : *Colaniella* ex. gr. *parva* (COLANI), G2, Attica (Mt Beletsi, Mavrinora), isolated sample.

Fig. 3 : *Robuloides gibbus* REICHEL, G530, Hydra Island, Episcopi section, Episcopi formation.

Fig. 4 : *Colaniella* ex. gr. *lepida* (WANG), G 555, Hydra Island, Episcopi section, Episcopi formation.

Fig. 5 : *Tetrataxis* sp., G 151, Hydra Island, Cap Rigas section, Mamantos formation.

Fig. 6 : *Colaniella* ex. gr. *parva* (COLANI), Hydra Island, Episcopi section, Episcopi formation.

Fig. 7 : *Dagmarita chanakchiensis* REITLINGER, G 243, Hydra Island, Cap Bisti section, Episcopi formation.

Fig. 8 : *Abadahella* sp., G1, Attica (Mt Beletsi, Mavrinora), isolated sample.

Fig. 9 : *Tetrataxis planulata* MOROZOVA, G 491a, Hydra Island, Cap Rigas, Cap Rigas formation.

Fig. 10 : *Neoendothyra sp.*, G 558, Hydra Island, Coupe d'Episcopi, Episcopi formation.

Fig. 11 : *Globivalvulina vonderschmitti* REICHEL G 324, Chios Island, Marmara section.

Fig. 12 : *Globivalvulina kantharensis* REICHEL, G 491, Hydra Island, Cap Rigas section, Cap Rigas formation.

Fig. 13 : microfacies with Hemigordiopsids, G 211, Hydra Island, Lehusis section, Marmari formation.

Fig. 14 : *Climacammina valvulinoides* LANGE, G 237, Hydra Island, Cap Bisti section, Episcopi formation.

Fig. 15 : *Paraglobivalvulina mira* var. *gracilis* included in *Permcalculus* sp., G 118, Hydra Island, Cap Rigas section, Episcopi formation.

Fig. 16 : *Climacammina sphaerica* POTIEVSKAIA, G 505, Hydra Island, Episcopi section, Episcopi formation.

Scale: Fig. 3, 4, 12 = 100 μm
Fig. 1, 2, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16 = 500 μm

Plate 3

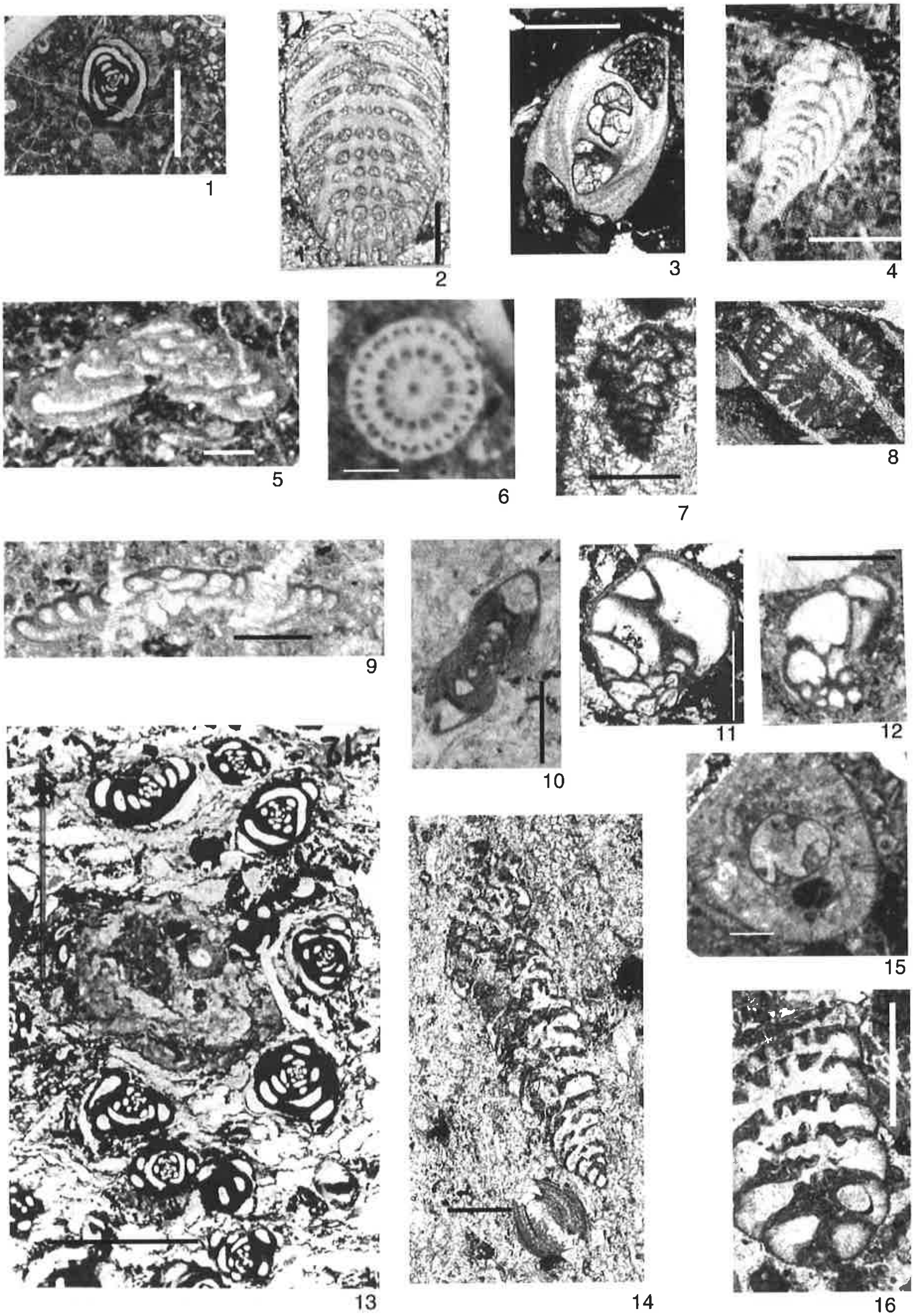


Plate 4

Fig. 1 : *Paleofusulina* aff. *sinensis*, G 550, Hydra Island, Episcopi section, Episcopi formation.

Fig. 2 : *Paradoxiella* sp. G 220, Hydra Island, Lehusis section, Episcopi formation.

Fig. 3 : *Codonofusiella schubertelloides* SHENG, G 520, Hydra Island, Episcopi section, Episcopi formation.

Fig. 4 : *Neoschwagerina margaritae* DEPRAT, G 513, Hydra Island, Episcopi section, Marmari formation.

Fig. 5 : *Globivlavulina vonderschmitti* REICHER, G 371, Chios Island, Parpanda section.

Fig. 6 : *Paraglobivalvulina mira* REITLINGER, G 170, Hydra Island, Episcopi section, Episcopi formation.

Fig. 7 : *Lasiodiscus* sp., G 582, Hydra Island, Episcopi section, Lehusis formation (bioconstruction).

Fig. 8 : *Staffella sphaerica* (ABICH), G 365, Chios Island, Marmara section.

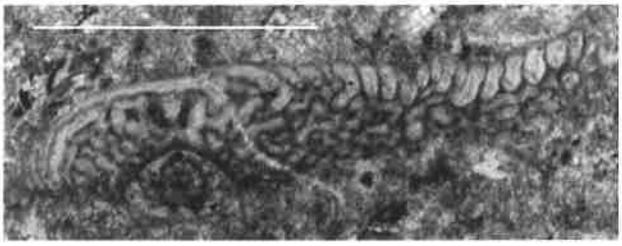
Fig. 9 : microfacies with Staffellids, G 209, Hydra Island, Lehusis section, Marmari formation.

Scale: Fig. 7 = 100 µm
Fig. 1, 2, 3, 4, 5, 6, 8, 9 = 500 µm

Plate 4

1

3



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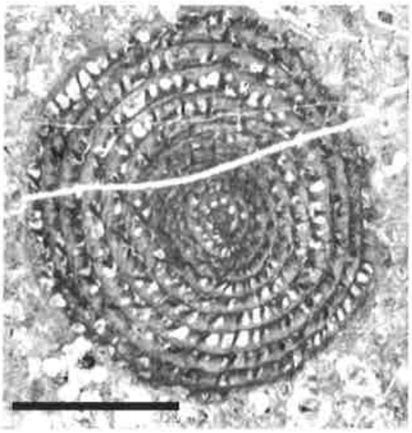

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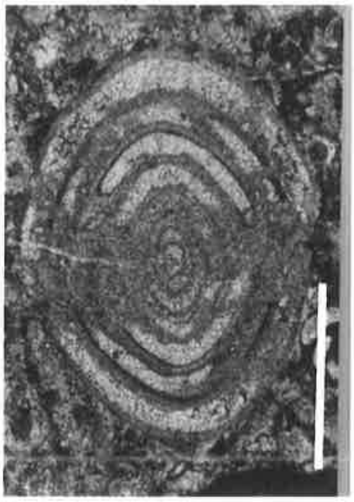

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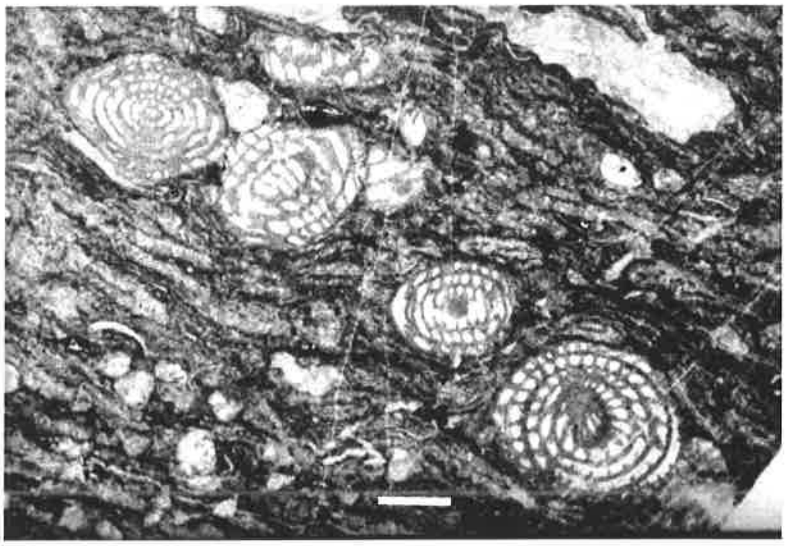

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Plate 5

Fig. 1 : *Tubiphytes obscurus* MASLOV, G 50, Attica (Mt Parnes), isolated sample.

Fig. 2 : *Bradyina sp.* , G 52, Attica (Mt Parnes), isolated sample.

Fig. 3 : *Staffella sisonghzengensis* (SHENG), G 355, Chios Island, Marmara section.

Fig. 4 : *Rugosofusulina directa* BENSCH, G 318, Chios Island, Marmara section.

Fig. 5 : *Pseudofusulina tschernychewi* (SCHWELLIEN), G 196, Hydra Island, Lehusis section, Cap Rigas formation.

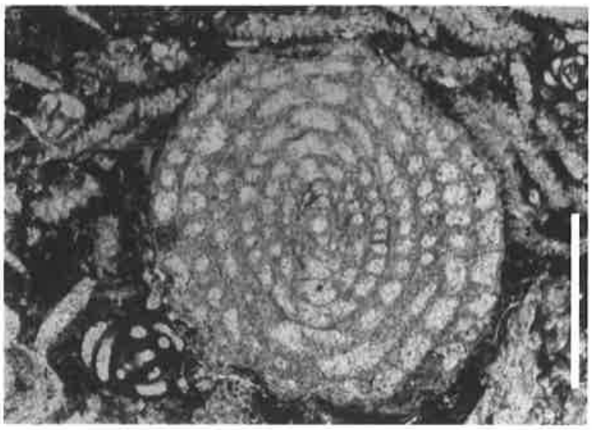
Fig. 6 : microfacies with *Tubiphytes obscurus* MASLOV, Hydra Island, G 189, Lehusis section, Lehusis formation (bioconstruction).

Scale: 500 µm

Plate 5

1

2



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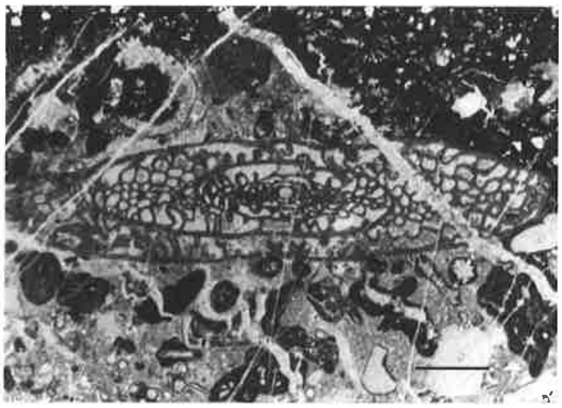

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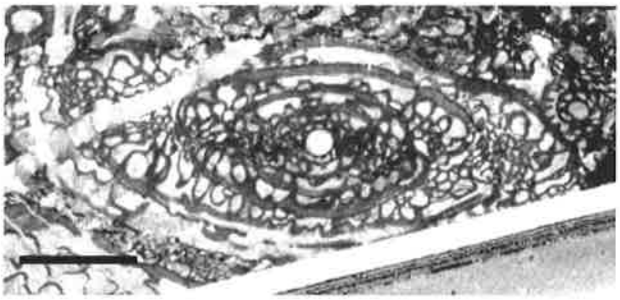

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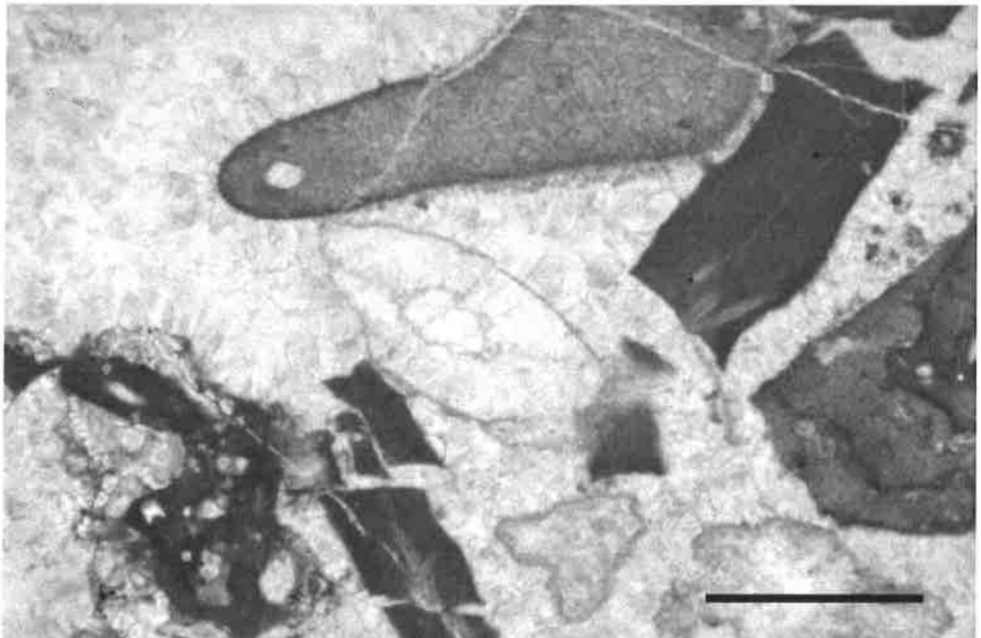


6

Plate 6

Fig. 1 : *Codonofusiella* sp. (a), *Reichelina* sp. (b), G 521, Hydra Island, Episcopi section, Episcopi formation.

Fig. 2 : *Pseudovermiporella nipponica* (ENDO) ; G 521, Hydra Island, Episcopi section, Episcopi formation.

Fig. 3 : *Paraglobivalvulinoides septulifer* ZANINETTI & JENNY-DESHUSSES ; Be 14, Attica (Mt Beletsi).

Fig. 4 : *Reichelina media* MIKLUCO-MACLAY, G 553, Hydra Island, Episcopi section, Episcopi formation.

Fig. 5 : *Paleofusulina* sp., G 564, Hydra Island, Episcopi section, Episcopi formation.

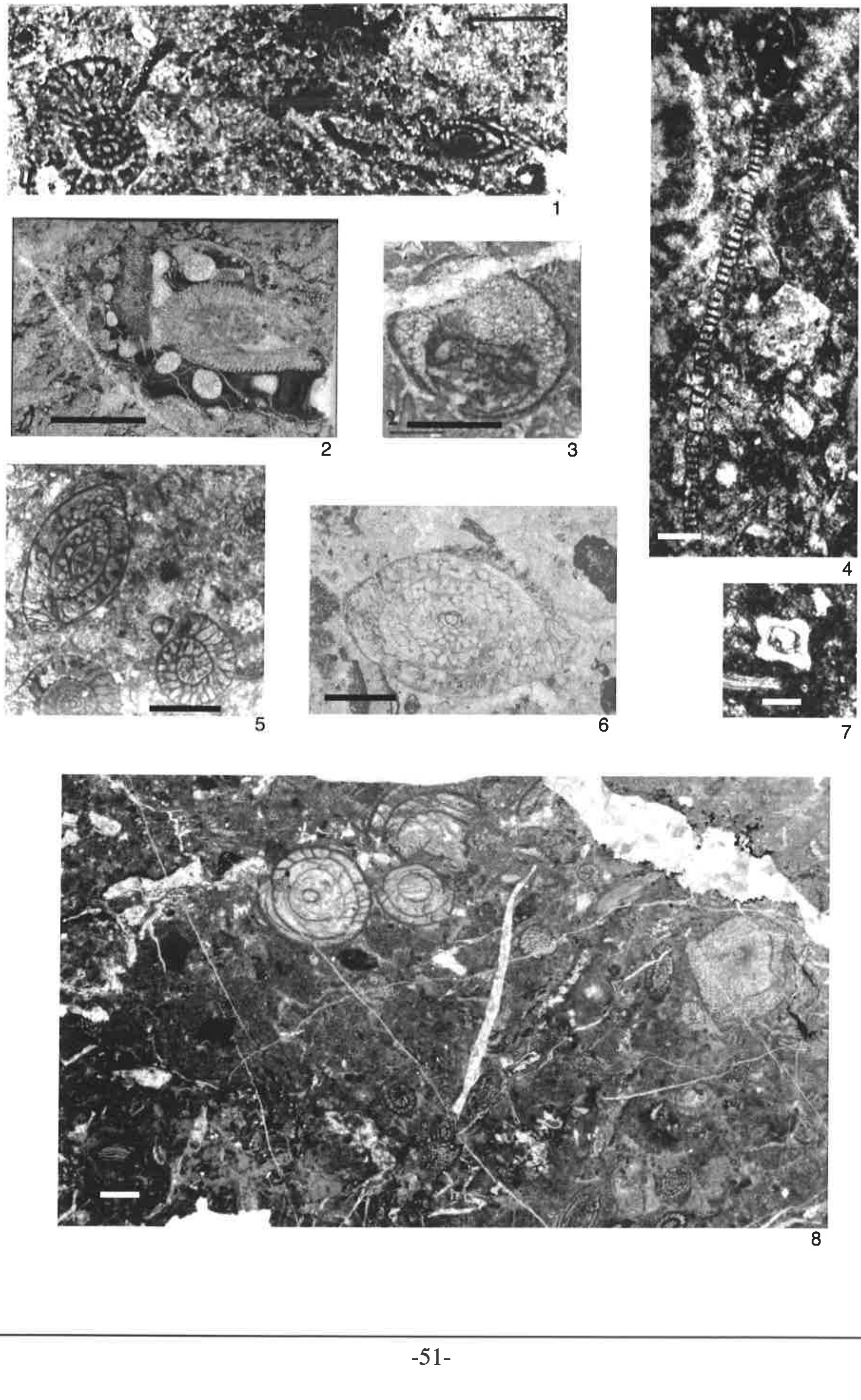
Fig. 6 : *Paleofusulina* sp., G 50, Attica (Mt Parnes), isolated sample.

Fig. 7 : *Rectostipulina quadrata* JENNY-DESHUSSES, G537, Hydra Island, Episcopi section, Episcopi formation.

Fig. 8 : microfacies with *Schwagerina* sp., G17, Attica (H. Mercurios), isolated sample.

Scale : Fig. 7 = 100 μm
Fig. 1, 2, 3, 4, 5, 6, 8 = 500 μm

Plate 6



1.5 Armenia

Introduction

The sections studied in this paper were sampled and logged during Excursion 102 organized after the International Geological Congress XXVII Session, in Moscow, in August 1984. Samples presented here illustrate only Late Permian deposits. Geological and stratigraphic descriptions can be found in Baud et al., 1989; see also Kotlyar et al., 1983; Miklukho-Maclay, 1954; Pronina, 1988; Reitlinger, 1965; Rostovtsev & Azarian, 1973; Scherbovitch, 1969 and Stepanov et al., 1969.

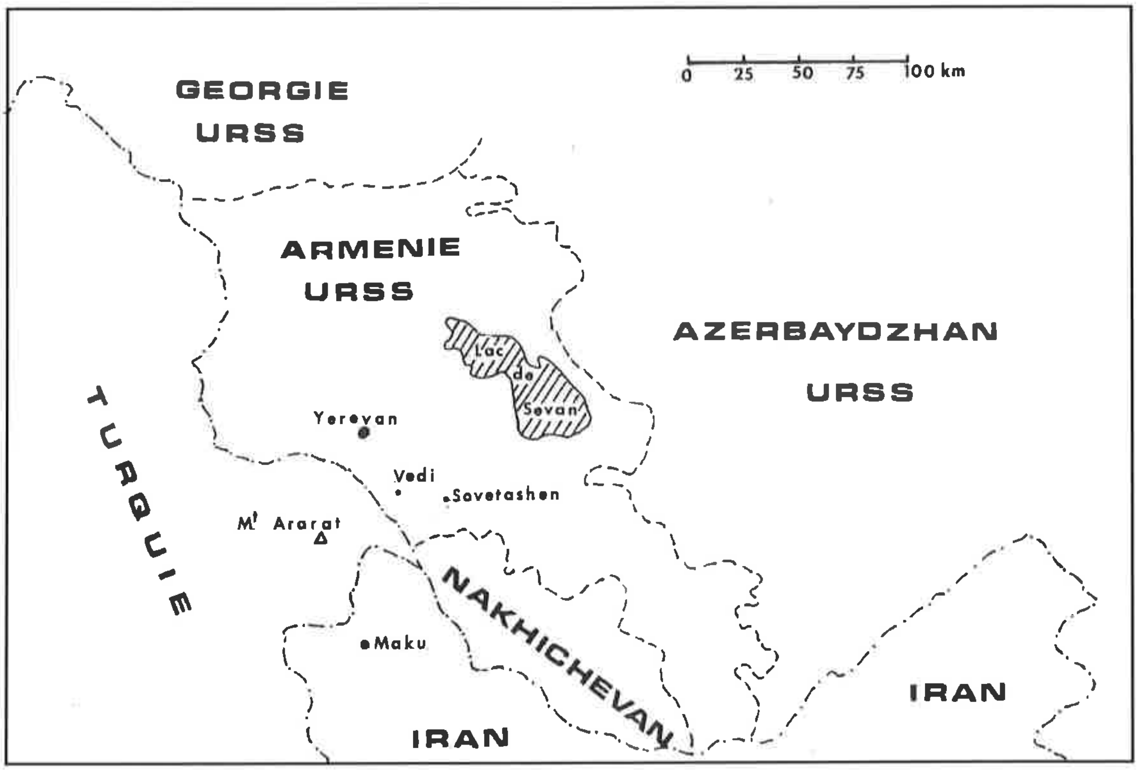


Fig. 1.5.1 Localisation of the Vedi and Sovetachen sections.

	Series	stages GSSP	Tethyan stages	Armenia fusulinids	 small foraminifers	 algae
Permian	Lopingian	Changhsingian	Dorashamian	Reichelina Codonofusiella Nankinella	Paraglobivalvulina Rectostipulina Cyclogyra Paradagmarita Dagmarita Neoendothyra Globivalvulina Robuloides Lasiodiscus	Gymnocodium Permocalculus Tubiphytes
		Wuchiapingian	Djulfian			
	Guadalupian	Capitanian	Midian			
		Wordian	Murgabian			
		Roadian	Kubergandian			

Fig. 1.5.2 Faunal association table of Armenia

List of foraminifers and algae of Armenia

Eotuberitina reitlingerae MIKLUKO-MACLAY
Climacammina sp.
Deckerella sp.
Geinitzina ex.gr. *postcarbonica* (SPANDEL)
Geinitzina primitiva POTIEVSKAIA
Geinitzina reperta BYKOVA
Geinitzina uralica SULEIMANOV
Langella ocarina var. *grandis* (SELLIER de CIVRIEUX & DESSAUVAGIE)
Nodosaria armeniensis EFIMOVA
Nodosaria postgeinitzi EFIMOVA
Nodosaria longissima SULEIMANOV
Pachyphloia ex.gr. *ovata* (LANGE)
Pachyphloia pedicula LANGE
Pachyphloia iranica BOZORGNIA
Pseudolangella fragilis SELLIER de CIVRIEUX & DESSAUVAGIE
Pseudotristix solida REITLINGER
Protonodosaria proceraformis GERKE
Robuloides gibbus REICHEL
Robuloides lens REICHEL
Frondina permica SELLIER de CIVRIEUX & DESSAUVAGIE
Ichtyolaria latilimbata SELLIER de CIVRIEUX & DESSAUVAGIE
Dagmarita chanakchiensis REITLINGER
Paradagmarita monodi LYS & MARCOUX
Globivalvulina vonderschmitti REICHEL
Paraglobivalvulina mira REITLINGER
Agathammina sp.
Cyclogyra sp.
Glomospira sp.
Hemigordius sp.
Hemigordius permicus GROZDILOVA
Hemigordius reicheli LYS
Lasiodiscus sp.
Meandrospira sp.
Pseudovermiporella nipponica (ENDO)
Rectocornuspira kahlori BRONNIMANN, ZANINETTI & BOZORGNIA
Neoendothyra parva (LANGE)
Neoendothyra reicheli REITLINGER
Codonofusiella sp.
Codonofusiella iniqua CHEDJIA
Codonofusiella ex gr. *kwangsiana* (SHENG)
Codonofusiella sphaerica SOSNINA
Nankinella sp.
Reichelina sp.
Reichelina media MIKLUKO- MACLAY
Staffella sp.
Schubertella sp.

Permocalculus sp.
Gymnocodium bellerophontis (ROTHPLETZ)
Mizzia sp.
Tubiphytes obscurus MASLOV

Rectostipulina quadrata JENNY- DESHUSSES

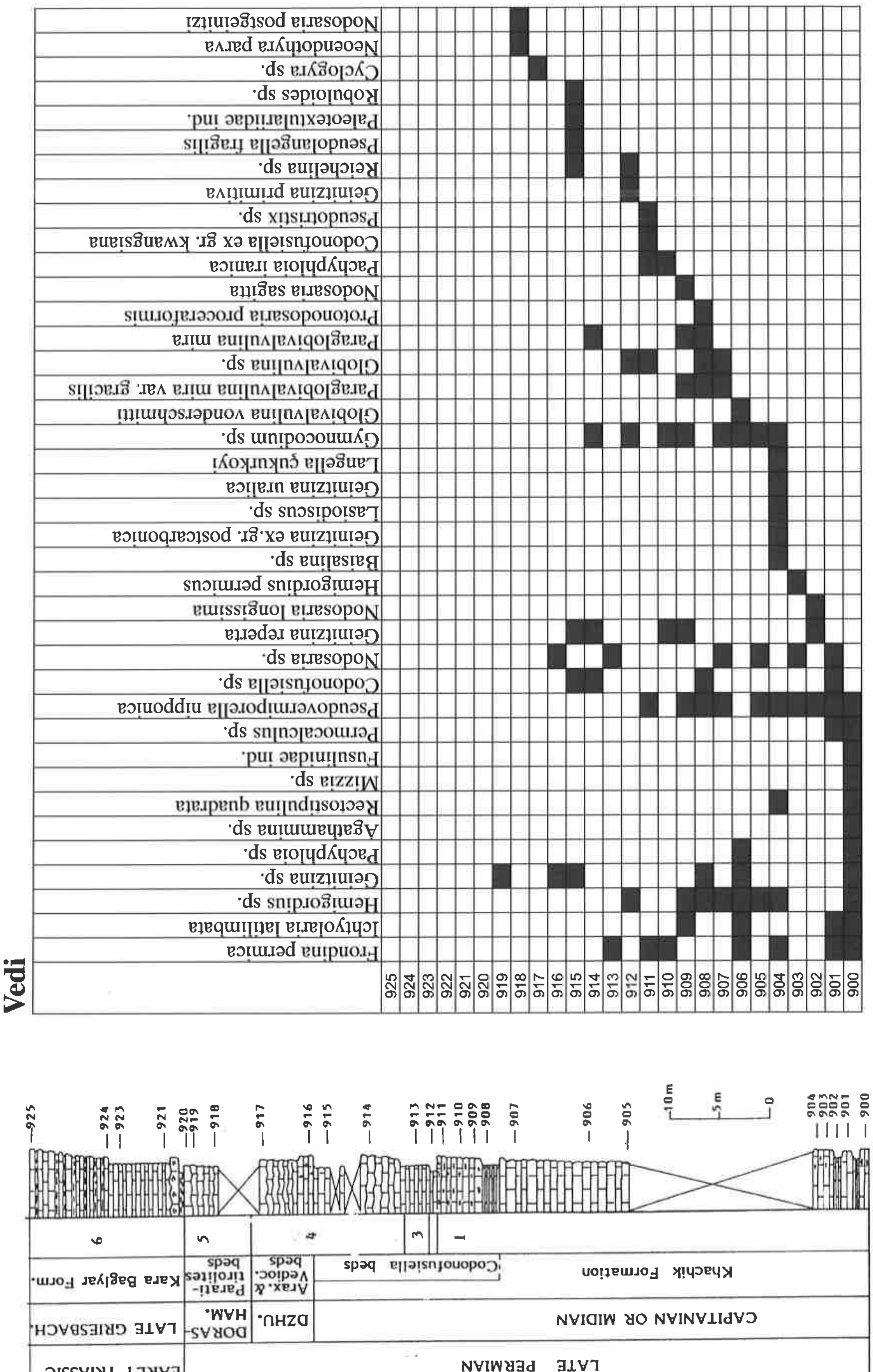


Fig. 1.5.3 Log (Baud et al., 1989) and faunal inventory of Vedi section.

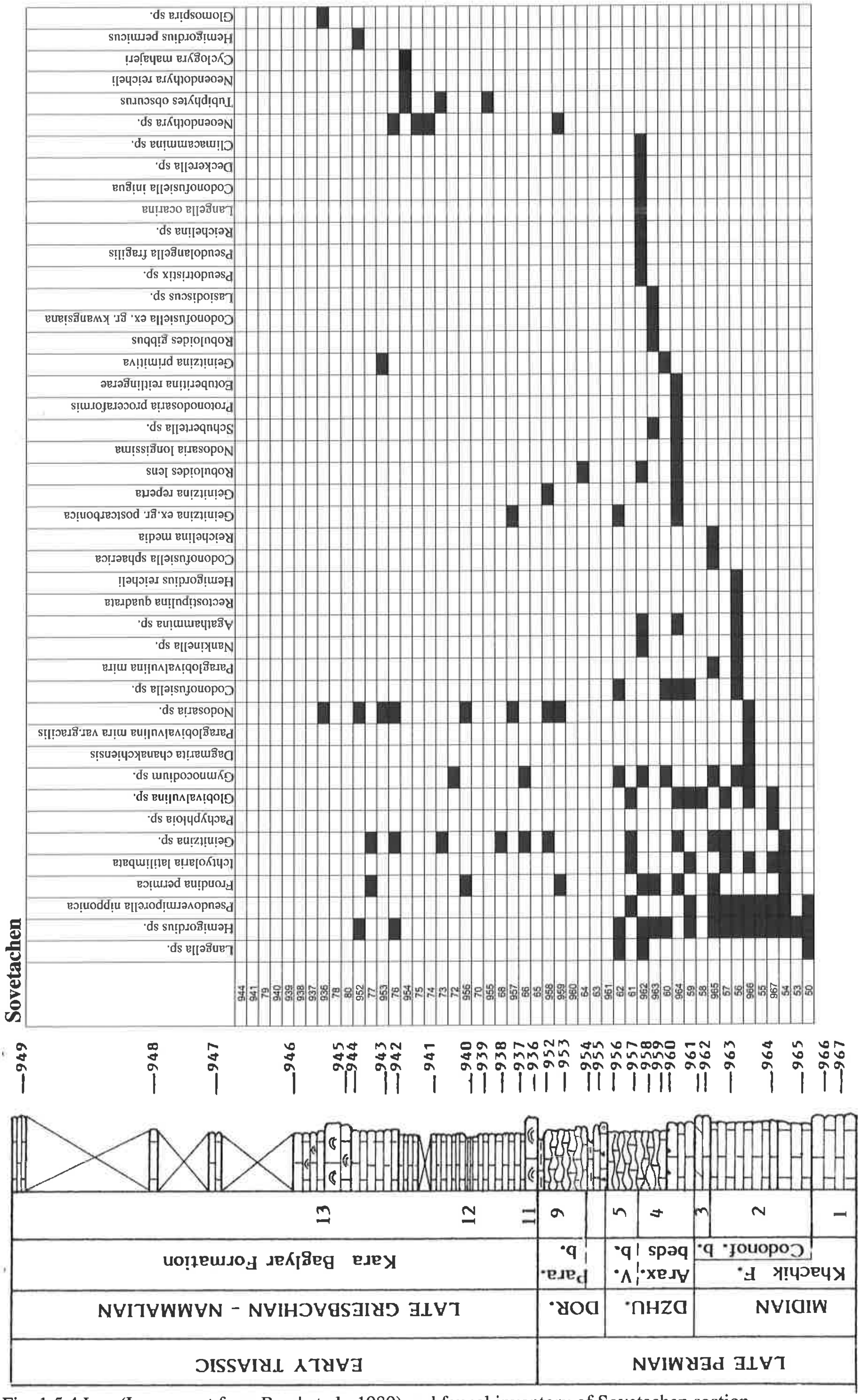


Fig. 1.5.4 Log (Lower part from Baud et al., 1989) and faunal inventory of Sovetachen section.

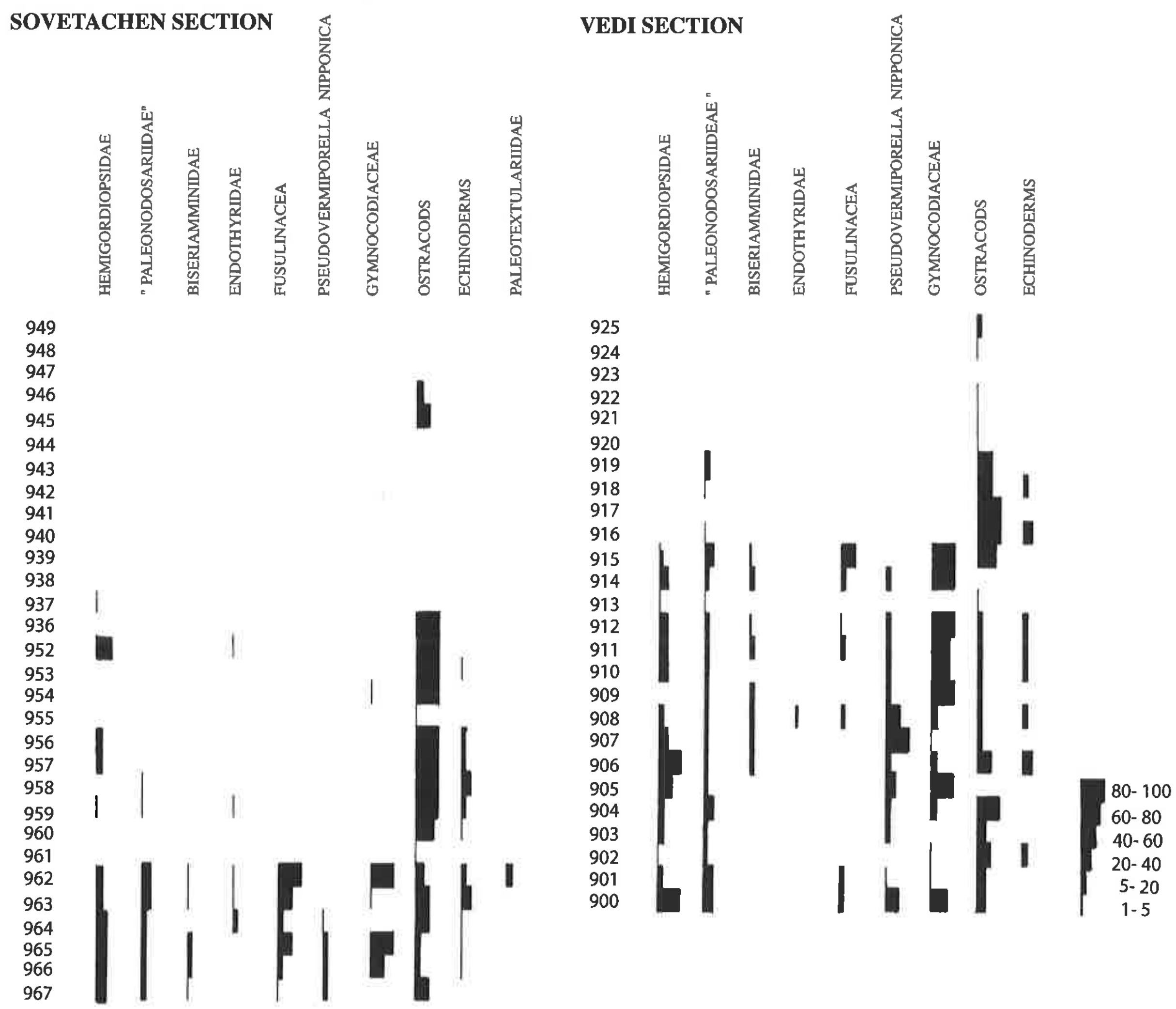


Fig. 1.5.5 Estimation table (%) of the main bioclasts of Sovetachen and Vedi Sections (Armenia).

Micropaleontological remarks on Permian deposits in Armenia

« Paleonodosariidae »

This group is represented by a number of individuals of both species *Geinitzina* ex. gr. *postcarbonica* (SPANDEL) and *Pachyphloia* ex. gr. *ovata* (LANGE). Many other species are also present.

Individuals of these previous taxa developing dwarf forms are observable in association with Hemigordiopsidae and ostracods, in the deposits below the Permo- Triassic Boundary (PTB).

Kotlyar & al. (1983, pl. 1 Fig. 4) point out a doubtful section of *Colaniella* aff. *minima* (WANG) in the Dorasham area, not far from our stratigraphical sections of Vedi and Sovetachen. We did not find any individual of the taxon *Colaniella* in our material which could confirm this attribution.

Biseriamminidae

In this group, the species *Dagmarita chanakchiensis* REITLINGER is very frequent.

One section of *Paraglobivlavulina mira* REITLINGER shows extra apertural chamberlets which Reitlinger (1965) did not notice (Jenny-Deshusses, 1983, fig.2, j-k-l-m), (Pl.7, fig. 2).

Paradagmarita monodi LYS & MARCOUX is also present.

Sovetachen is the reference section where the holotype of *Dagmarita chanakchiensis* was described (Reitlinger, 1965), and it is valuable for other species : Paraglobivalvulina mira REITLINGER, *Neoendothyra reicheli* REITLINGER, *Baisalina pulchra* REITLINGER.

Good sections of these taxa, except for *Baisalina pulchra* REITLINGER, can be observed in both stratigraphical sections Vedi and Sovetachen.

Hemigordiopsidae

Numerous individuals of the genus *Hemigordius* have been observed. This taxon, also, develop dwarf forms in the deposits below the PTB.

Pseudovermiporella nipponica (ENDO) displayed so numerous individuals that it seemed interesting to separate this taxon from other hemigordiopsids in the estimation tables (Fig. 1.5.3, 1.5.4).

Typical individuals of the genus *Cyclogyra* have been observed, along with characteristic other Permian foraminifers (Pl. 7, figs. 9, 10).

Fusulinacea

In both stratigraphic sections, we have observed good individuals of the species *Codonofusiella* ex .gr. *kwangsiana* (SHENG). These individuals are closely comparable with those found in the Upper Permian deposits of the Chhidru section in the Salt Range, in Pakistan (Pl. 7, fig.14; Pl. 13, fig. 2).

Calcareous algae

Gymnocodium sp. and *Permocalculus* sp. were too recrystallized to determine a specific species assignment.

Incertae sedis

Rectostipulina quadrata JENNY-DESHUSSES has been observed whithout doubt (Pl. 7, fig.7) in three levels of the two sections.

Biofacies

In the Vedi section, algal biofacies alternate with ostracod biofacies.

In the Sovetachen section, ostracod biofacies is the most important.

In both sections, ostracod biofacies end with observable Permian deposits, in association either with dwarf "Paleonodosariids", or with dwarf individuals of *Hemigordius*.This is characteristic for the Late Permian deposits of this area.

Plate 7

Fig. 1 : *Ichtyolaria latilimbata* S. de C. & DESS., CJ 965, Sovetachen section.

Fig. 2 : *Paraglobivalvulina mira* REITLINGER, CJ 909, Vedi section.

Fig. 3 : *Paraglobivalvulina mira* var. *gracilis*, CJ 909, Vedi section.

Fig 4 : N*eoendothyra* sp., CJ 959, Sovetachen section.

Fig. 5 : *Langella* sp., CJ 962, Sovetachen section.

Fig. 6 : *Dagmarita chanakchiensis* REITLINGER, CJ 966, Sovetachen section.

Fig. 7 : *Rectostipulina quadrata* JENNY-DESHUSSES, CJ 904', Vedi section.

Fig. 8 : microfacies with Hemigordiopsidae (a); *Codofusiella* sp. (b), CJ 962, Sovetachen section.

Fig. 9 : *Cyclogyra sp*., CJ 917 Vedi section.

Fig. 10 : *Cyclogyra* sp. CJ 954', Sovetachen section.

Fig. 11 : *Codonofusiella iniqua* CHEDJIA, CJ 962, Sovetachen section.

Fig. 12 : *Codonofusiella nana* ERK, CJ 967, Sovetachen section.

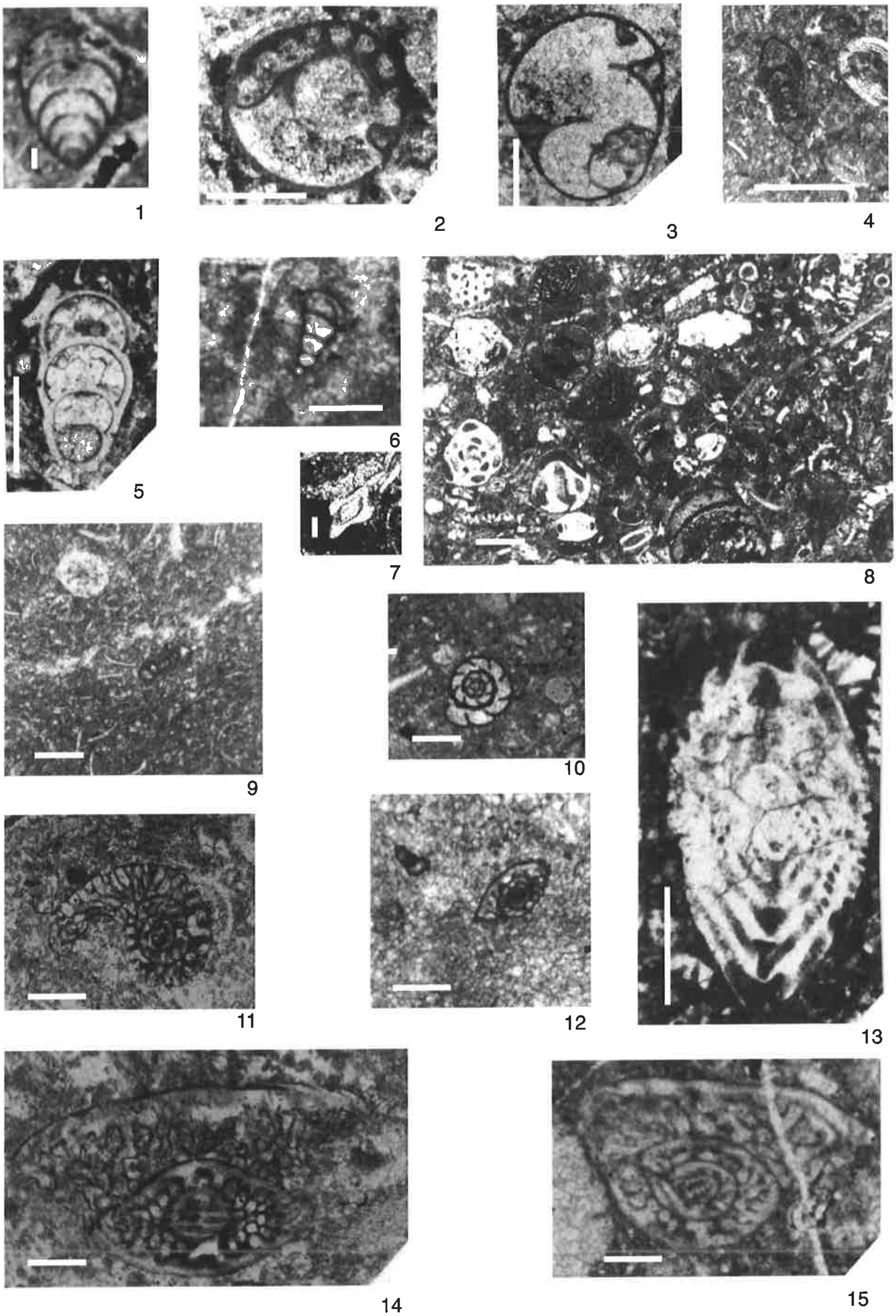
Fig. 13 : *Nankinella* sp., CJ 962, Sovetachen section.

Fig. 14 : *Codonofusiella* ex. gr. k*wangsiana* SHENG, CJ 962, Sovetachen section.

Fig. 14 : Codonofusiella ex. gr. *kwangsiana* SHENG, CJ 911, Vedi section.

Scale : Fig. 1, 5, 6, 7, 8, 9, 10 = 100 µm
Fig. 2, 3, 4, 11, 12, 13, 14, 15 = 500 µm

Plate 7



1.6 Iran

Introduction

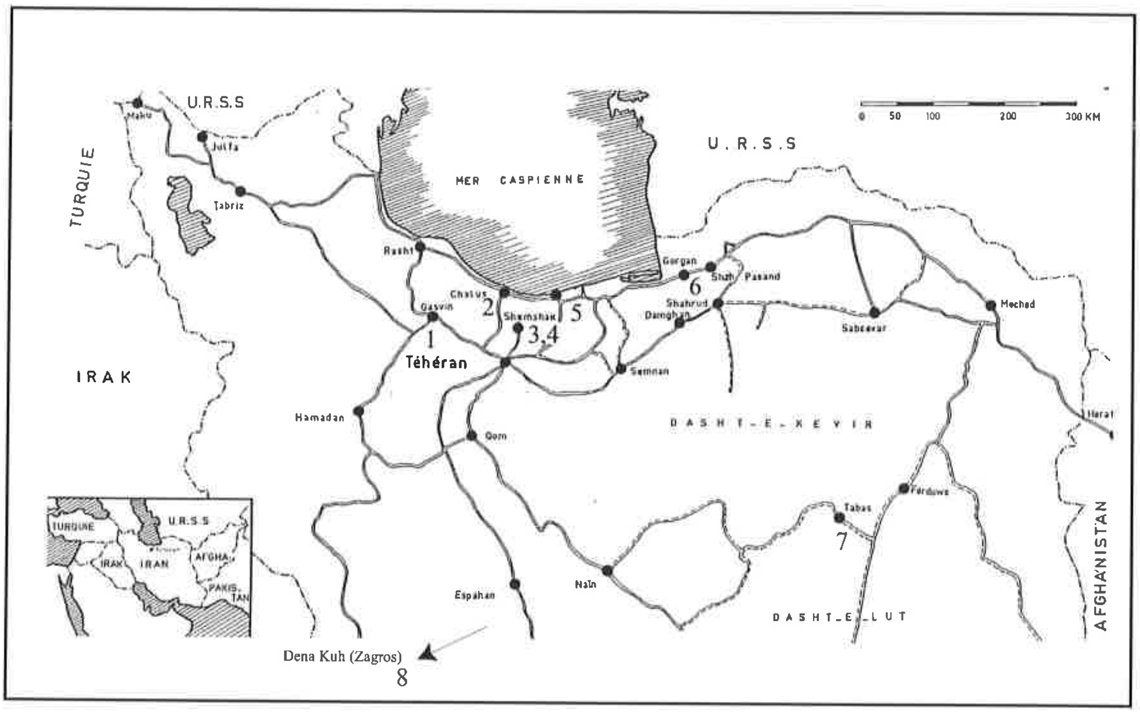


Fig. 1.6.1 Localisation of the lithological sections in Alborz Mountains, Central Iran and Zagros Mountains

1) Sinak, Central Iran
2) Rudbarak, Central Alborz Mountains
3) Dorud, type locality, Central Alborz Mountains
4) Ruteh, type Locality, Cenrtral Alborz Mountains
5) Emarat I, II,III, Central Alborz Mountains
6) Gheselgnaleh, Eastern Alborz Mountains
7) Kuh e Jamal, Central Iran
8) Dena Kuh, Zagros Mountains

The sections in the Alborz Mountains and in Central Iran were sampeld and logged in August and September 1978; micropaleontological analysis has been regrouped in Jenny-Deshusses, (1983a and b) and reworked later.
Samples of the Dena Kuh section in the Zagros Montains have been collected in March 2002, with the help of Prof. G. Stampfli, F. Rosselet and S. Bagheri, from the Geological Institute of Lausanne University. Further general geological, stratigraphical, and paleontological study can be found in : Baud et al., 1989; Bronnimann & Zaninetti, 1972; Chateauneuf & Stampfli, 1979; Mohtat-Aghai & Vachard 2003; 2005; Partozoar, 1995; Ruttner, 1993.

Alborz Mountains:

- The **Rudbarak section** is located near the Rudbarak village, west of the Marzanabad village, situated along the main road to Chalus. The section has been studied along a bad track to an abandonated Pb-Zn mine, above Rudbarak village, on the N-W flank of the valley, at an altitude of 2000 meter.
- The **Dorud** and **Ruteh sections** are located in the Zaigun valley, 40 km north of Tehran. These two sections correspond to the lithological stratotypes of both Dorud formation and Ruteh formation (Assereto,1963).

- **Emarat sections** (Emarat I, II, III) have been sampled around Emarat village, on the western part of the main road between Tehran and Amol. Emarat village is located 30 km south of Amol.
- The **Gheselghaleh section** is situated in the eastern part of the Alborz Mountains, in the Fazelabad valley, 20 km south of this city, between Aliabad and former Shah-Pasand. It was difficult to go there because of the bad track conditions, especially after rainy weather (rivers to ford).

Further geological, stratigraphical, and paleontological study can be found in : Ahmadzadeh, 1958; Asserto, 1963; Bozorgnia, 1973; Coquel et al., 1977; Corsin & Stampfli, 1977; Glaus, 1964; Isler, 1977; Jenny, 1977; Jenny & Stampfli, 1978; Jenny & Jenny.Deshusses, 1978a, b, c; Jenny et al., 1978; Kahler, 1976; Lys et al., 1978; Mehrnush and Partoazar, 1977; Stampfli, 1978; Zaninetti et al., 1972.

Fig. 1.6.2 Megapermichnus, silicified print in Ruteh Formation limestone near Gheselghaleh (Jenny & Jenny-Deshusses, 1978).

Central Iran:

- **Sinak section** is located in the south-western part of Sinak village, which is situated near Jafarabad, east of the main road Tehran-Hamadan, 40km south of Qazvin city.
- **Kuh e Jamal section** is situated on the south flank of the Kuh e Jamal Mountain, south of the road between Tabas and Ferdows.

Further geological, stratigraphical, and paleontological study can be found in : Baghbani, 1992; Bronnimann et al., 1973; Iranian-Japanese Research Group, 1981; Taraz, 1969; 1974.

Zagros Mountains:

Dena Kuh section is located near Ab e Sepah village, in the Sang e Boghun valley, north of Chenarbaram; this village is situated on the main road between Yakuj and Sharekort. See also Gaillot & Vachard 2007.

List of foraminifers and algae of Iran

Eotuberitina reitlingerae MIKLUKO-MACLAY
Climacammina sp.
Climacammina elegans (MOELLER)
Climacammina moelleri var. *timanica* REITLINGER
Climacammina valvulinoides LANGE
Cribrogenerina sp.
Cribrogenerina sumatrana SCHUBERT
Deckerella sp.
Paleotextularia sp.
Calvezina ottomana SELLIER de CIVRIEUX & DESSAUVAGIE
Colaniella ex.gr. *minima* (WANG)
Geinitzina ex.gr. *postcarbonica* (SPANDEL)
Geinitzina primitiva POTIEVSKAIA
Geinitzina reperta BYKOVA
Geinitzina uralica SULEIMANOV
Langella acantha LANGE
Langella conica SELLIER de CIVRIEUX & DESSAUVAGIE
Langella ocarina var. *grandis* (SELLIER de CIVRIEUX & DESSAUVAGIE)
Langella perforata (LANGE)
Nodosaria longissima SULEIMANOV
Nodosaria sagitta MIKLUKO- MACLAY
Protonodosaria praecursor GERKE
Pachyphloia ex.gr. *ovata* (LANGE)

Pachyphloia pedicula LANGE
Pachyphloia iranica BOZORGNIA
Pseudolangella fragilis SELLIER de CIVRIEUX & DESSAUVAGIE
Pseudotristix sp.
Robuloides sp.
Frondina permica SELLIER de CIVRIEUX & DESSAUVAGIE
Ichtyolaria latilimbata SELLIER de CIVRIEUX & DESSAUVAGIE
Dagmarita chanakchiensis REITLINGER
Paradagmarita monodi LYS & MARCOUX
Globivalvulina graeca REICHEL
Globivalvulina vonderschmitti REICHEL
Paraglobivalvulina mira REITLINGER
Paraglobivalvulina mira var. *gracilis* (ZANINETTI & ALTINER)
Agathammina sp.
Cyclogyra sp.
Hemigordius ssp.
Hemigordius permicus GROZDILOVA
Hemigordius ovatus var. *miminus* GROZDILOVA
Hemigordius reicheli LYS
Meandrospira sp.
Planinvoluta sp.
Pseudovermiporella nipponica (ENDO)
Rectocornuspira kahlori BRONNIMANN, ZANINETTI & BOZORGNIA

Neoendothyra parva (LANGE)
Neoendothyta bronnimanni BOZORGNIA
Neoendothyra reicheli REITLINGER

Boultonia willisi LEE
Codonofusiella sp.
Codonofusiella nana ERK
Minojapanella sp.
Nankinella orbicularia LEE
Reichelina sp.
Staffella sphaerica (ABICH)
Staffella zisonghzengensis (SHENG)

Girvanella permica PIA
Gymnocodium bellerophontis (ROTHPLETZ)
Permocalculus sp.
Mizzia cornuta KOCHANSKY & HERAK.
Tubiphytes obscurus MASLOV
Undgarella uralica MASLOV

Rectostipulina quadrata JENNY- DESHUSSES

	Series	Stages GSSP	Tethyan stages	Elburz (Iran)		
				fusulinids	small foraminifers	algae
Permian	Lopingian	Changhsingian	Dorashamian	Dunbarula Reichelina Codonofusiella Nankinella Staffella	Paraglobivalvulinoides Paraglobivalvulina Paradagmarita Rectostipulina Cyclogyra Colaniella Dagmarita Globivalvulina Robuloides Lasiodiscus	Mizzia Gymnocodium Permocalculus Tubiphytes
		Wuchiapingian	Djulfian			
	Guadalupian	Capitanian	Midian	Staffella Boultonia Minojapanella	Climacammina Neoendthyra Teatrataxis Dagmarita Globivalvulina	Gymnocodium Tubiphytes
		Wordian	Murgabian			
		Roadian	Kubergandian			
	Cisuralian	Kungurian	Bolorian			
		Artinskian	Artinskian			
		Sakmarian	Sakmarian			
		Asselian	Asselian	Pseudoschwagerina Rugosofusulina Pseudofusulina Triticites		Girvanella

Fig. 1.6.3. Faunal association table of the Alborz Mountains, Iran

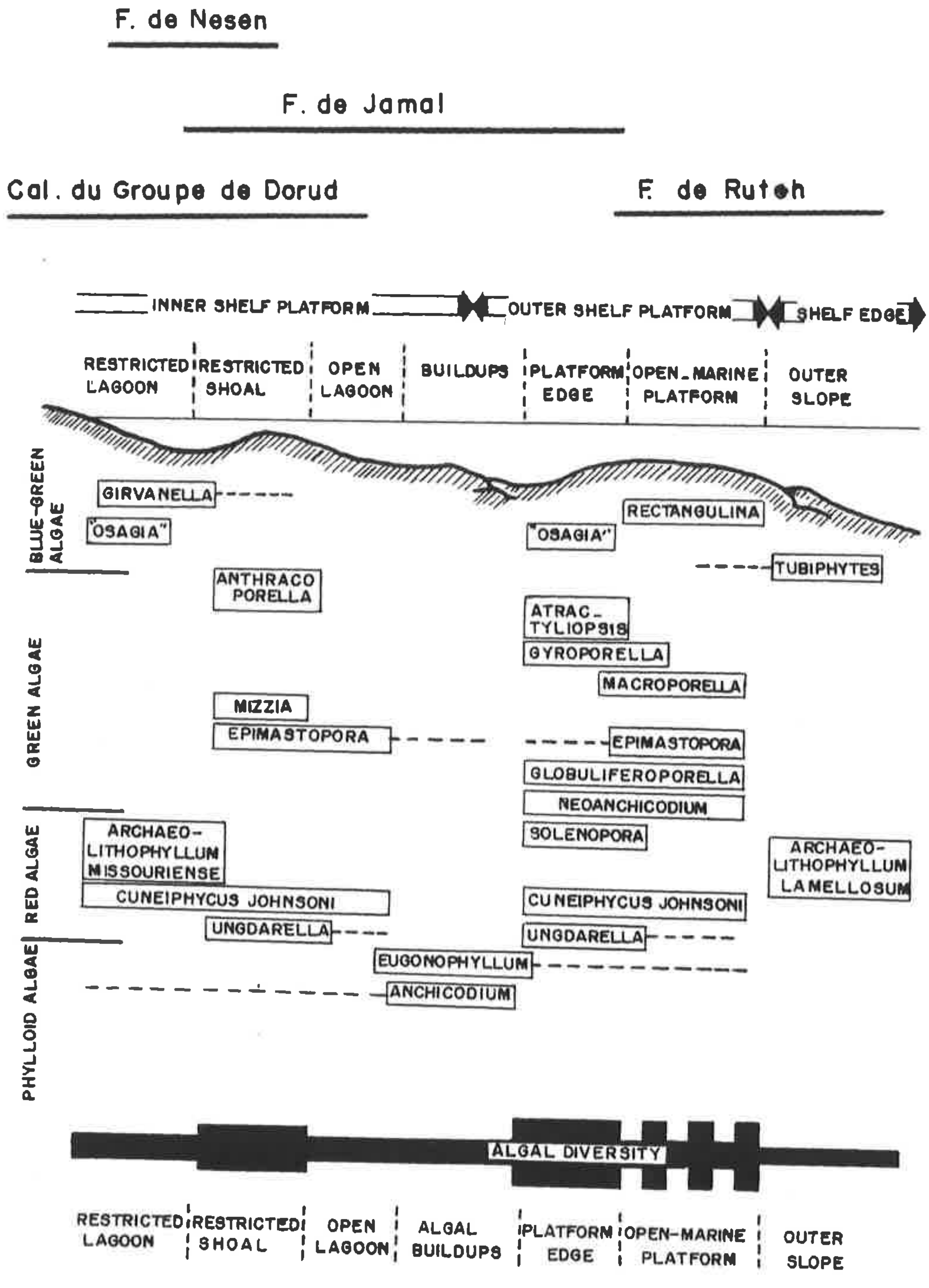


Fig.1.6.4 Paleogeographical reconstruction based on algal "life position" proposed by Fluegel (1979), from Jenny-Deshusses (1983a)

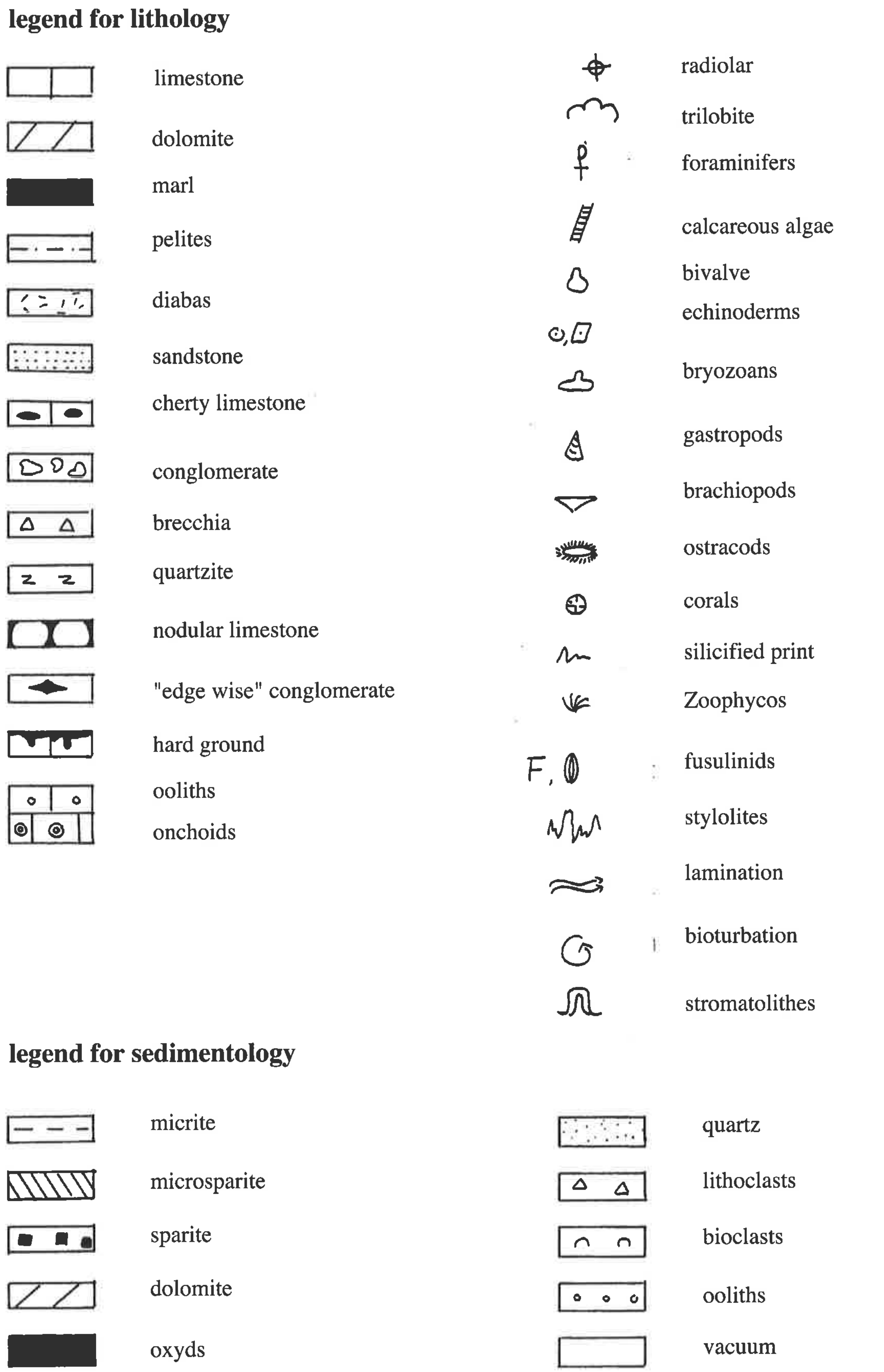


Fig. 1.6.5 Legend for log's lithology and for sedimentology analysis of the sections in Alborz Mountains and Central Iran.

RUDBARAK SECTION

Samples: CD thickness: 90 m.

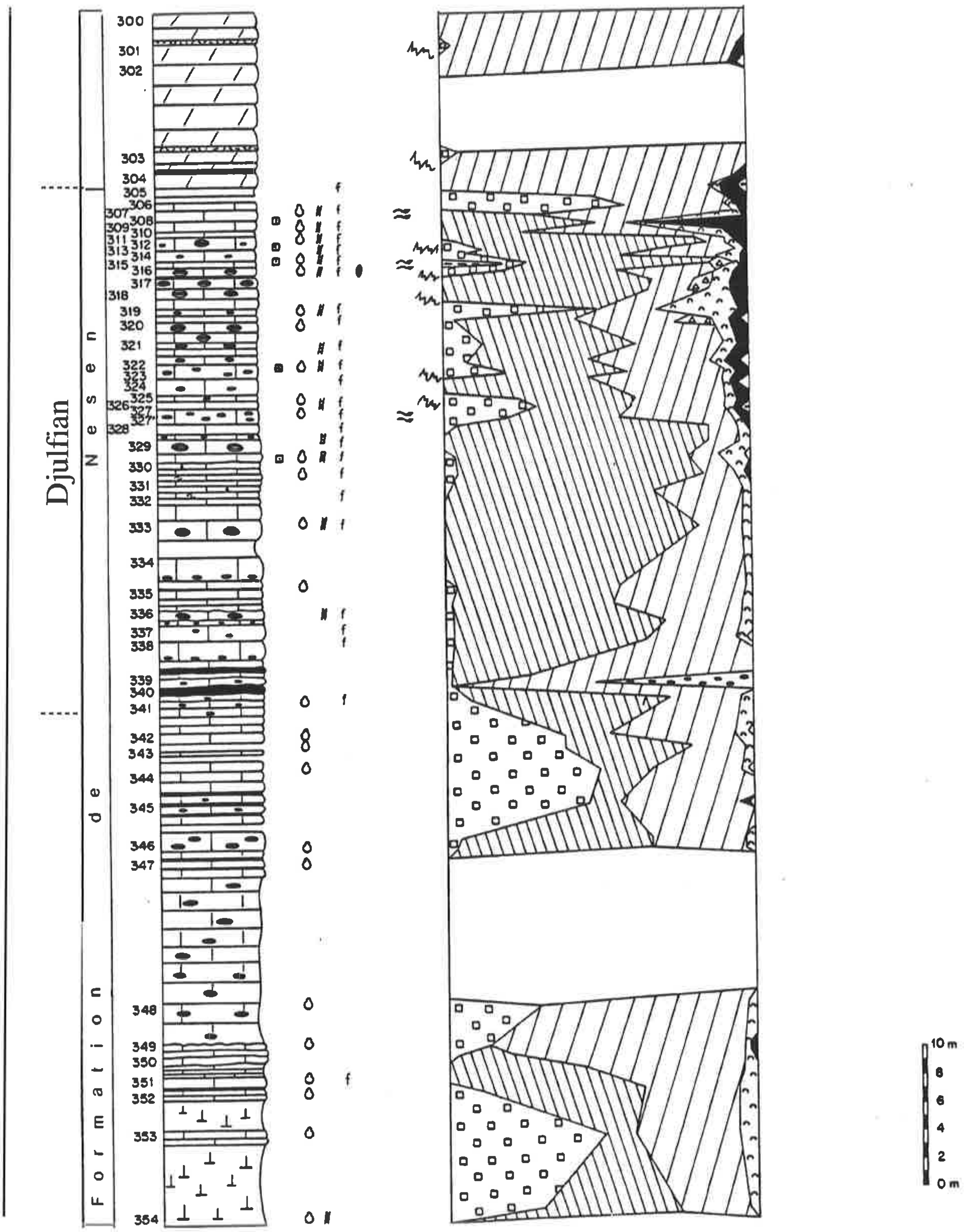


Fig. 1.6.6 Log and sedimentology analysis of Rudbarak section (Alborz Mountains, Iran)

COUPE DE RUDBARAK

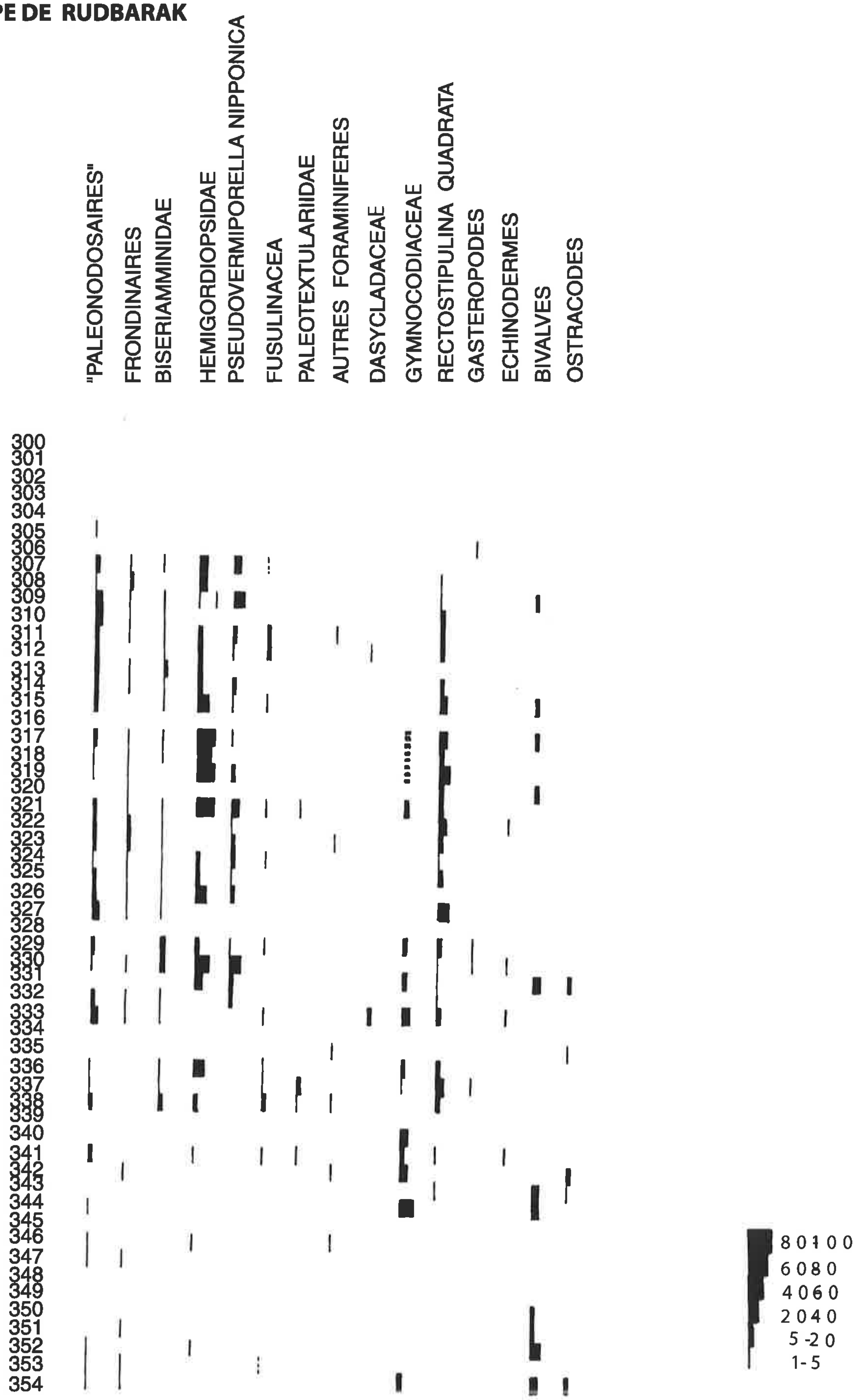


Fig. 1.6.7 Estimation table (%) of the main bioclasts in Rudbarak section, Central Alborz, Iran

Rudbarak

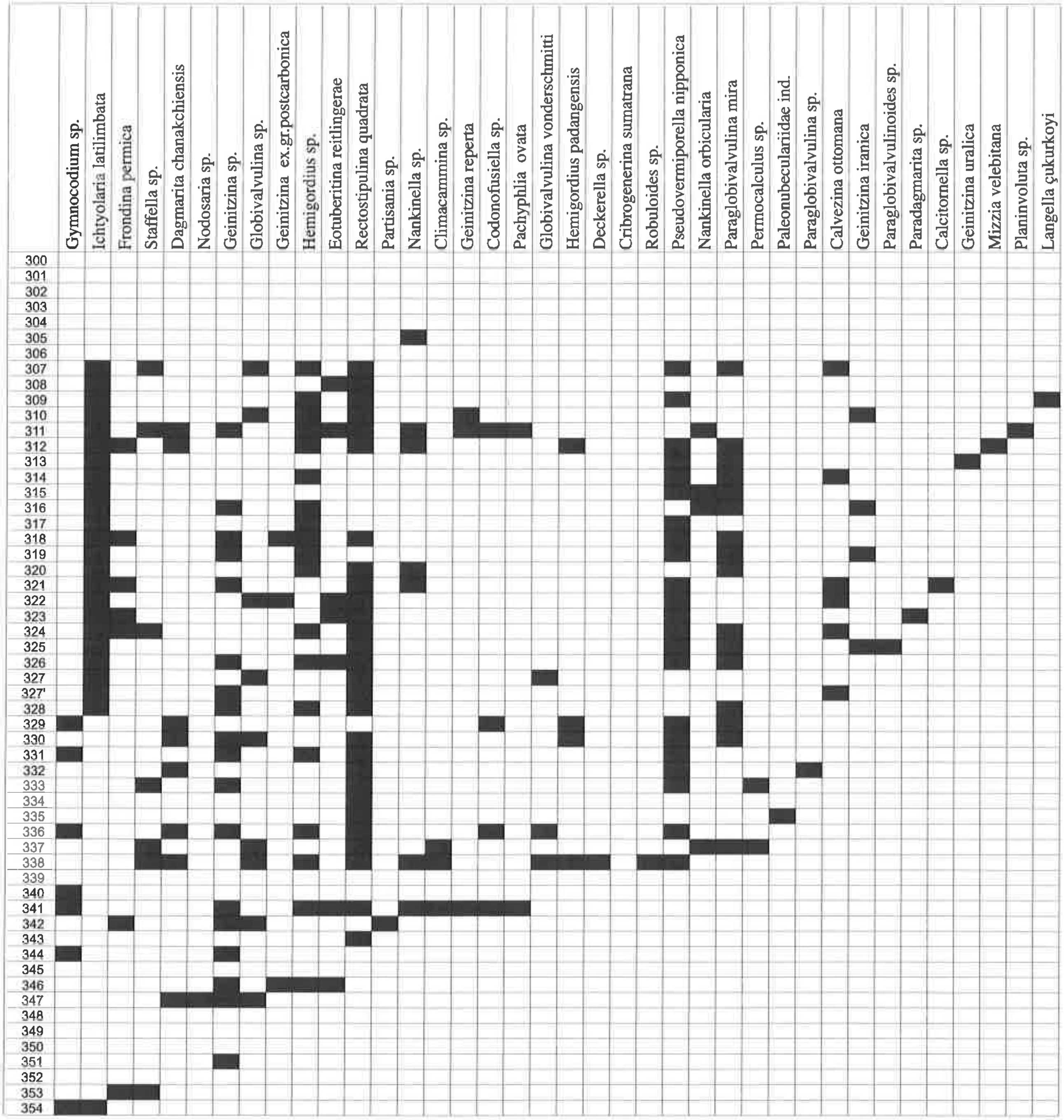


Fig. 1.6.8 Faunal inventory table of Rudbarak section, Central Alborz, Iran.

DORUD SECTION

N 36°0′ / E 51° 29′ samples: CD thickness: 300m

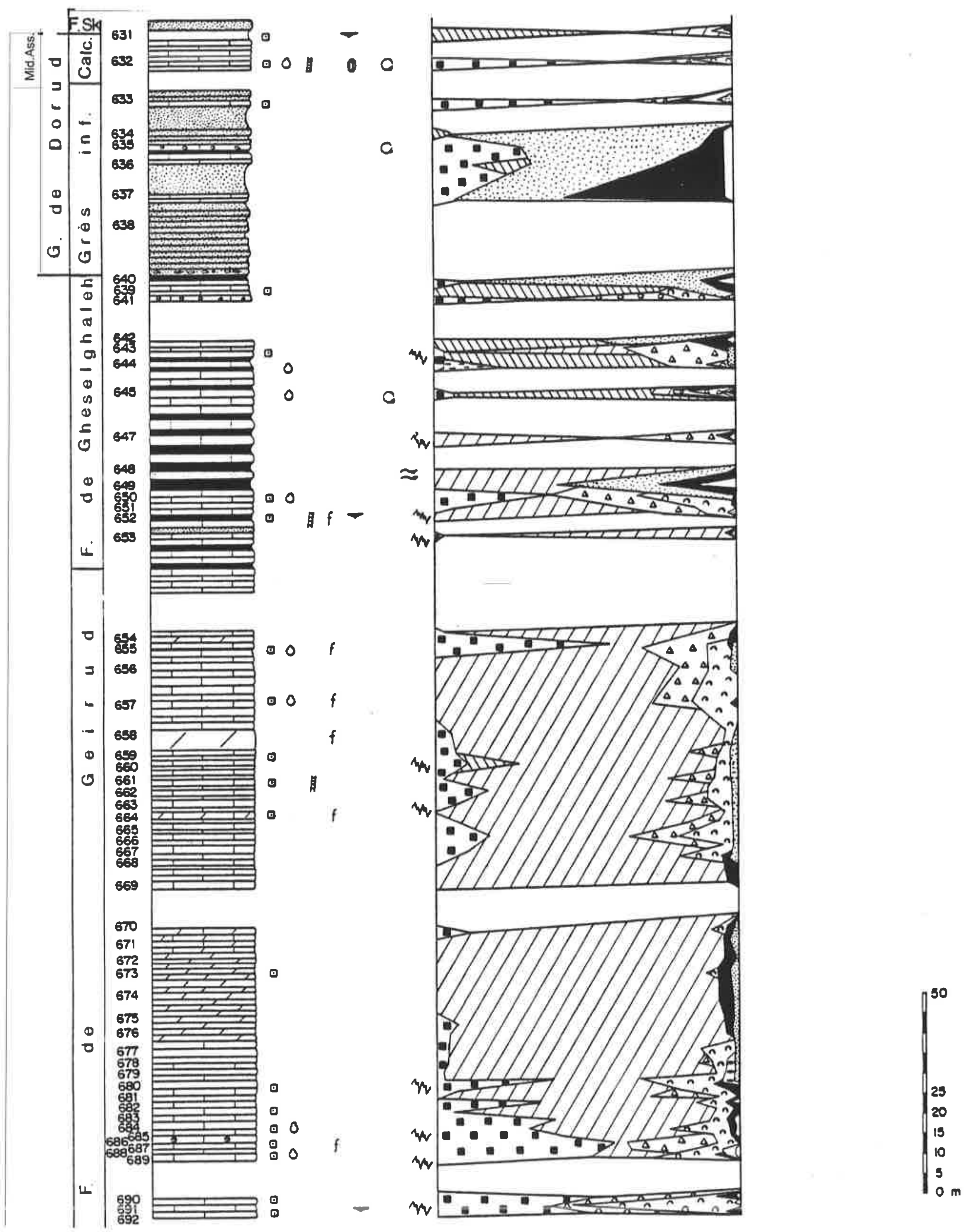


Fig. 1.6.9 Log and sedimentological analysis odf Dorud section, type locality, Central Alborz Mountains, Iran

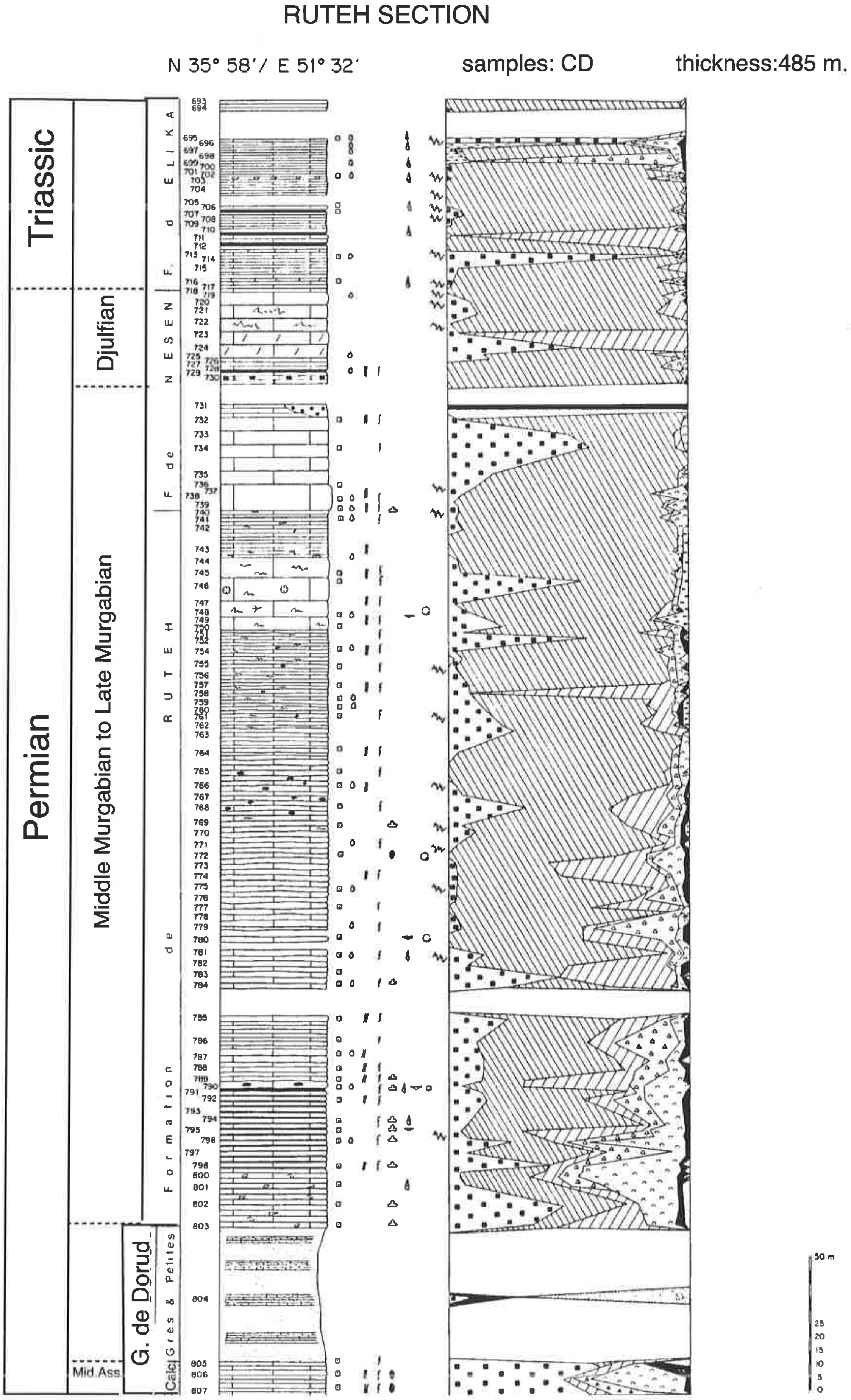


Fig. 1.6.10 Log and sedimentology analysis of Ruteh section (Alborz Mountains, Iran).

RUTEH SECTION (Late Permian)

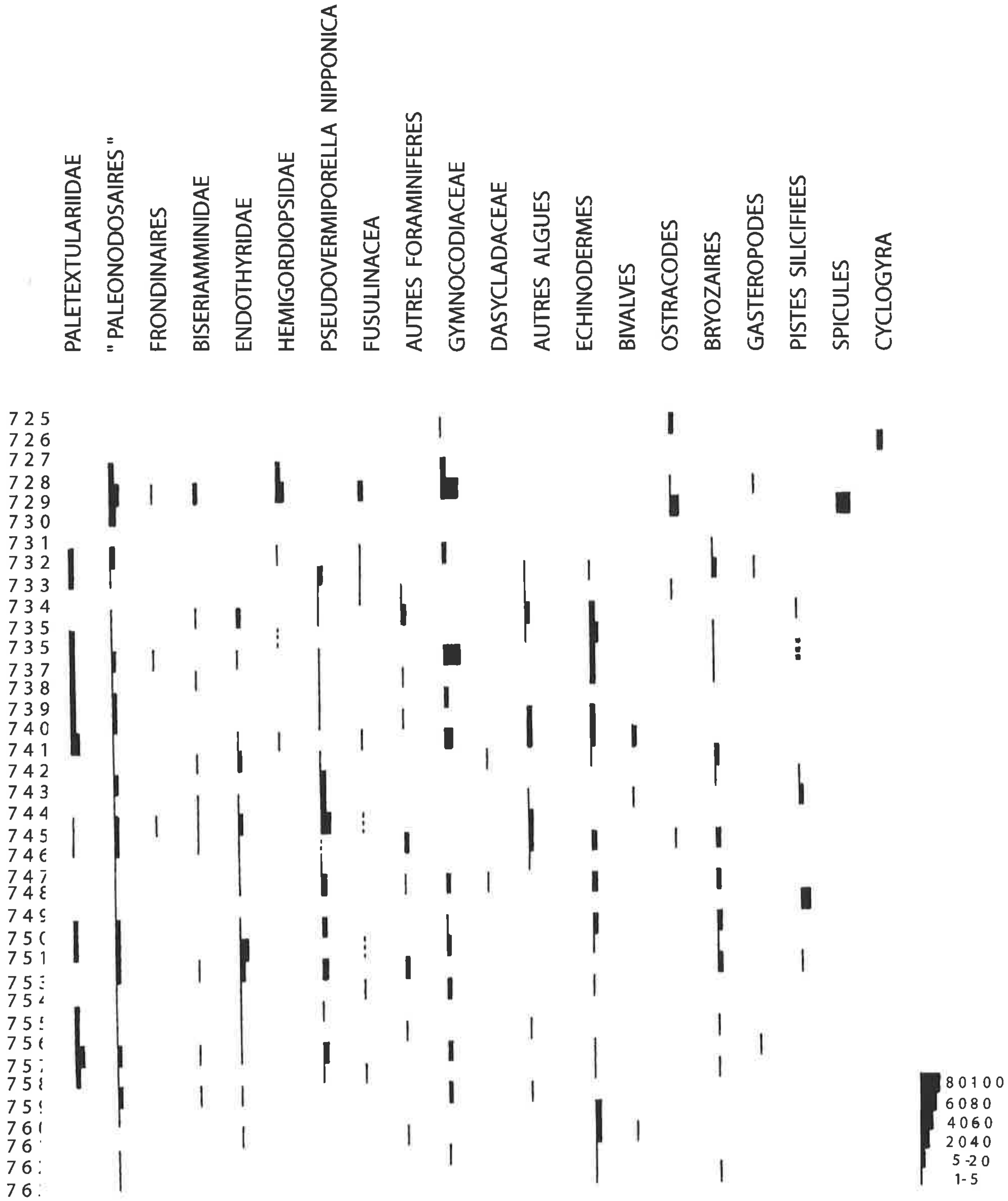


Fig. 1.6.11 Estimation table (%) of the main bioclasts in Ruteh section, type locality, Central Alborz, Iran

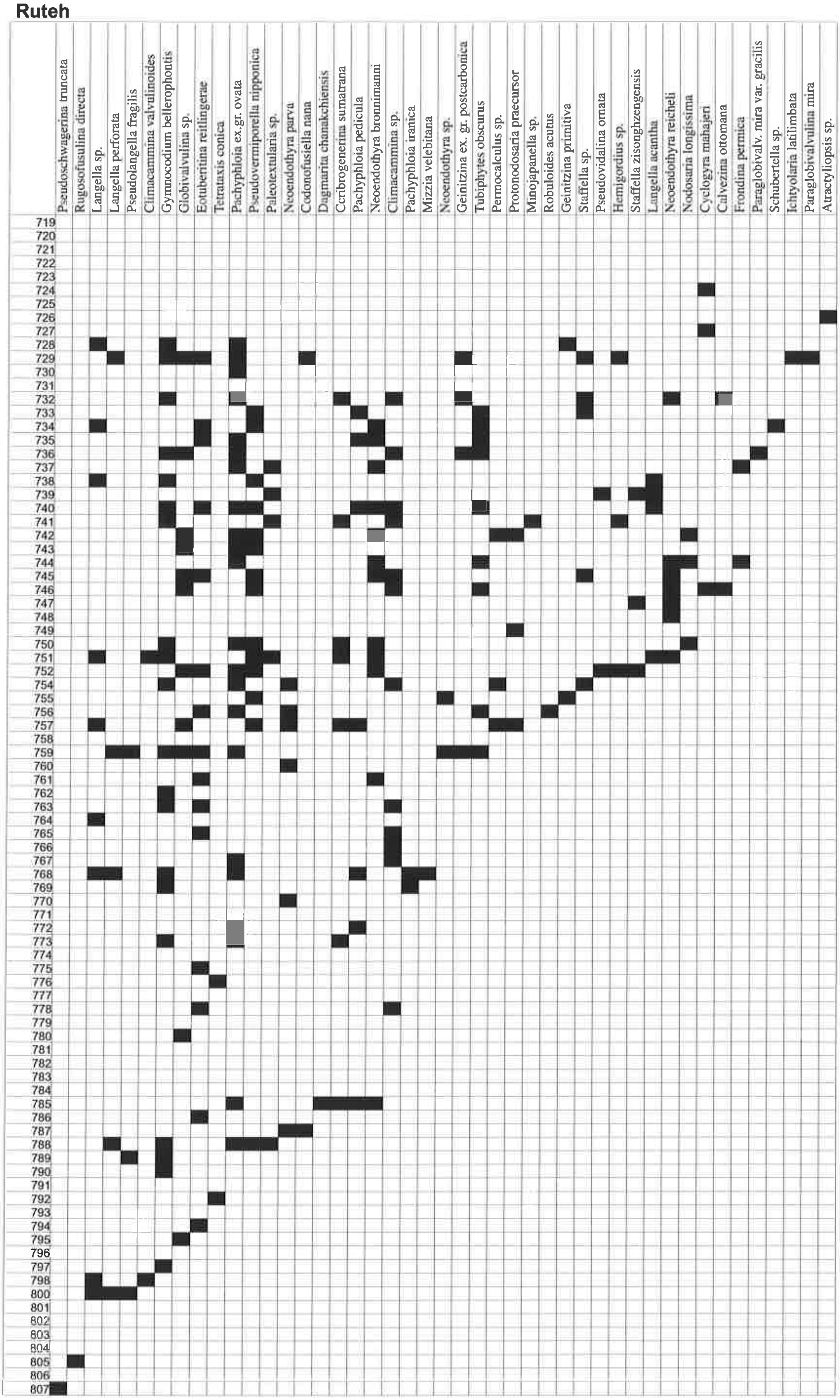


Fig. 1.6.12 Faunal inventory table of Ruteh section, Central Alborz, Iran.

EMARAT I SECTION

N 36° 17'/ E 52° 20' Samples: CD thickness: 300m

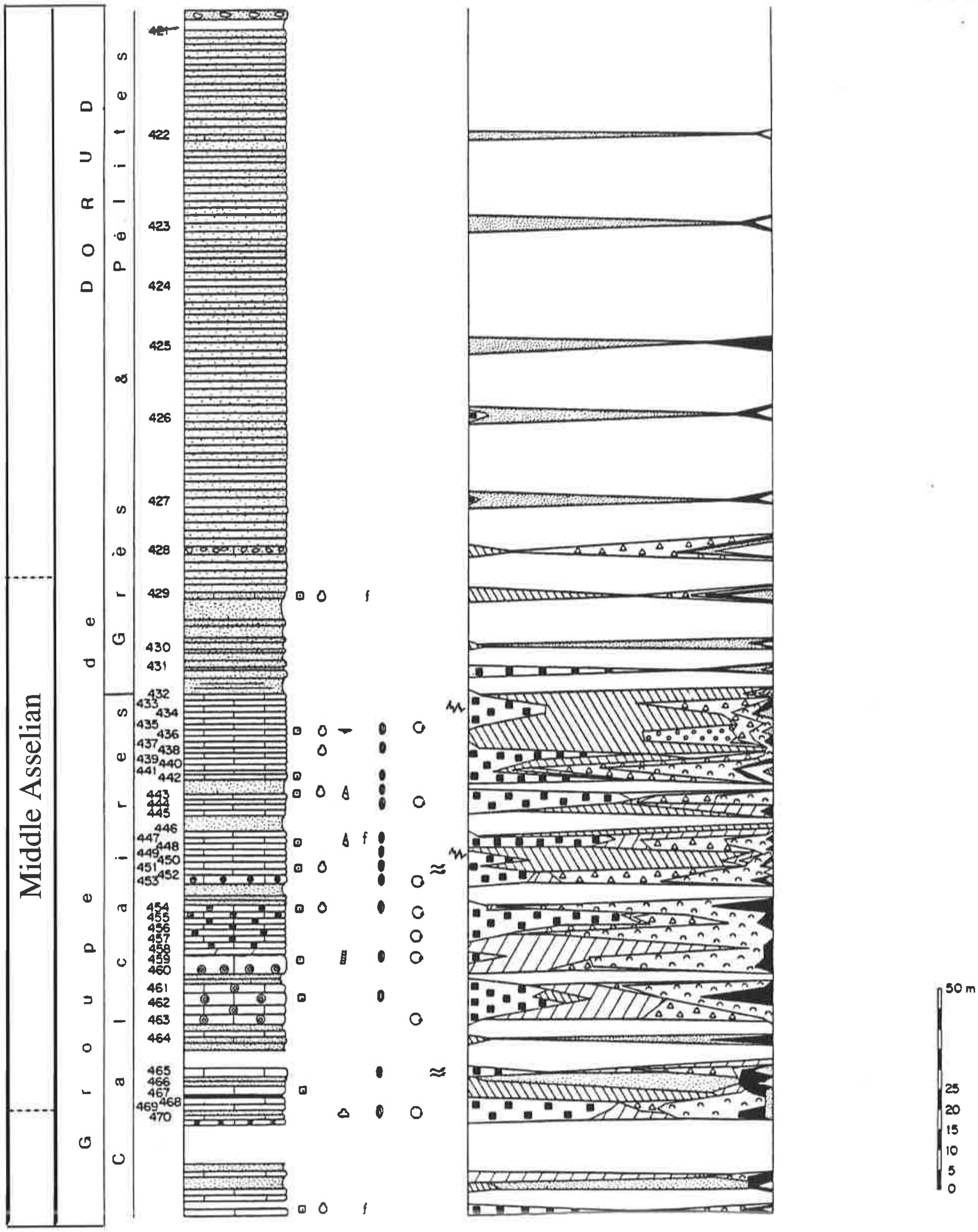


Fig. 1.6. 13 Log and sedimentology analysis of Emarat I section (Alborz Mountains, Iran).

Emarat I

	Nankinella sp.	Pseudofusulina sp.	Pseudofusulina tchernyschevi	Staffella sp.	Paleotextularia sp.	Pseudoschwagerina truncata	Nodosaria sp.	Triticites contractus	Schubertella sp.	Triticites sp.	Girvanella permica	Eotuberitina reitlingerae	Geinitzina ex. gr. postcarbonica
429							■						
430													
431													
432									■				
433							■						
434													
435													
436								■	■				
437								■	■				
438							■		■			■	
439	■												
440													
441													
442													
443			■					■		■			
444													
445													■
446	■												
447								■					
448											■	■	
449													
450	■		■						■	■			
451								■					
452													
453													
454		■					■						
455				■									
456		■	■			■							
457	■				■								
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466													
467		■											
468		■	■										
469	■												
470													
471													

Dorud

	Eotuberitina reitlingerae	Girvanella permica	Pseudofusulina vulgaris
631	■		
632			■
633	■	■	

Fig. 1.6.14 Faunal inventory tables of Emarat I (Lower Permian) and Dorud sections (type locality), Central Alborz, Iran.

EMARAT II (MIDDLE PERMIAN)

N 36°20'/ E 52°20'   Samples: CD   thickness: 420 m

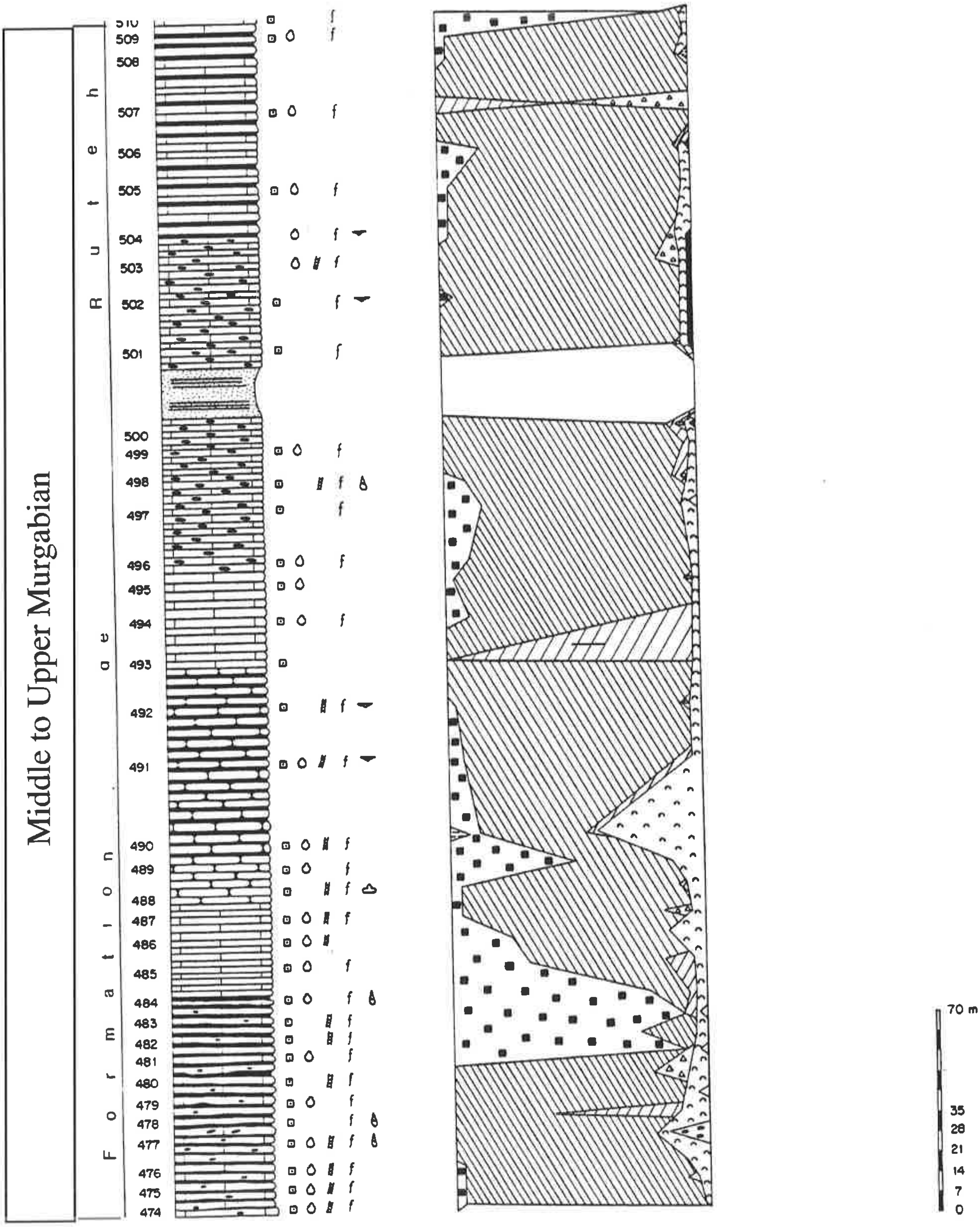

Fig. 1.6.15 Log and sedimentology analysis of Emarat II section, Central Alborz, Iran

Emarat II & III

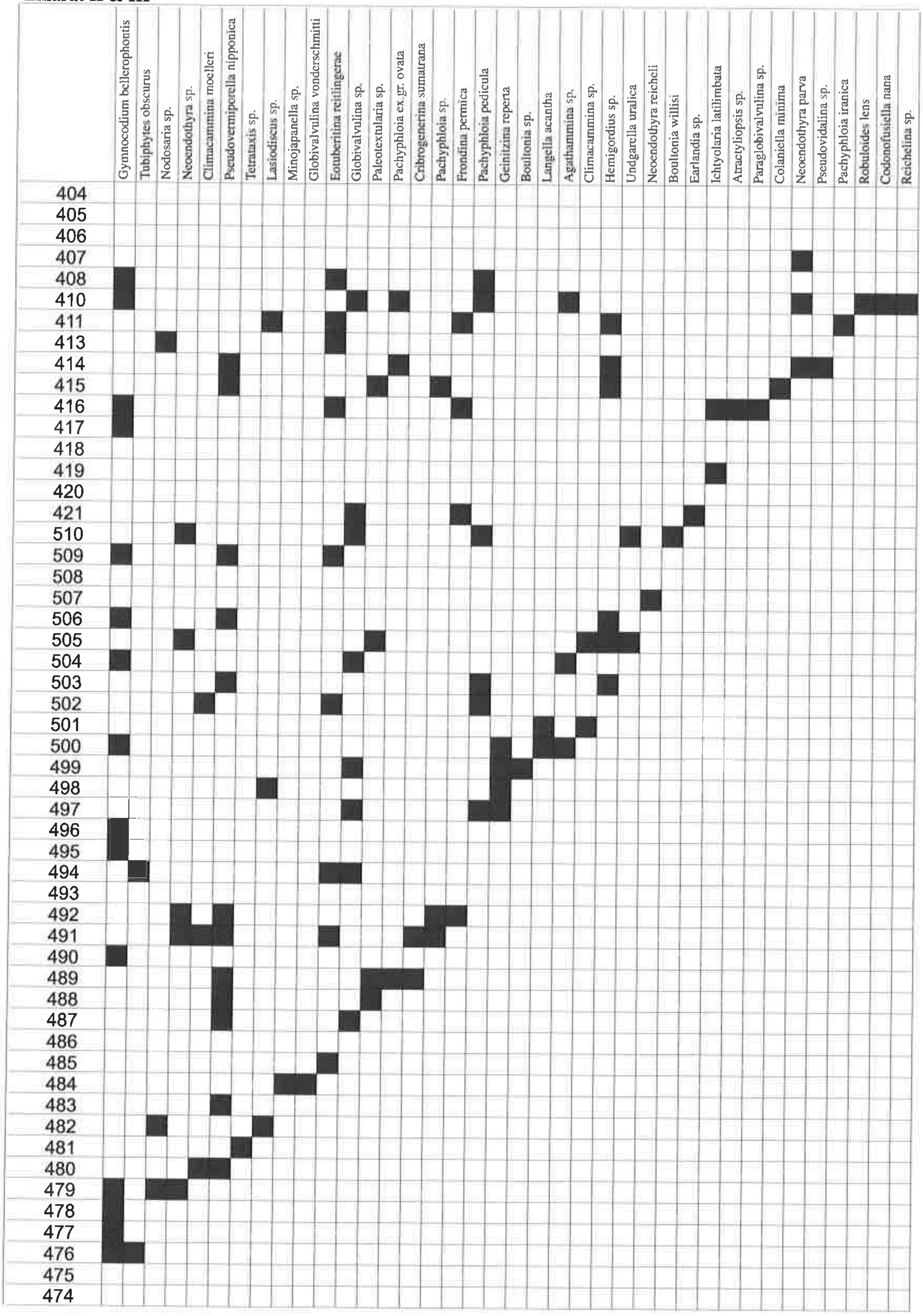

Fig. 1.6.16 Faunal inventory table of Emarat II section, Central Alborz, Iran.

EMARAT III (LATE PERMIAN)

36°30 / E 52°20 Samples: CD thickness: 120m

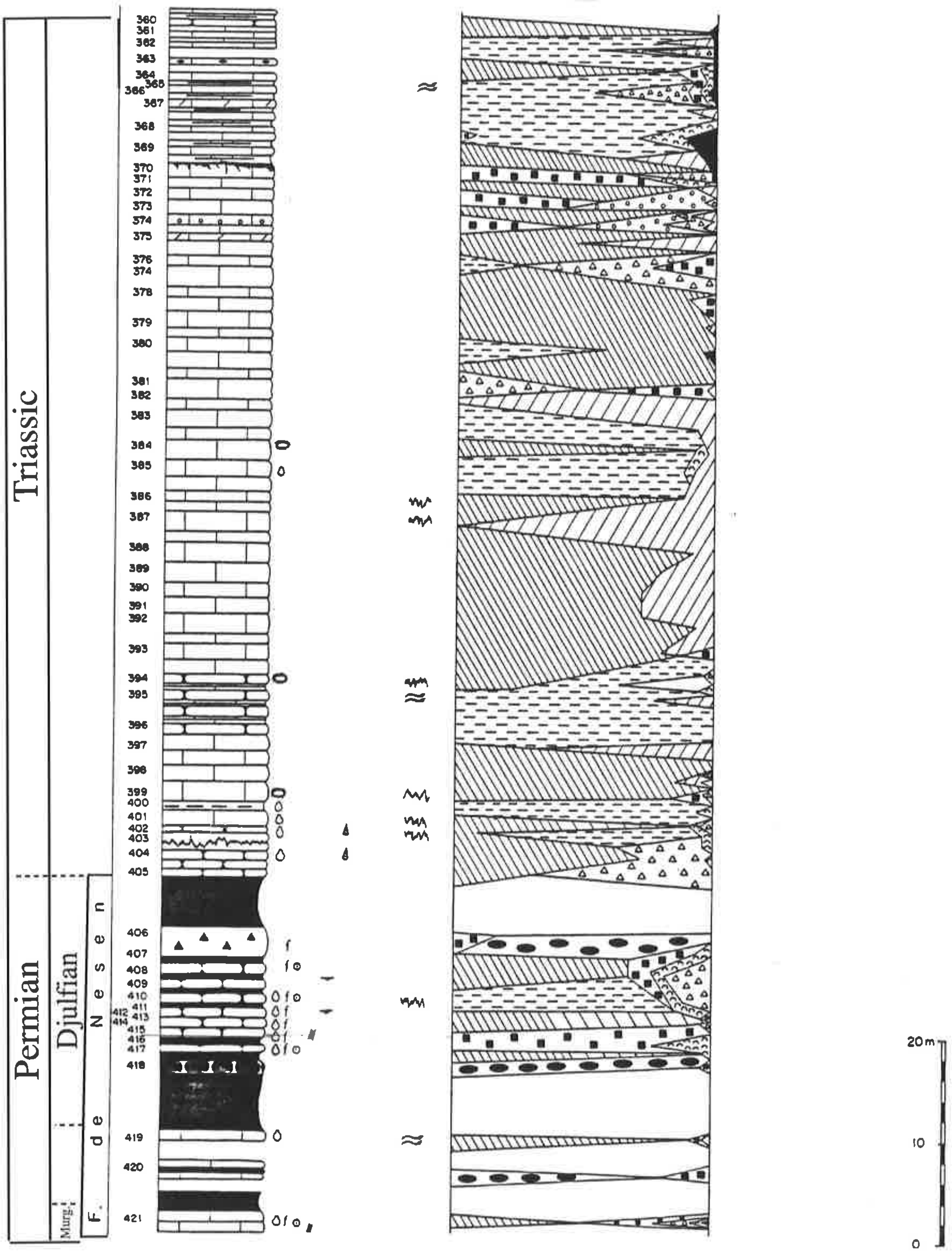

Fig. 1.6.17 Log and sedimentology analysis of Emarat III section, Central Alborz Mountains, Iran,

GHESELGHALEH SECTION

sample: CD thickness: 360m

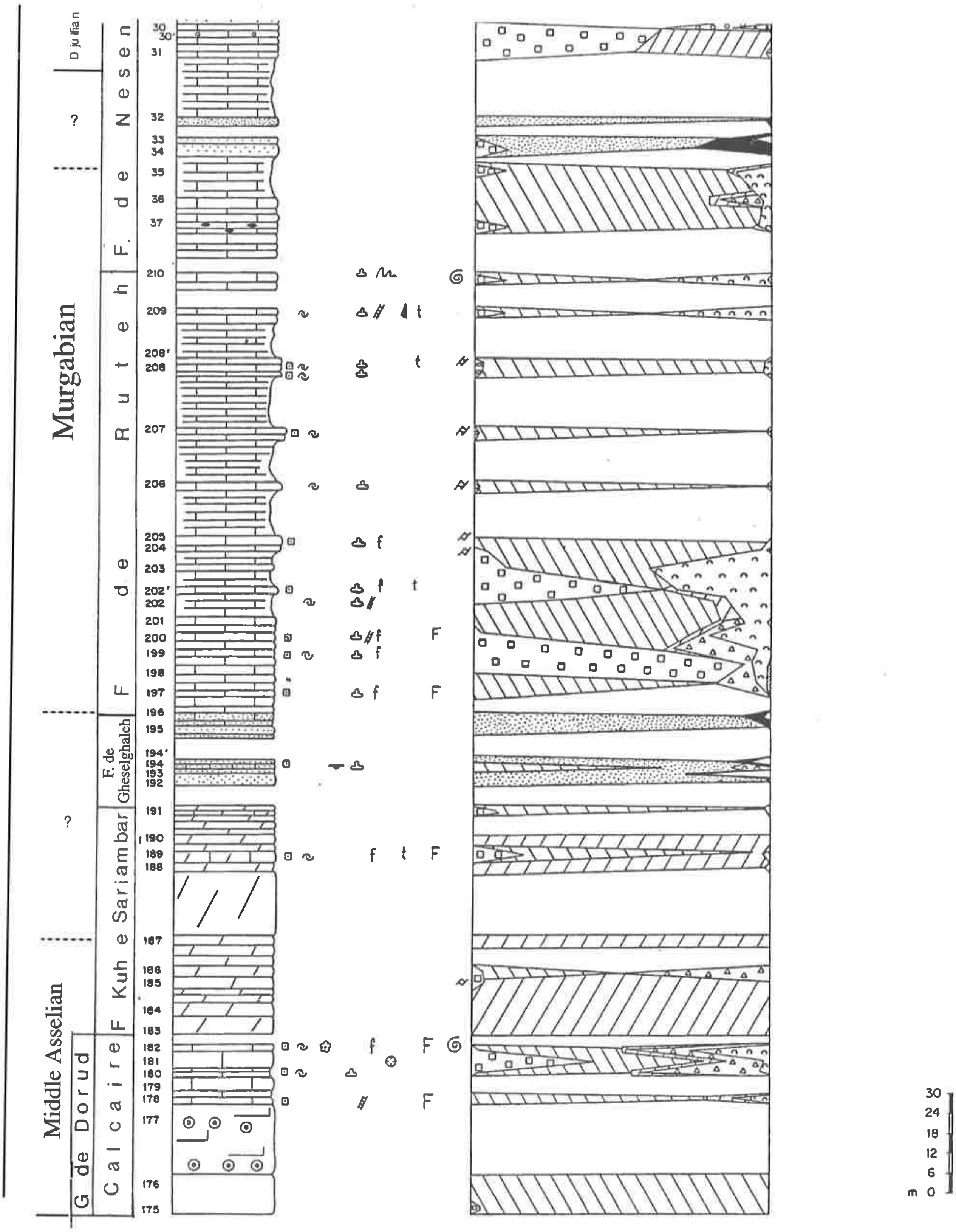

Fig. 1.6.18 Log and sedimentology analysis of Gheselghaleh section, Eastern Alborz Mountains, Iran

Gheselghaleh section

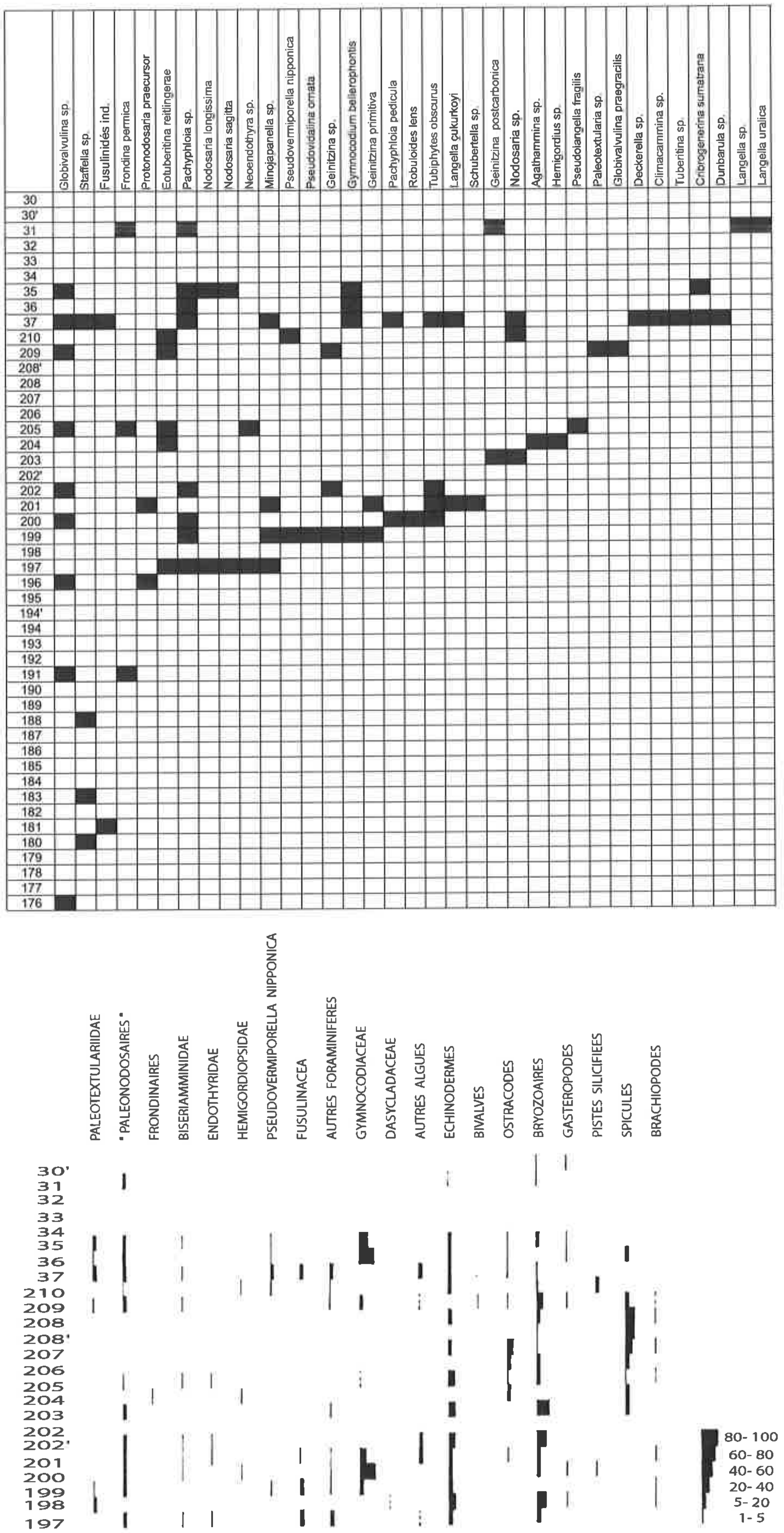

Fig. 1.6.19 Faunal inventory table and estimation table (%) of the main bioclasts in Gheselghaleh section, Eastern Alborz, Iran.

	Series	Stages GSSP	Tethyan stages	Elburz (Iran): fusulinids	Elburz (Iran): small foraminifers	Elburz (Iran): algae
Permian	Lopingian	Changhsingian	Dorashamian		— ? — — — ? — Paraglobivalvulina, Dagmarita, Globivalvulina	— ? — — Mizzia, Gymnocodium, Permocalculus, Tubiphytes
		Wuchiapingian	Djulfian			
	Guadalupian	Capitanian	Midian	Pseudodoliolina, Chusenella	Globivalvulina, Dagmarita, Climacammina	Mizzia
		Wordian	Murgabian	Neoschwagerina, Nankinella, Staffella		
		Roadian	Kubergandian			
	Cisuralian	Kungurian	Bolorian			
		Artinskian	Artinskian			
		Sakmarian	Sakmarian			
		Asselian	Asselian			

Fig. 1.6.20 Faunal association table of the Central Iran.

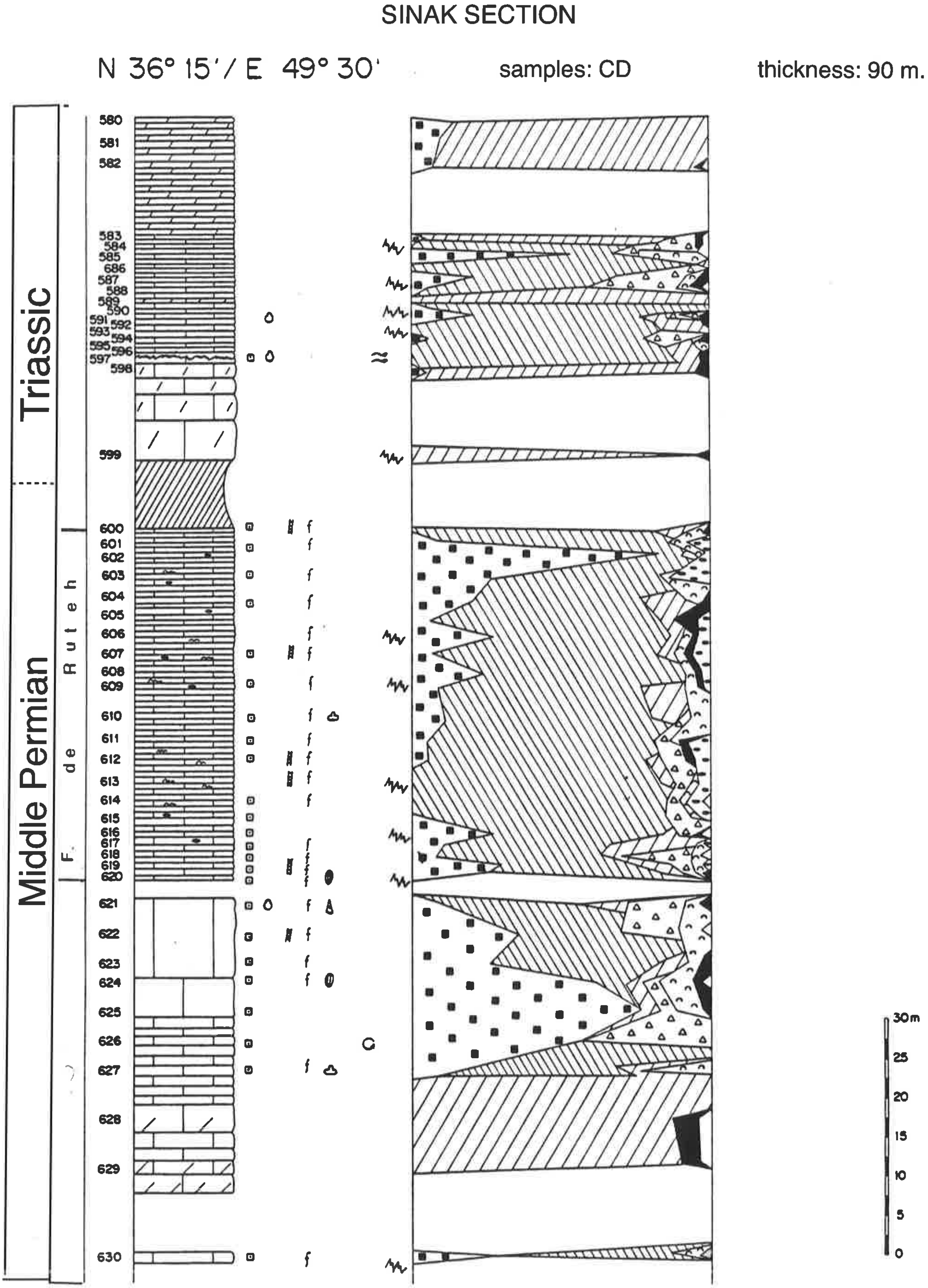

Fig. 1.6.21 Log and sedimentology analysis of Sinak section, Central Iran

Sinak

	Langella perforata	Climacammina elegans	Globivalvulina sp.	Pachyphloia ex.gr. ovata	Tetrataxis planulata	Pseudovermiporella nipponica	Neoendothyra bronnimanni	Climacammina sp.	Geinitzina ex.gr.postcarbonica	Geinitzina uralica	Langella sp.	Tauridium sp.	Neoendothyra reicheli	Eotuberitina reitlingerae	Cribrogenerina sumatrana	Hemigordius sp.	Mizzia velebitana	Climacammina valvulinoides	Deckerella sp.	Paleotextularia sp.	Frondina permica	Globivalvulina vonderschmitti	Pachyphloia pedicula	Protonodosaria praecursor	Geinitzina reperta	Ichtyolaria latilimbata	Langella çukurkoyi	Cyclogyra mahajeri
580																												
581																												
582																												
583																												
584																												
585																												
586																												
587																												■
588																												■
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600	■	■				■															■					■	■	
601						■	■		■				■											■	■			
602						■	■		■												■	■						
603													■	■														
604		■			■				■																			
605														■														
606			■						■				■					■					■					
607			■						■			■	■								■	■						
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616													■	■														
617													■															
618												■	■															
619				■																								
620								■	■	■	■																	
621							■																					
622						■																						
623																												
624					■																							
625	■																											
626	■		■	■																								
627																												
628																												
629																												
630	■	■																										

Fig. 1.6.22 Faunal inventory table of Sinak section, Central Iran.

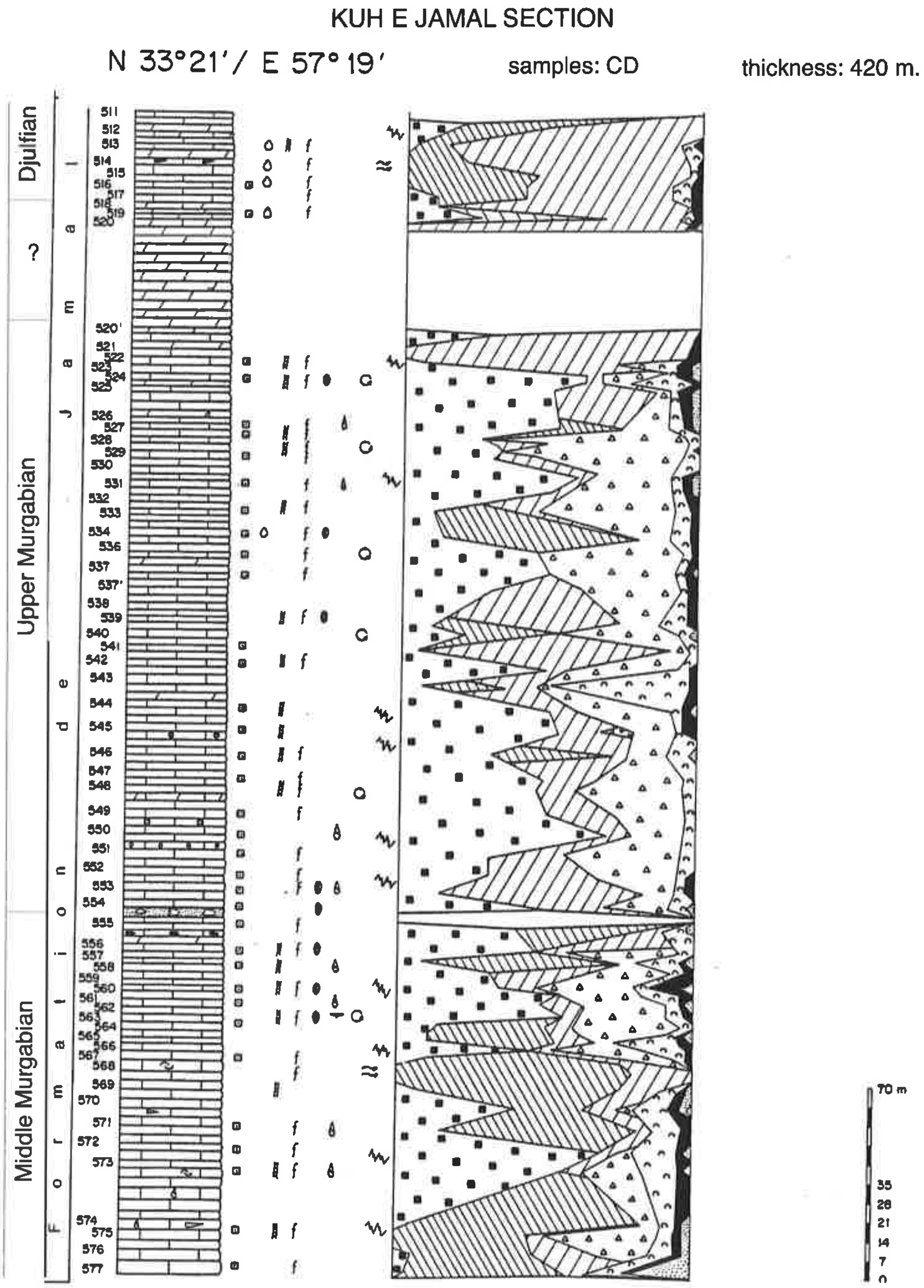


Fig. 1.6.23 Log and sedimentology analysis of Kuh e Jamal section, Central Iran

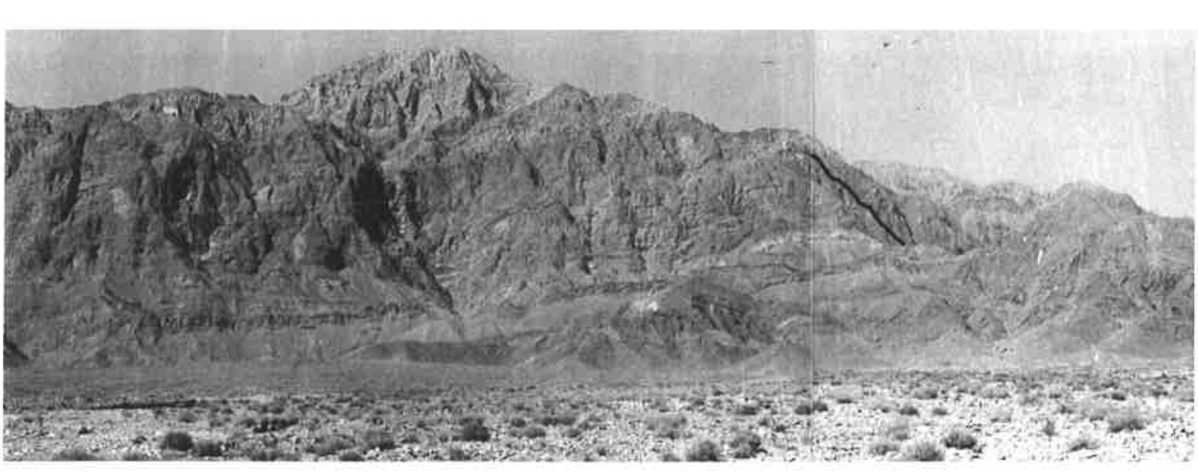


Fig. 1.6.24 Kuh e Jamal section in the Shotori Range, near Tabas, Central Iran

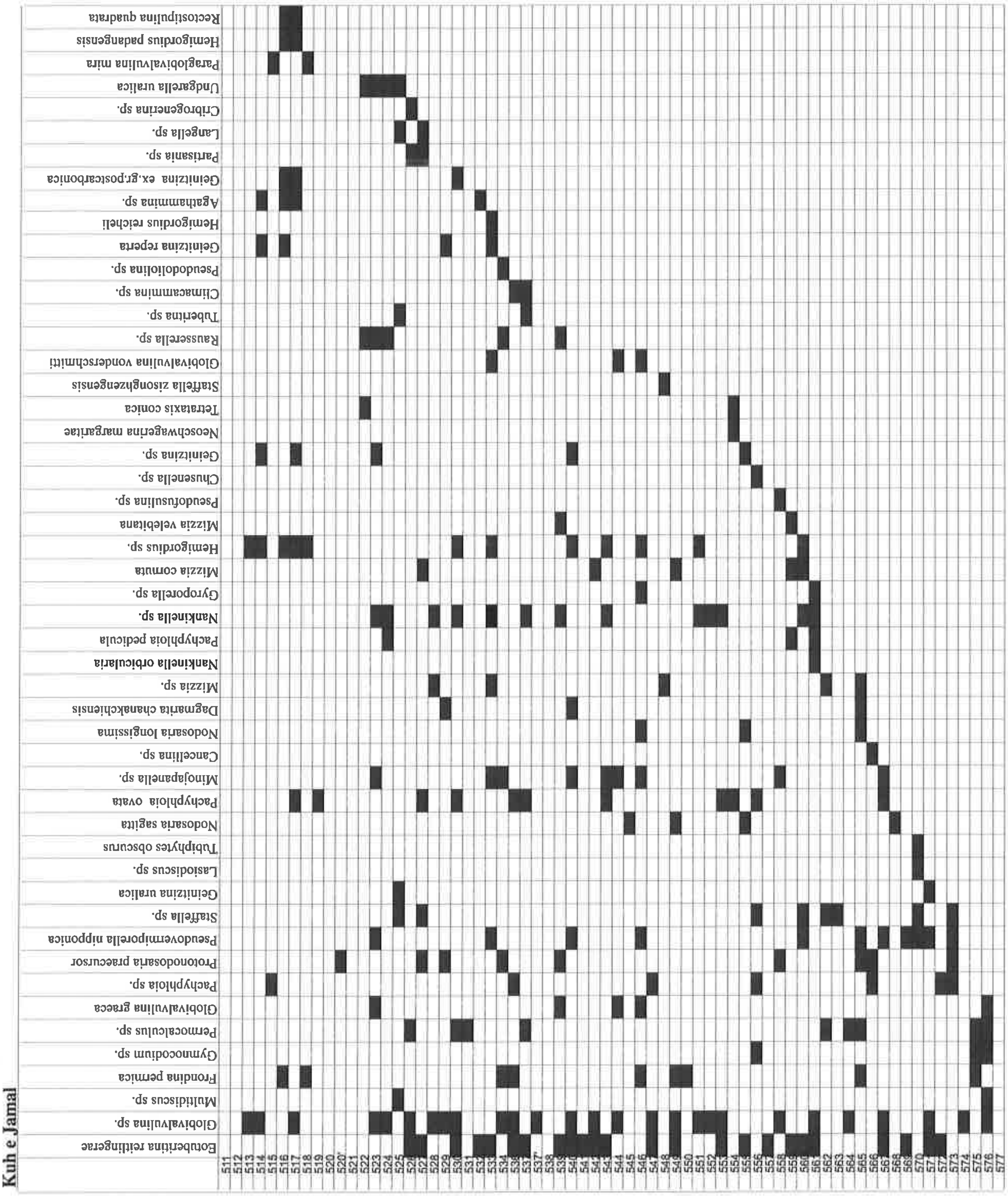


Fig. 1.6.25 Faunal inventory table of Kuh e Jamal section, Central Iran.

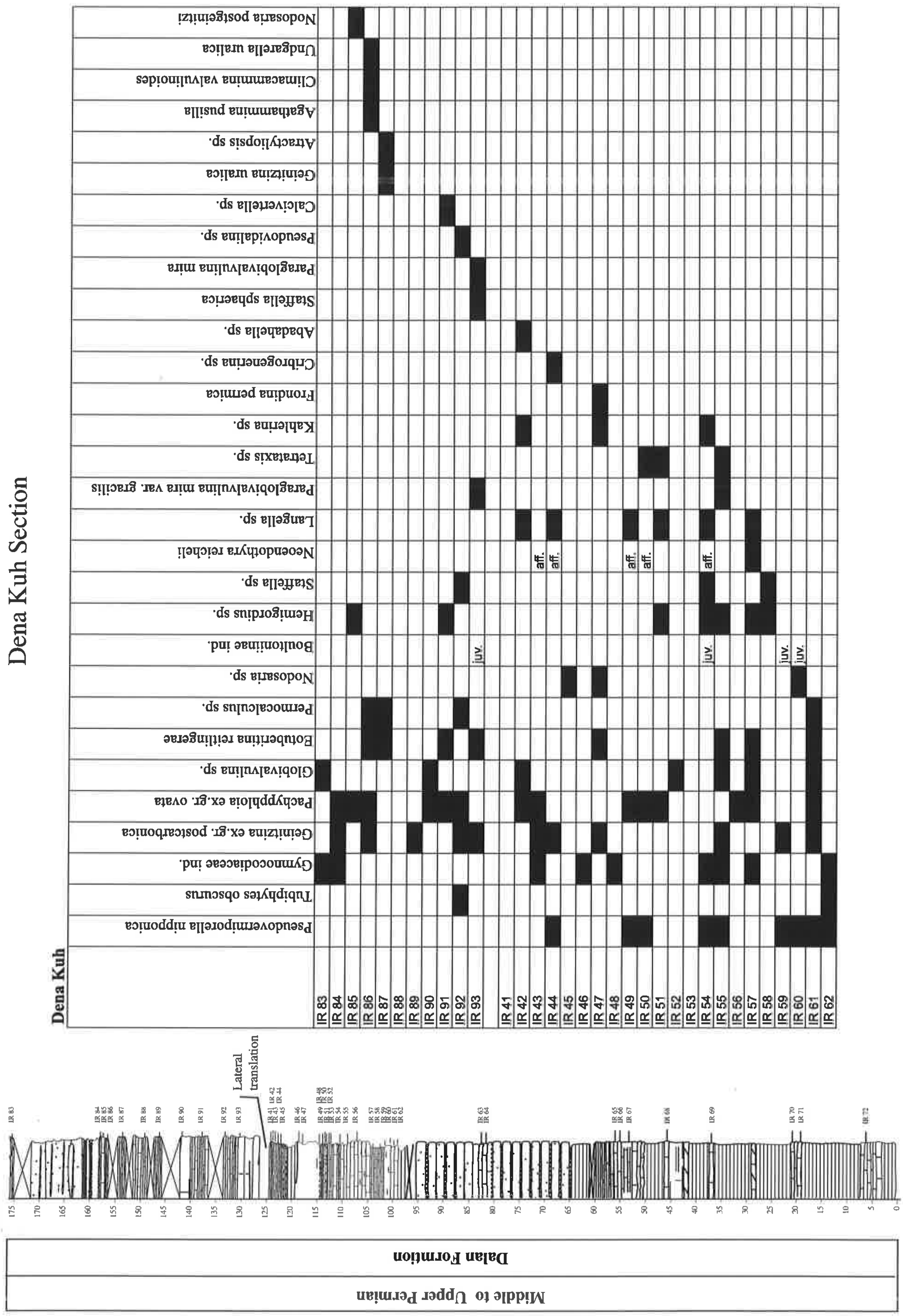


Fig 1.6.26 Log and faunal inventory table of Dena Kuh section, Zagros Mountains, Iran

Micropaleontological remarks on Permian deposits in Iran

"Paleonodosariidae "

The genus *Colaniella* ex. gr. *minima* WANG has only been observed in the Late Permian Emarat III section, in the central part of the Alborz Mountains (Pl. 10, fig. 1).
We didn't find this taxon in the samples collected in the Kuh e Jamal section of Central Iran. Nevertheless, this species is mentioned and illustrated in the Bagh e Vang section (Partoazar, H., 1995, pl. VI, fig. 1-9). It seems that the upper part of the Jamal Formation in the Kuh e Jamal section is more dolomitic than in the Bagh e Vang section.
Despite serious efforts we were unable to find this taxon in the Zagros Mountains.

Biseriamminidae

This group of foraminifers was of highest importance to us when we began to study Permian foraminifers in the Alborz Mountains. It compensated the rarity of fusulinids and enabled us to propose faunal association biostratigraphy for this area (Jenny-Deshusses, 1983a).
All main taxa of this group have been observed in our material. The faunal assemblage with *Paraglobivalvulina mira* REITLINGER is one of the typical biofacies for the Upper Permian deposits in the Alborz Mountains (Pl. 10, fig. 9) in association with Staffellids and *Rectostipulina quadrata* JENNY-DESHUSSES. This is even the main characteritic faunal association for the Late Permian deposits in this area.
In the Rudbarak section of the Alborz Mountains the taxon *Paraglobivalvulina* was very rich in individuals with well-oriented cuttings allowing us to improve our knowledge of the morphology of this genus (Jenny-Deshusses 1983b, 1988).

Hemigordiopsidae

Individuals of this group are numerous in the deposits of the Upper Permian Nesen formation of the Alborz Mountains, especially in the Rudbarak section. This section comprises black fetid flaser bedded limestones.

Fusulinacea

Even though this group was poor in individuals and species diversity, we observed some characteristic taxa, especially in the reef limestone of the calcareous part of the Lower Permian Dorud Group in the Alborz Mountains (Pl. 8, figs. 1-6). There, fusulinids often were used as the nucleus in onchoids formed by the Cyanophyta algae Girvanella; this represent a typical biofacies for the Lower Permian calcareous formation of the Dorud group.
In Central Iran, *Neoschwagerina schuberti* DEPRAT (Pl. 11, figs. 11-12) and *Chusenella tieni* (CHEN) (Pl. 11, fig.9) gave a good age assignment, Wordian for the middle part the Jamal formation in the Kuh e Jamal section.
Staffellids (Pl. 11, fig. 5) are very frequent in the Middle and Late Permian deposits, but strongly recrystallized.

Endothyracea

The Alborz Mountains are a special area in the Tethyan realm where numerous individuals and species taxa of the Paleotextulariidae (Pl. 9, figs 2- 4), Tetrataxiidae (Pl. 9, figs 7-8) and Endothyridae (Pl. 9, figs, 5, 13) families have been observed. They are here characteristic of the Middle Permian Ruteh formation deposits.
In comparison, individuals of Paleotextulariidae and Tetrataxiidae families participate to the biofacies of the Upper Permian Episcopi Formation in Greece.

The deposits of the Middle Permian Marmari formation (Greece) reveals a more enclosed environment than its time- equivalent deposits in the Alborz Mountains.

Incertae sedis

Rectostipulina quadrata JENNY-DESHUSSES is very numerous in the Upper Permian Nesen Formation sediments, especially in the Rudbarak section where the type of the species was definite (Jenny-Deshusses, 1985).

Calcareous algae

Cyanophyta algea Girvanella is present in the Lower Permian deposits in the Alborz Mountains; there individuals of this genus develop algal ball sedimentation. This is the typical biofacies for the Calcareous Lower Permian formation of the Dorud group in the Alborz Mountains.

The faunal inventory of the Dena Kuh section reveals a very poor assemblage. This latter could be compared to the Arabian platform.

Plate 8

Fig. 1 : *Darvasites simplex* (CHEN), CD 443, Alborz Mountains, Emarat I section, Calcareous Formation of the Dorus group.

Fig. 2 : *Triticites contractus* (SCHELLWIEN), CD 437, Alborz Mountains, Emarat I section, Calcareous Formation of the Dorud group.

Fig. 3 : *Rugosofusulina directa* BENSCH, CD 632, Alborz Mountains, Dorud section, Lower Sandy Formation of the Dorud group.

Fig. 4 : *Pseudofusulina vulgaris* (SCHELLWIEN), CD 806, Alborz Mountains, Ruteh section, Calcareous Formation of the Dorud group.

Fig. 5 : *Pseudoschwagerina truncata* RAUSER, CD 807, Alborz Mountains, Ruteh section, calcareous Formation of the Dorud group.

Fig. 6 : *Pseudofusulina tchernychewi* (SCHELLWIEN), CD 457, Alborz Mountains, Emarat I section, Calcareous Formaiton of the Dorud group.

scale: 500 μm

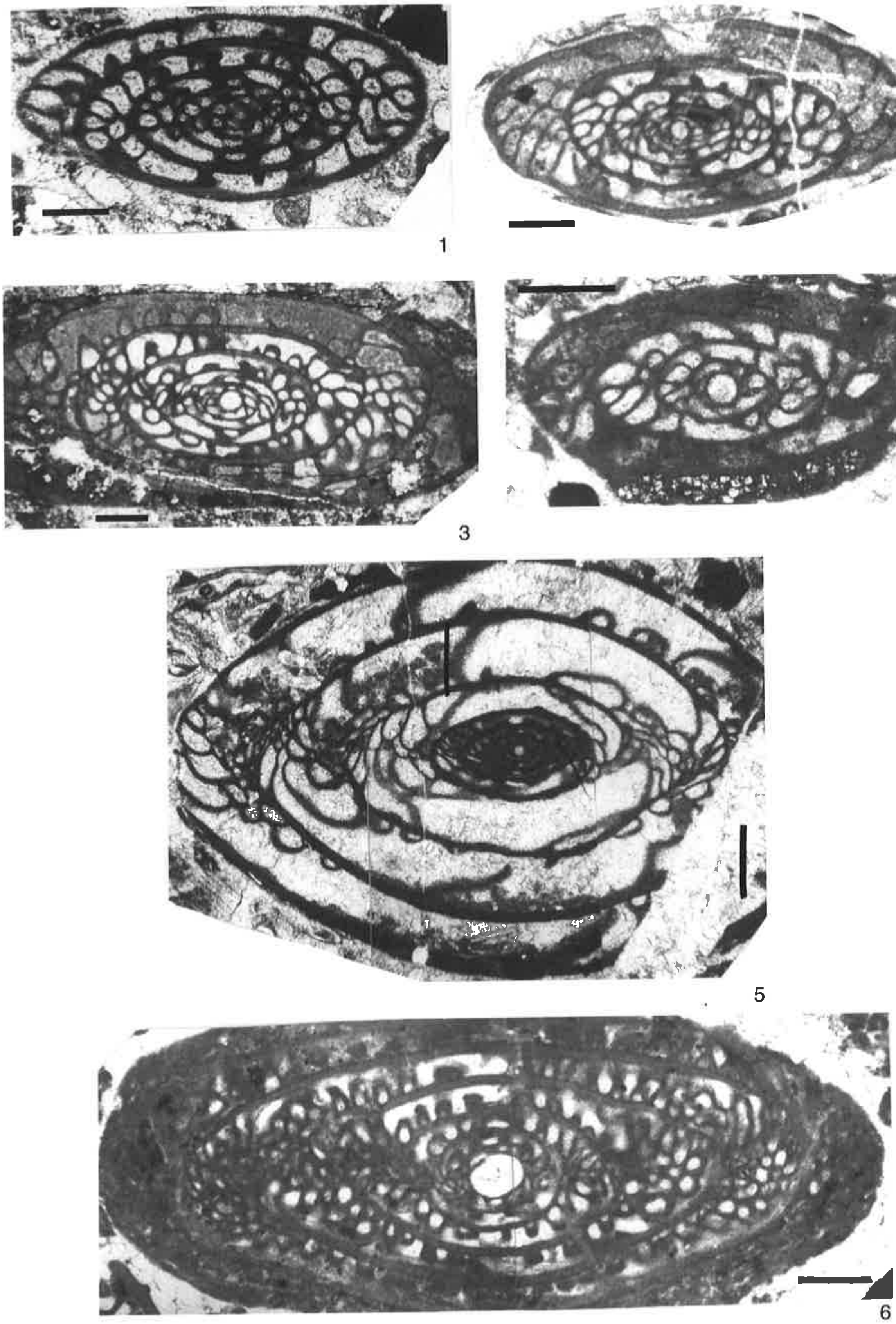


Plate 8

Plate 9

Fig. 1 : *Pseudodoliolina* sp., éch 40 (Vollmer samples, ETHZ), Alborz Mountains.

Fig. 2 : *Climacammina elegans* (MOELLER), CD 732, Alborz Mountains, Ruteh section, Nesen Formation.

Fig. 3 : *Cribrogenerina sumatrana* (VOLZ), CD 491, Alborz Mountains, Emarat II, Ruteh Formation.

Fig. 4 : *Climacammina moelleri* var. *timanica* REITLINGER, CD 739, Alborz Mountains, Ruteh section, Nesen Formation.

Fig. 5 : *Neoendothyra reicheli* REITLINGER, CD 481, Alborz Mountains , Emarat II section, Ruteh Formation.

Fig. 6 : *Eotuberitina reitlingerae* MIKLUKO- MACLAY, CD 746, Alborz Mountains, Ruteh section, Ruteh Formation.

Fig. 7 : *Tetrataxis* sp., CD 604, Central Iran , Sinak section, Ruteh Formation.

Fig. 8 : *Tetrataxis conica* EHRENBERG, CD 481, Alborz Mountains, Emarat II section, Ruteh Formation.

Fig. 9 : *Nodosaria longissima* SULEIMANOV, CD 750, Alborz Mountains, Ruteh section, Ruteh Formation.

Fig. 10 : *Pseudolangella fragilis* S. de C. & DESS., CD 789, Alborz Mountains, Ruteh section, Ruteh Formation.

Fig. 11 : *Langella gigantea* JENNY- DESHUSSES, CD 198a, Alborz Mountains, Gheselghaleh section, Ruteh Formation.

Fig. 12 : *Globivalvulina cyprica* REICHEL, CD 473, Alborz Mountains, Emarat, isolated sample.

Fig. 13 : *Neoendothyra bronnimanni* BOZORGNIA, ,CD 746, Alborz Mountains, Ruteh section, Ruteh Formation.

scale : Fig. 1, 2, 3, 4, 8, 9,11, = 500 µm
Fig. 5, 6, 7, 10, 12, 13 = 100 µm

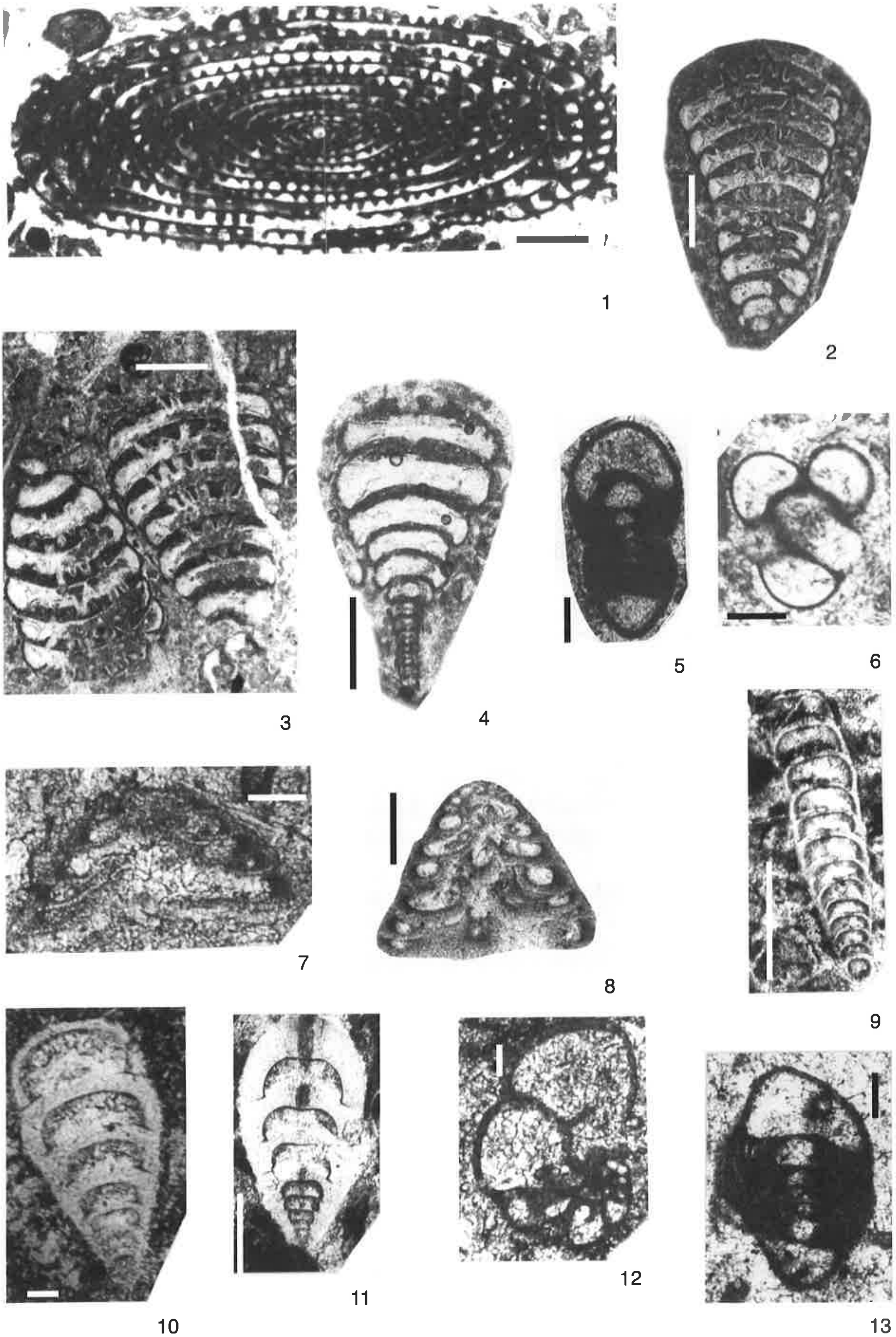


Plate 9

Plate 10

Fig. 1 : *Colaniella* ex. gr. *parva* (COLANI), CD 415, Alborz Mountains, Emarat III section, Nesen Formation.

Fig. 2 : *Rectostipulina quadrata* JENNY-DESHUSSES, Alborz Mountains CD 310, Rudbarak section, Nesen Formation.

Fig. 3 : *Hemigordius permicus* GROZDILOVA, CD 315', Alborz Mountains, Rudbarak section, Nesen Formation.

Fig. 4 : *Nankinella orbicularia* LEE, CD 316, Alborz Mountains, Rudbarak section, Nesen Formation.

Fig. 5 : *Paraglobivalvulina mira* REITLINGER, CD 324, Alborz Mountains, Rudbarak section, Nesen Formation.

Fig. 6 : *Paraglobivalvulina mira* REITLINGER, CD 316, Alborz Mountains, Rudbarak section, Nesen Formation.

Fig. 7 : *Paraglobivalvinoides septulifer* ZANINETTI & JENNY-DESHUSSES, CD 314, Alborz Mountains, Rudbarak section, Nesen Formation.

Fig. 8 : *Paraglobivalvulina mira* REITLINGER, CD 323, Alborz Mountains, Rudbarak section, Nesen Formation.

Fig. 9 : Microfacies; CD 316, Alborz Mountains, Rudbarak section, Nesen Formation, *Rectostipulina quadrata* (a), *Staffella* sp.(b), *Paraglobivlavulina mira* (c).

Fig. 10 : *Geinitzina reperta* BYKOVA, CD 415, Alborz Mountains, Emarat section, Nesen Formation.

Fig. 11 : *Ichtyolaria latilimbata* S. de C. & DESSAUVAGIE, CD 317, Alborz Mountains, Rudbarak section, Nesen Formation.

Scale : Fig. 1, 4, 5, 6, 7, 8, 9 = 500 μm
Fig. 2, 3, 10, 11 = 100 μm

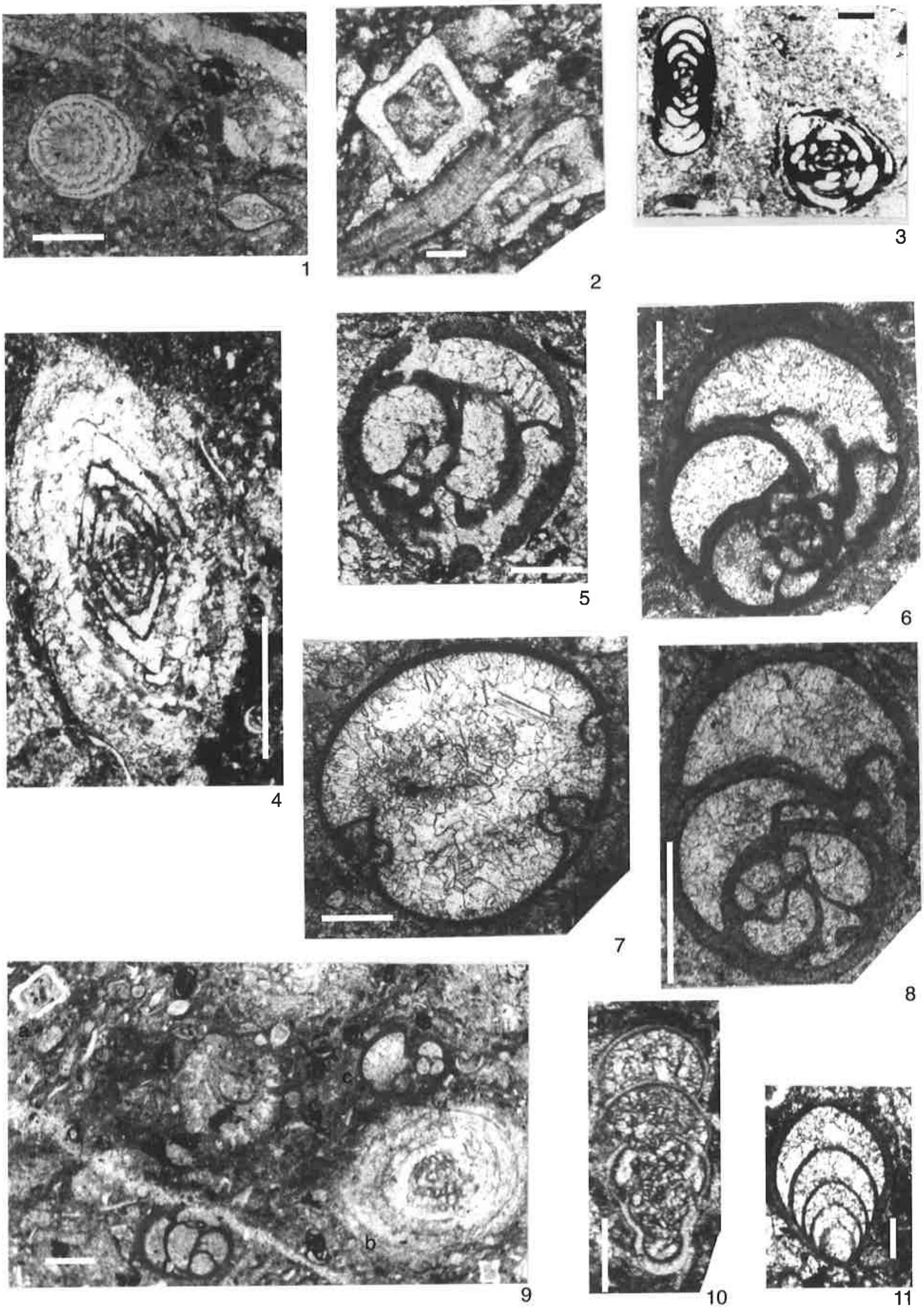


Plate 10

Plate 11

Fig. 1 : *Tuberitina collosa* REITLINGER, CD 612, Central Iran, Sinak section, Ruteh Formation.

Fig. 2 : *Mizzia cornuta* KOCHANSKY & HERAK, CD 565, Central Iran, Kuh e Jamal section, Jamal Formation.

Fig. 3 : *Dagmarita chanakchiensis* REITLINGER, CD 529, Central Iran, Kuh e Jamal section, Jamal Formation.

Fig. 4 : *Globivalvulina graeca* REITLINGER, CD 539, Central Iran, Kuh e Jamal section, de Jamal Formation.

Fig. 5 : *Nankinella orbicularia* LEE, CD 526, Central Iran, Kuh e Jamal section, Jamal Formation.

Fig. 6 : *Climacammina valvulinoides* LANGE, CD 609, Central Iran, Sinak section, Ruteh Formation.

Fig. 7 : *Cribrogenerina sumatrana* (VOLZ), CD 613, Central Iran, Sinak section, Ruteh Formation.

Fig. 8 : *Globivalvulina graeca* REITLINGER, CD 539, Central Iran, Kuh e Jamal section, Jamal Formation.

Fig. 9 : *Chusenella tieni* (CHEN), CD 556, Central Iran, Kuh e Jamal section, Jamal Formation.

Fig. 10 : *Cribrogenerina sumatrana* (VOLZ), CD 613, Central Iran, Sinak section, Ruteh Formation.

Fig. 11 : *Neoschwagerina schuberti* KOCHANSKY-DEVIDE, CD 556, Central Iran , Kuh e Jamal section, Jamal Formation.

Fig. 12 : *Neoschwagerina schuberti* KOCHANSKY-DEVIDE, CD 556, Central Iran , Kuh e Jamal section, Jamal Formation.

Scale : Fig. 2, 4, 5, 6, 7, 8, 9,10,11,12 = 500 μm
Fig. 1, 3 = 100 μm

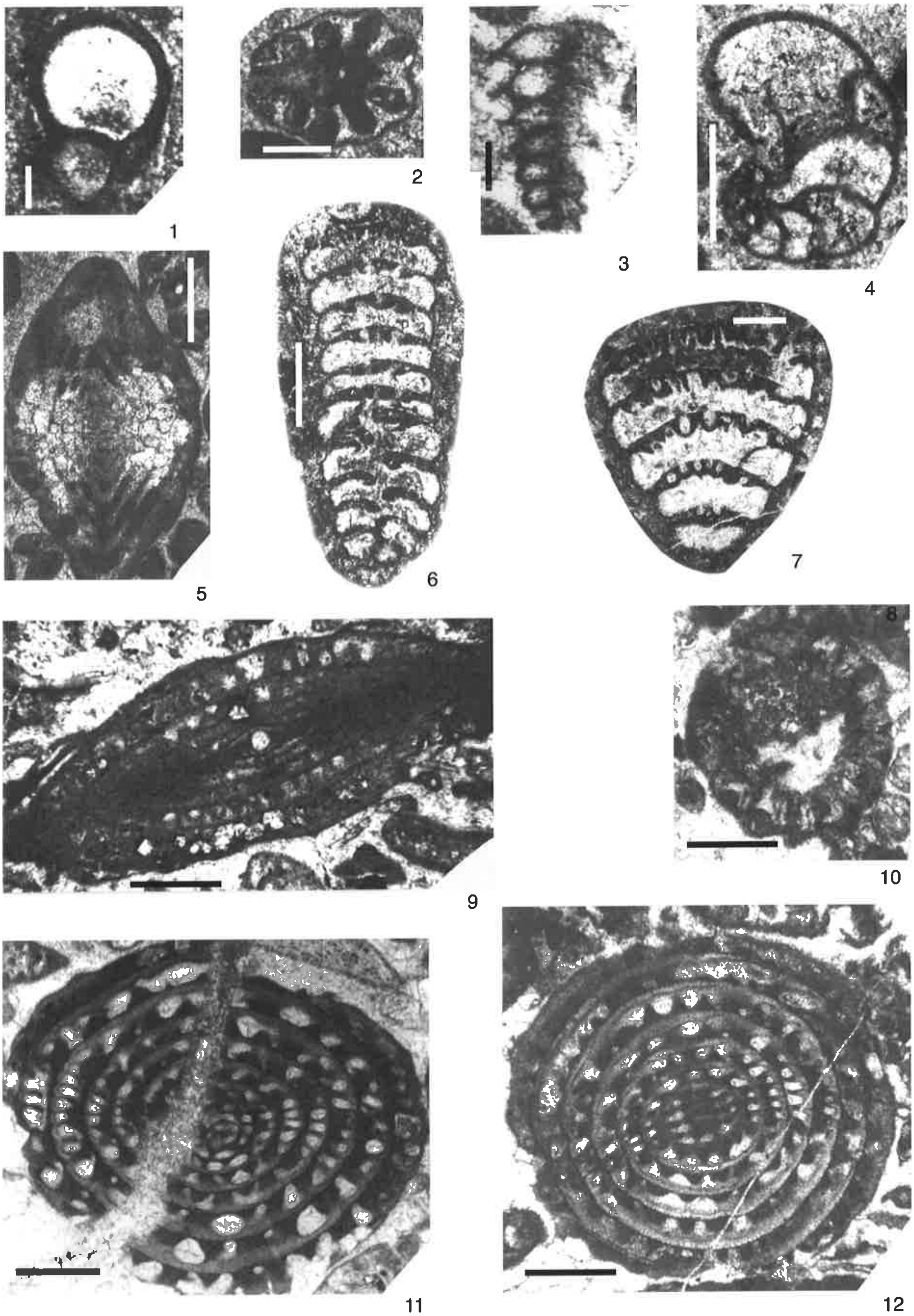


Plate 11

1. 7 Salt Range (Pakistan)

Introduction

We describe the faunal assemblage from two sections of Late Permian deposits in the Salt Range, the Nammal section and the Chhidru section. In these localities, samples were collected during an international fieldtrip-meeting in Dec. 1987.
For more details on geology and sedimentology of this area, Kummel and Teichert, 1970; Okimura and Ishii, 1981; Pakistani-Japanese Group, 1985; Okimura 1988; Baud et al., 1989; Shi et al., 1995; Baud et al., 1996; Atudorei 1999; Mertmann 1999; 2003 can be consulted.

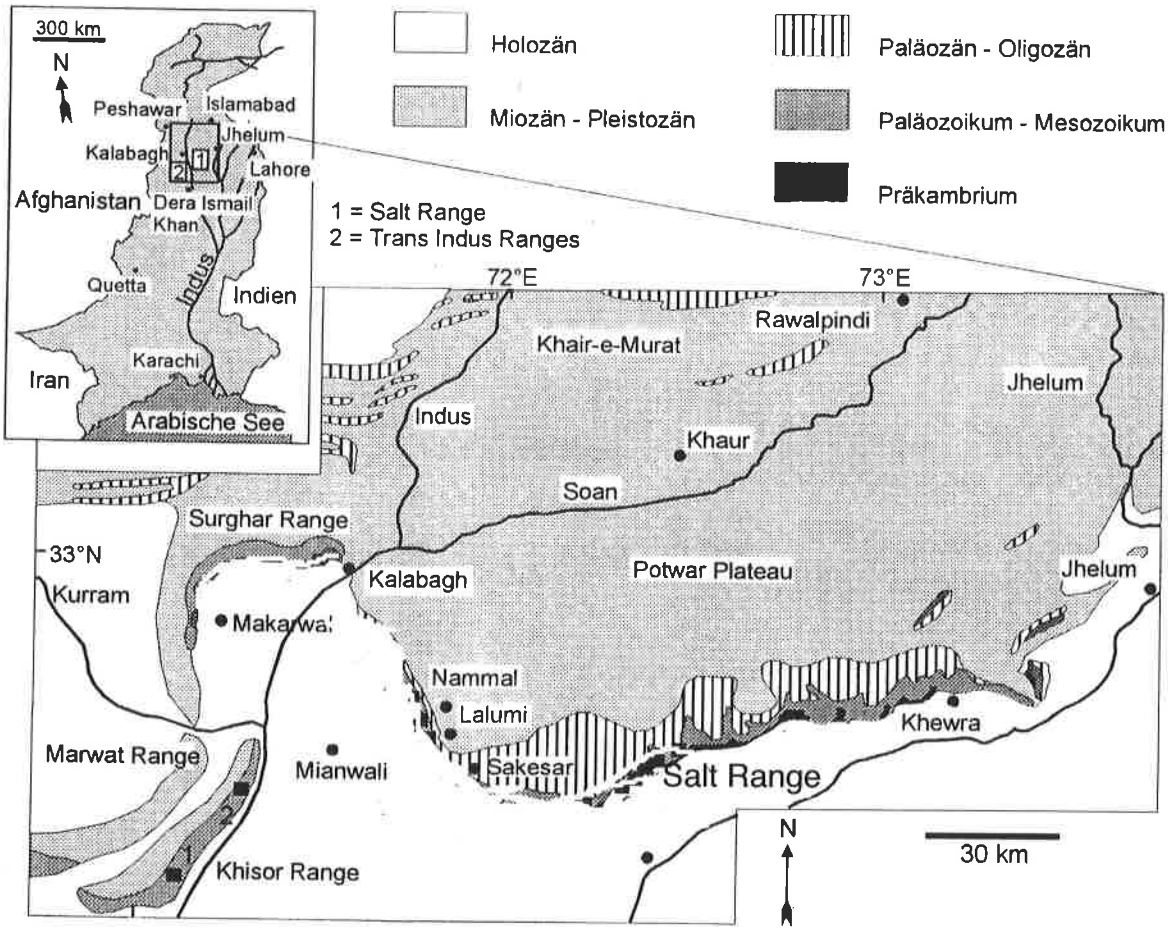


Fig. 1.7.1 Localization of Nammal section (modified from Mertmann, 1999)

	Series	GSSP stages	Tethyan stages	Salt Range (Pakistan) fusulinids	small foraminifers	algae
Permian sup.	Lopingian	Changhsingian	Dorashamian	Reichelina Codonofusiella Nankinella Staffella	Paraglobivalvulinoides Paraglobivalvulina Colaniella Paradagmarita Rectostipulina Cyclogyra Dagmarita Baisalina Globivalvulina Robuloides Lasiodiscus	Atractyliopsis Mizzia Gymnocodium Permocalculus Tubiphytes
		Wuchiapingian	Djulfian			

Fig. 1.7.2 Faunal association table of the Salt Range (Pakistan).

List of foraminifers and algae of the Salt Range (Pakistan)

Earlandia sp.
Eotuberitina reitlingerae MIKLUKO-MACLAY
Tuberitina sp.
Climacammina sp.
Deckerella sp.
Abadahellah sp.
Colaniella ex.gr. *parva* (COLANI)
Colaniella ex.gr. *lepida* (WANG)
Geinitzina ex.gr. *postcarbonica* (SPANDEL)
Geinitzina primitiva POTIEVSKAIA
Geinitzina reperta BYKOVA
Geinitzina uralica SULEIMANOV
Langella çukurkoyi SELLIER de CIVRIEUX & DESSAUVAGIE
Langella ocarina SELLIER de CIVRIEUX & DESSAUVAGIE
Nodosaria armeniensis EFIMOVA
Nodosaria longissima SULEIMANOV
Protonodosaria praecursor GERKE
Pachyphloia ex.gr. *ovata* (LANGE)
Pachyphloia pedicula LANGE
Pachyphloia iranica BOZORGNIA
Pseudotristix solida REITLINGER
Robuloides lens REICHEL
Robuloides gibbus REICHEL
Frondina permica SELLIER de CIVRIEUX & DESSAUVAGIE
Ichtyolaria latilimbata SELLIER de CIVRIEUX & DESSAUVAGIE
Dagmarita chanakchiensis REITLINGER
Paradagmarita sp.
Globivalvulina kantharensis REICHEL
Globivalvulina ovata CUSHMAN & WATERS
Globivalvulina vonderschmitti REICHEL
Paraglobivalvulina mira REITLINGER
Paraglobivalvulina mira var. *gracilis* (ZANINETTI & ALTINER)
Agathammina sp.
Agathammina pusilla (GEINITZ)
Baisalina pulchra REITLINGER
Cyclogyra sp.
Hemigordius ssp.
Hemigordius renzi REICHEL
Meandrospira sp.
Planinvoluta sp.
Pseudovermiporella nipponica (ENDO)
Neoendothyra sp.
Codonofusiella sp. and ex. gr. *kwangsania* SHENG
Minojapanella sp.
Nankinella sp.
Nanlingella sp.
Reichelina media MIKLUKO-MACCLAY
Staffella sp.
Staffella zisonghzengensis (SHENG)
Gymnocodium bellerophontis (ROTHPLETZ)
Mizzia sp.
Tubiphytes obscurus MASLOV
Rectostipulina quadrata JENNY- DESHUSSES

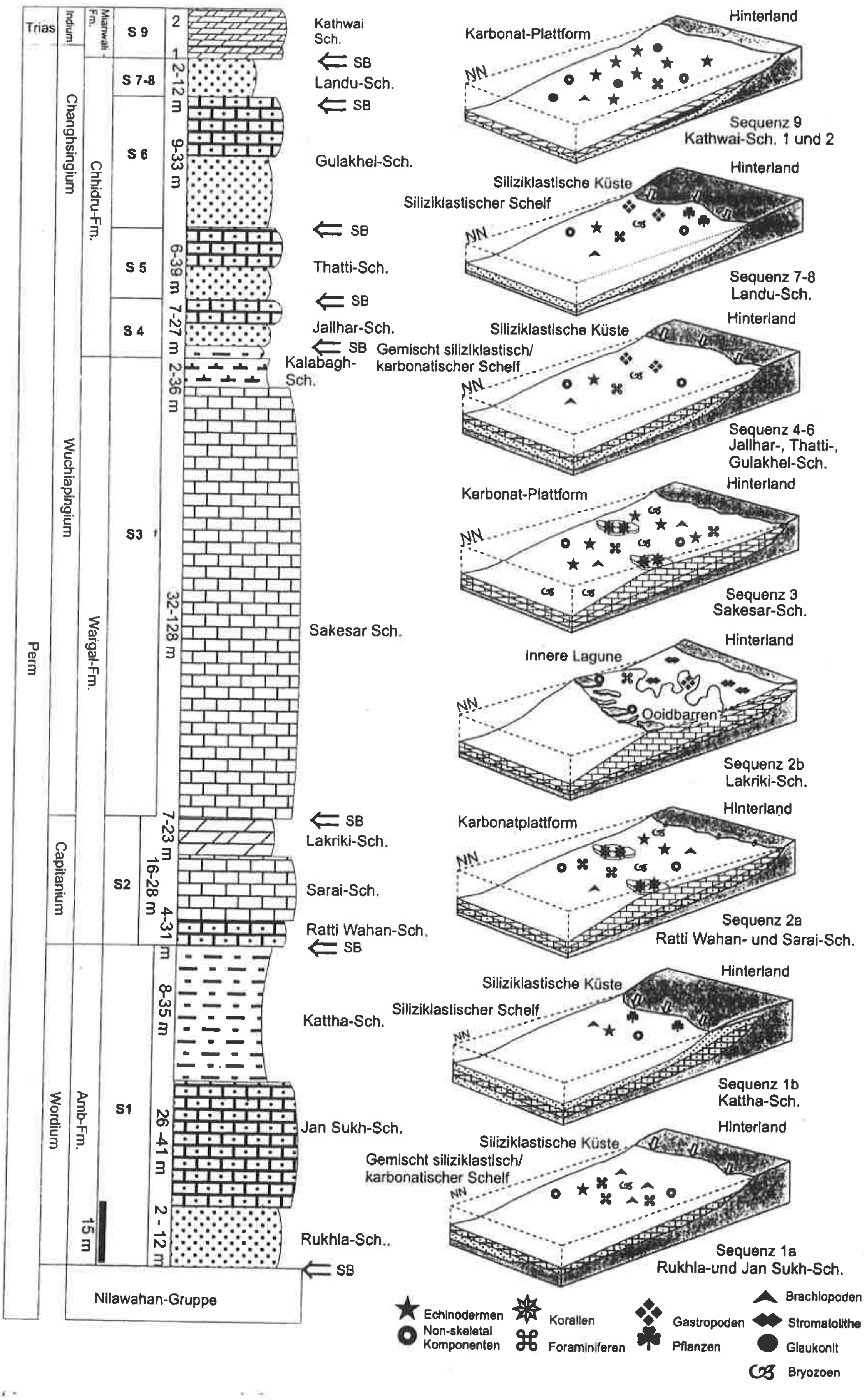


Fig. 1.7.3 Synthetic log and facies modell of Zaluch group (from Mertmann, 1999).

Nammal

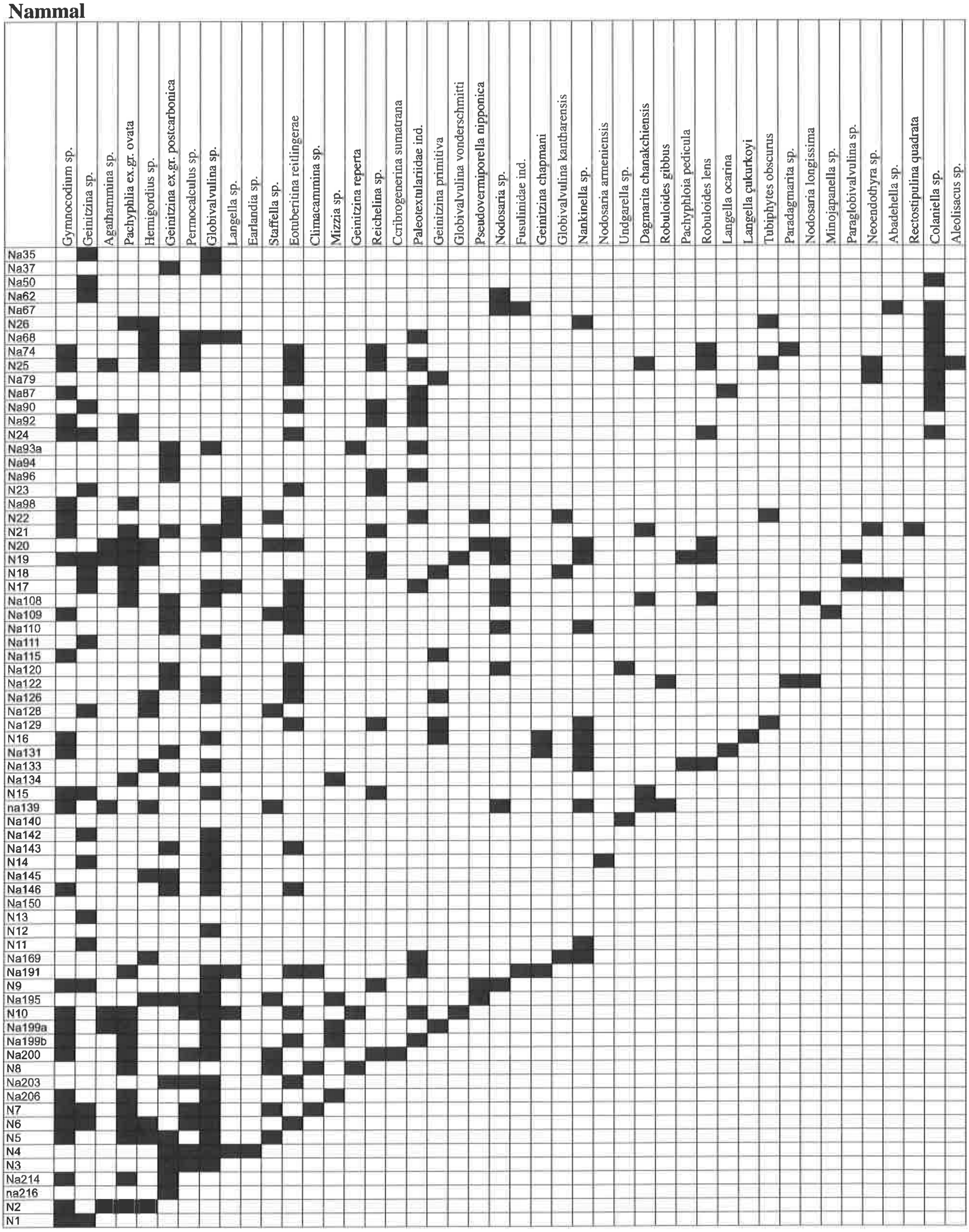


Fig. 1.7.4 Faunal inventory of Nammal section (Salt Range, Pakistan). Sample nummers are in reference of the section published in Baud et al., 1996 and Atudorei 1999.

NAMMAL SECTION

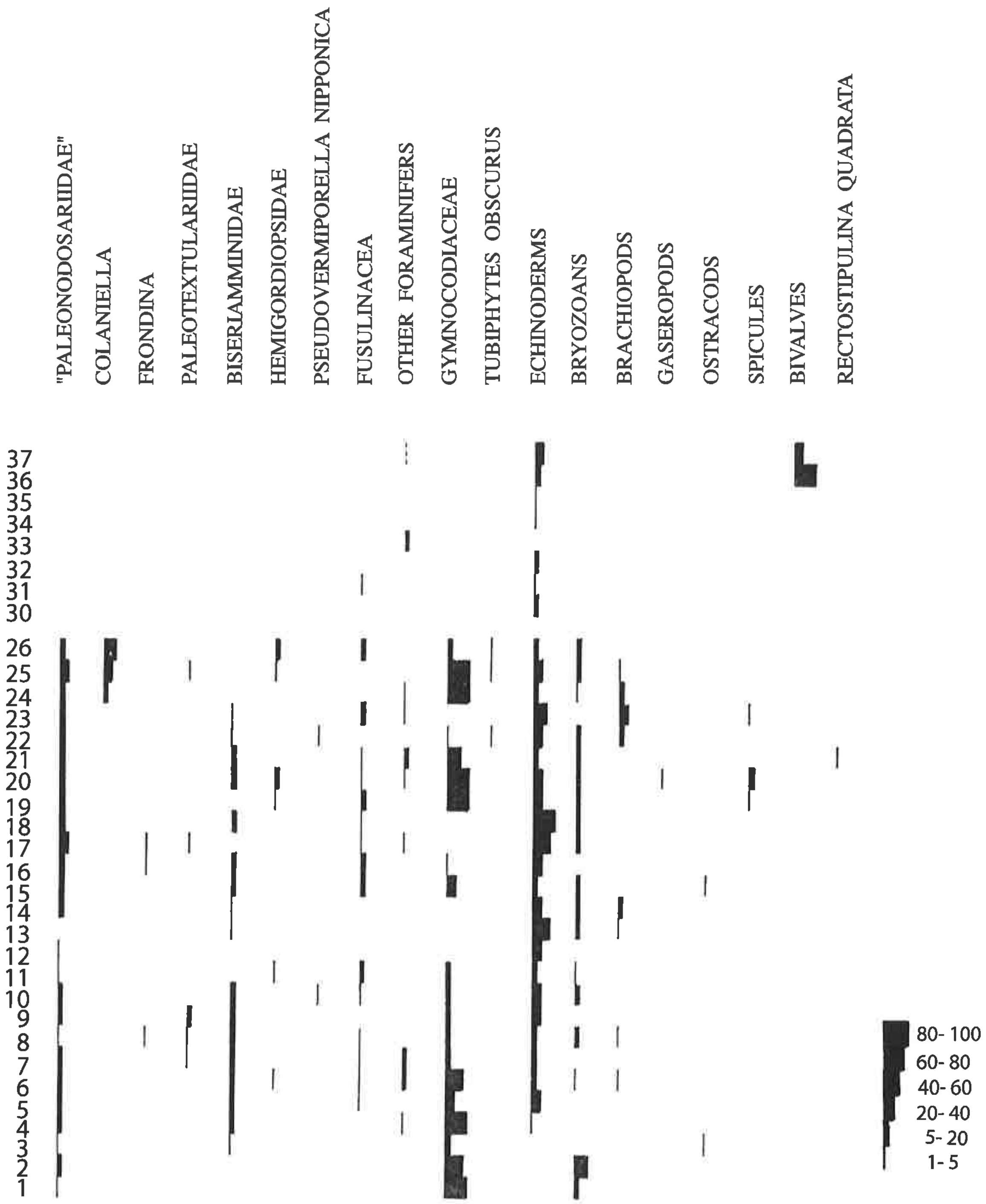


Fig. 1.7.5 Estimation table (%) of the main bioclasts in Nammal section (Salt Range Pakistan). Sample nummers are in reference of the section published in Baud et al., 1996 and Atudorei, 1999.

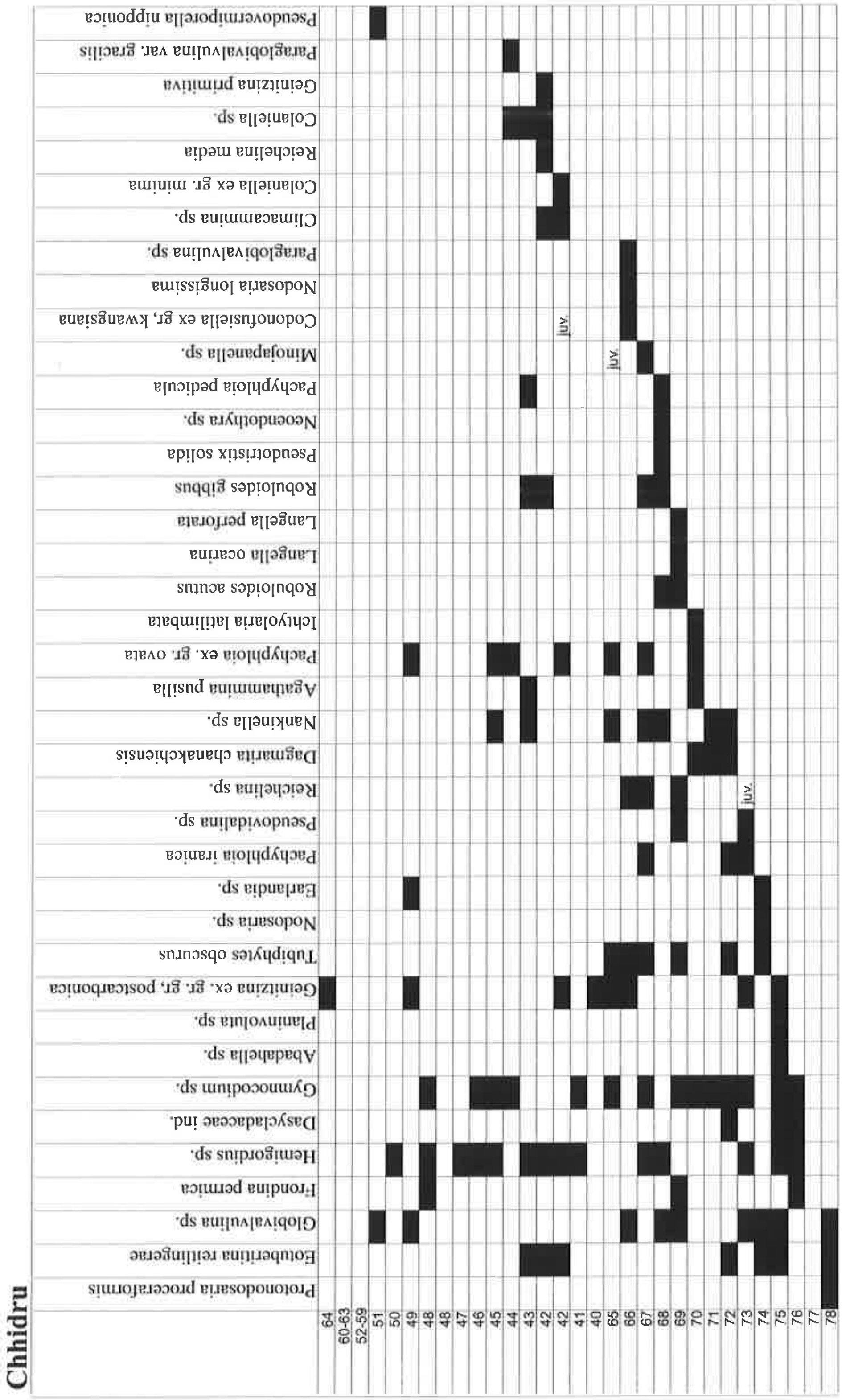


Fig. 1.7.6 Faunal inventory of Chhidru section (Salt Range, Pakistan). Unfortunetly, no log of the Chhidru section is available.

CHHIDRU SECTION

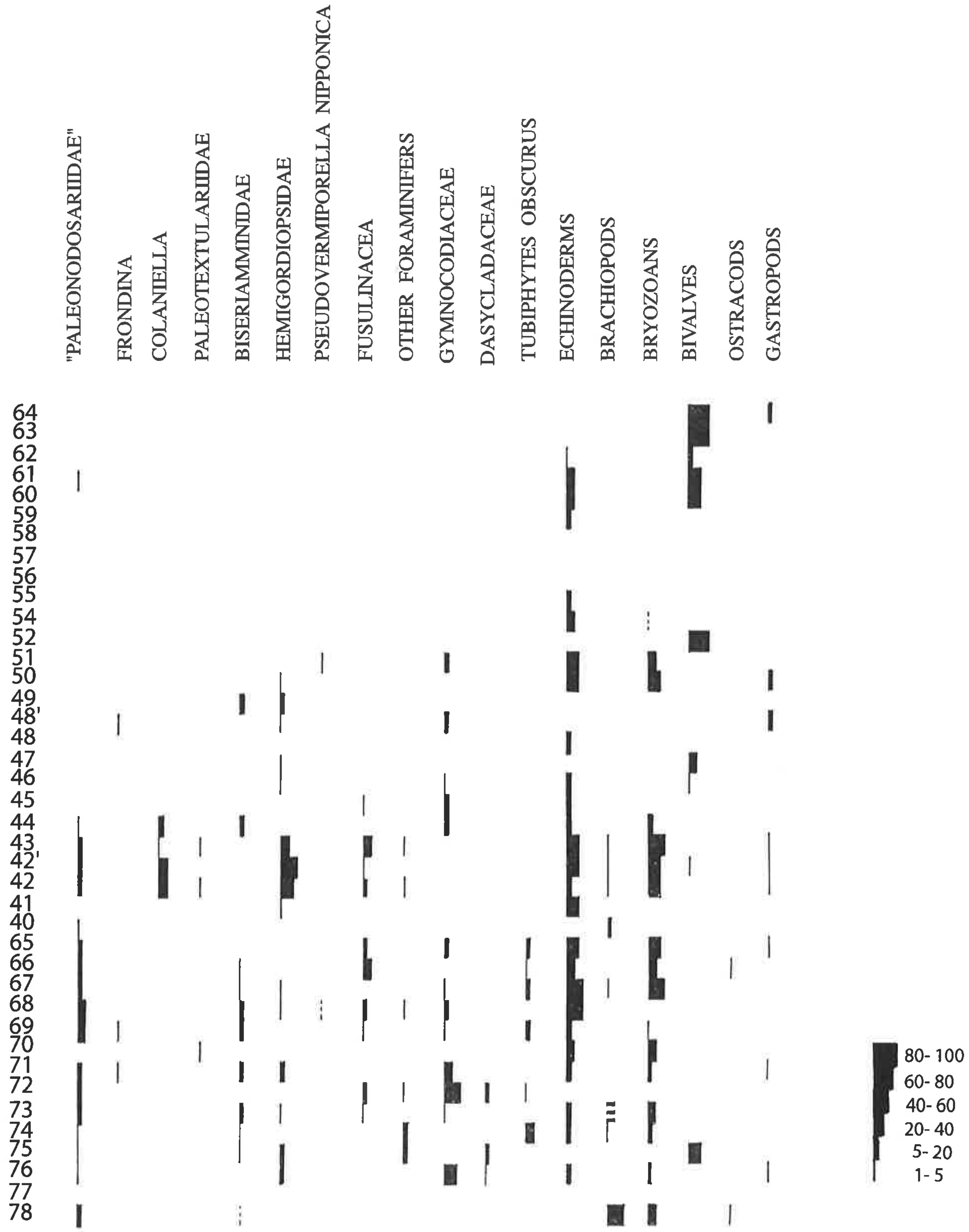


Fig. 1.7.7 Estimation table (%) of the main bioclasts in the Chhidru section (Salt Range, Pakistan).

Micropaleontological remarks on Permian deposits in the Salt Range (Pakistan)

« Paleonodosariidae »

Individuals of this group have been observed all along the sections of Nammal and Chhidru. We can notice the presence of the species *Colaniella* ex. gr. *minima* (WANG), *C.* ex.gr. *lepida* (WANG) (Pl. 12, fi. 7). and *C.* ex.gr. *parva* (COLANI) (Pl. 12, figs. 1, 3), though the sandy lithofacies.

Biseriamminidae

Every genera of this group are present but there are represented only by few individuals, (especially *Paraglobivalvulinoides septulifer* ZANINETTI & JENNY-DESHUSSES). Some individuals of *Paraglobivlavulina mira* REITLINGER show the typical thin wall feature which could be considered as a variety: *Paraglobivalvulina mira* var. *gracilis.*

Hemigordiopsidae

Few representative individuals and species corresponding to this group have been inventoried.

Fusulinacea

The presence of *Codofusiella* ex. gr. *kwangsiana* SHENG is noteforthy. This species is found in the same representative sections as those observed in the deposits of the Sovetachen and Vedi sections in Armenia (Pl. 7, fig.2; Pl.12, fig. 2). Nevertheless, this species is associated with Colaniellids in the Salt Range deposits, when Colaniellids have not yet surely been observed in Armenia.

Calcareous algae

Many individuals of the Gymnocodiaceae have been indexed in the Nammal section but very few in the Chhidru section. It could be that the sandy sedimentation of the Late Permian Chhidru Formation was not favorising algal living conditions.

Biofacies

Sandy sedimentation characterizes the Late Permian deposits in the Salt Range area. But it seems that at this location, this features affect less the benthic foraminifers diversity than in the sandy deposits of the Late Permian Miras Formation (Hydra Island, Greece).

Plate 12

Fig. 1 : Microfacies with quartz and *Colaniella* ex.gr. *parva* (COLANI), G 44, Salt Range, Chhidru section..

Fig. 2 : *Codonofusiella* ex. gr. *kwangsiana* SHENG, C 66, Salt Range, Chhidru section.

Fig. 3 : *Colaniella* ex.gr. *parva* (COLANI), G 44, Salt Range, Chhidru section.

Fig. 4 : *Robuloides lens* REICHEL, C 69, Salt Range, Chhidru section.

Fig. 5 : *Pseuditristix* sp., C 68, Salt Range, Chhidru section.

Fig. 6 : *Geinitzina uralica* SULEIMANOV, C 68, Salt Range, Chhidru section.

Fig. 7 : *Colaniella* ex. gr. *lepida* (WANG), N 26, Salt Range, Nammal section.

Fig. 8 : *Quasifusulina* sp., Na 191, Salt Range, Nammal section.

Fig. 9 : *Climacammina sphaerica* POTIEVSKAIA, Na 200, Salt Range, Nammal section.

Scale : Fig. 1, 2, 3, 6, 7, 8, 9 = 500 μm
Fig. 4, 5 = 100 μm

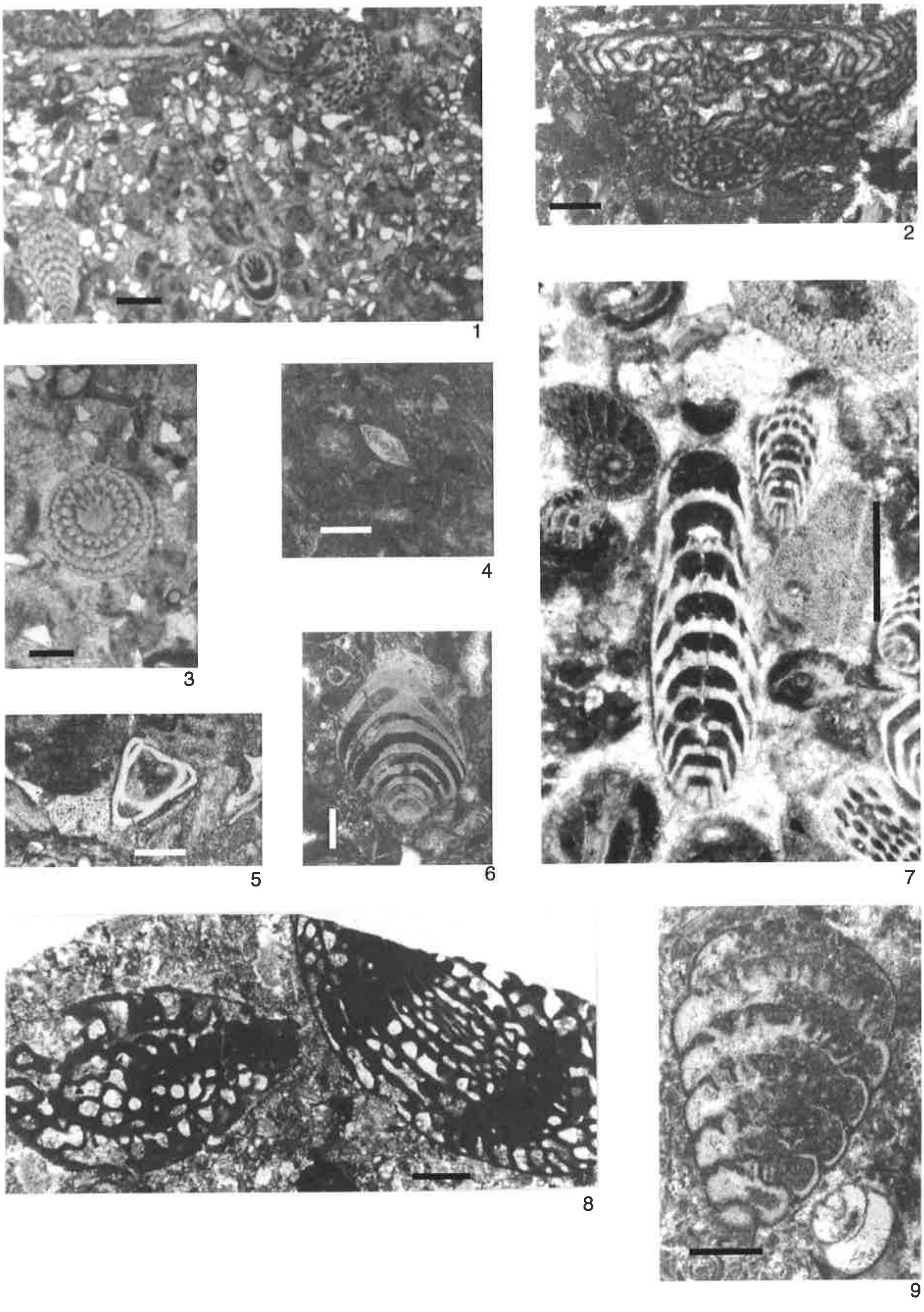


Plate 12

1. 8 South China

Introduction

The three sections studied in this paper illustrate the Upper Permian until the Permo-Triassic Boundary. Samples have been collected during many field trips. We reproduce here a work made around 1980. Shangsi and Meishan have along tradition of studied further developped in the aim of the Permian Triassic GSSP in Meishan.For further description and discussion please refere to : Deprat, 1912; Colani, 1924; Chen, 1934; Wang 1966; Baud et al., 1989; Lin et al., 1990; Yang et al., 1993; Jin et al., 1994; 2000; 2003; Stanley and Yang 1999; Tong and Shi, 2000; Yin et al., 2000; 2001; Tong 2004 and for an up to date state of the art Yin et al., 2007 and Gaillot and Vachard 2007 and reference herein.
Langfenya section is situated in the Sechouan province, near Shangsi.

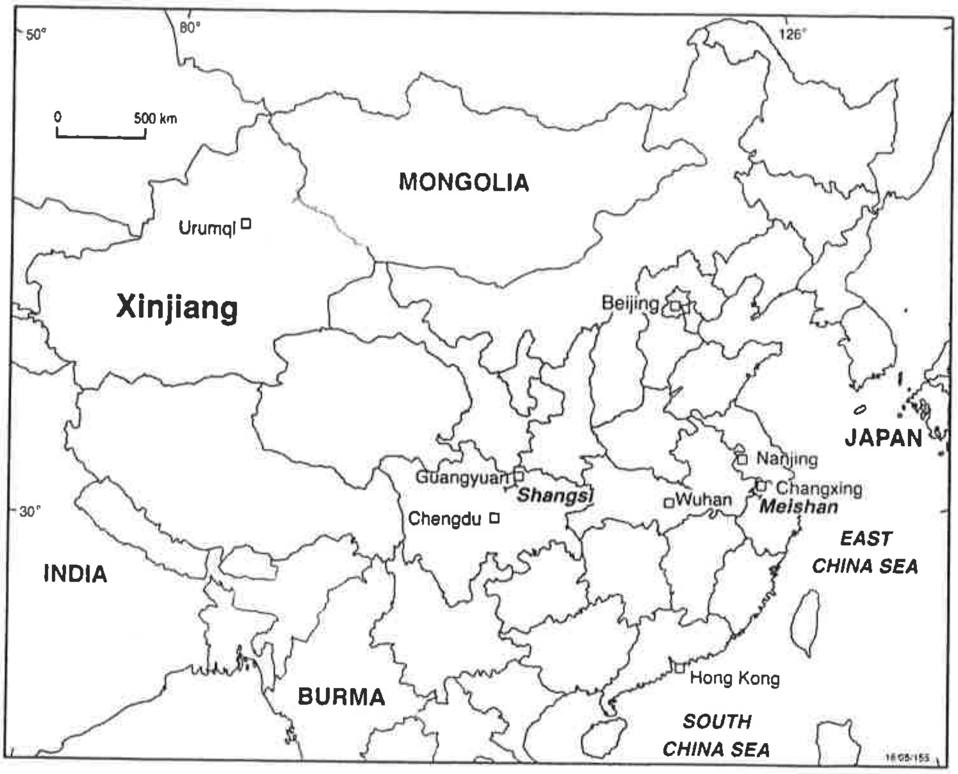


Fig. 1.8.1 Localization of Meishan and Shangsi sections.

	Series	Stages GSSP	Tethyan stages	China : Meishan fusulinids	small foraminifers	algae
Permian sup.	Lopingian	Changhsingian	Dorashamian	Paleofusulina Reichelina Codonofusiella Nankinella Staffella Boultonia	Colaniella Paraglobivalvulina Rectostipulina Dagmarita Baisalina Globivalvulina Robuloides Abadahella	Mizzia Gymnocodium Permocalculus Tubiphytes
		Wuchiapingian	Djulfian			

Fig. 1.8.2 Faunal association table of South China.

List of foraminifers and calcareous algae of South China

Eotuberitina reitlingerae MIKLUKO-MACLAY
Tuberitina sp.
Climacammina sp.
Cribrogenerina sp.
Tetrataxis sp
Calvezina ottomana S. de CIVRIEUX & DESS.
Colaniella ex gr. *parva* (COLANI)
Geinitzina ex gr. *postcarbonica* (SPANDEL)
Geinitzina reperta BYKOVA
Langella sp.
Pachyphloia ex gr. *ovata* (LANGE)
Pachyphloia pedicula LANGE
Robuloides lens REICHEL
Robuloides gibbus REICHEL
Frondina permica S. de CIVRIEUX & DESS.
Ichtyolaria latilimbata S. de CIVRIEUX & DESS.
Dagmarita chanakchiensis REITLINGER
Paradagmarita monodi LYS & MARCOUX
Globivalvulina sp.
Paraglobivalvulina mira REITLINGER
Paraglobivalvulina mira var. *gracilis* (ZANINETTI & ALTINER)
Agathammina sp.
Hemigordius ssp.
Hemigordius reicheli LYS
Meandrospira sp.
Planinvoluta sp.
Pseudovermiporella nipponica (ENDO)

Schubertella sp
Boultonia willisi LEE
Codonofusiella golubinensis SOSNINA
Paleofusulina sinensis SHENG
Paleofusulina ellipsoidalis SHENG
Nankinella sp.
Reichelina media MIKLOKO- MACLAY

Gymnocodium bellerophontis (ROTHPLETZ)
Permocalculus sp.
Tubiphytes obscurus MASLOV

Rectostipulina quadrata JENNY- DESHUSSES

LANGFENYA SECTION

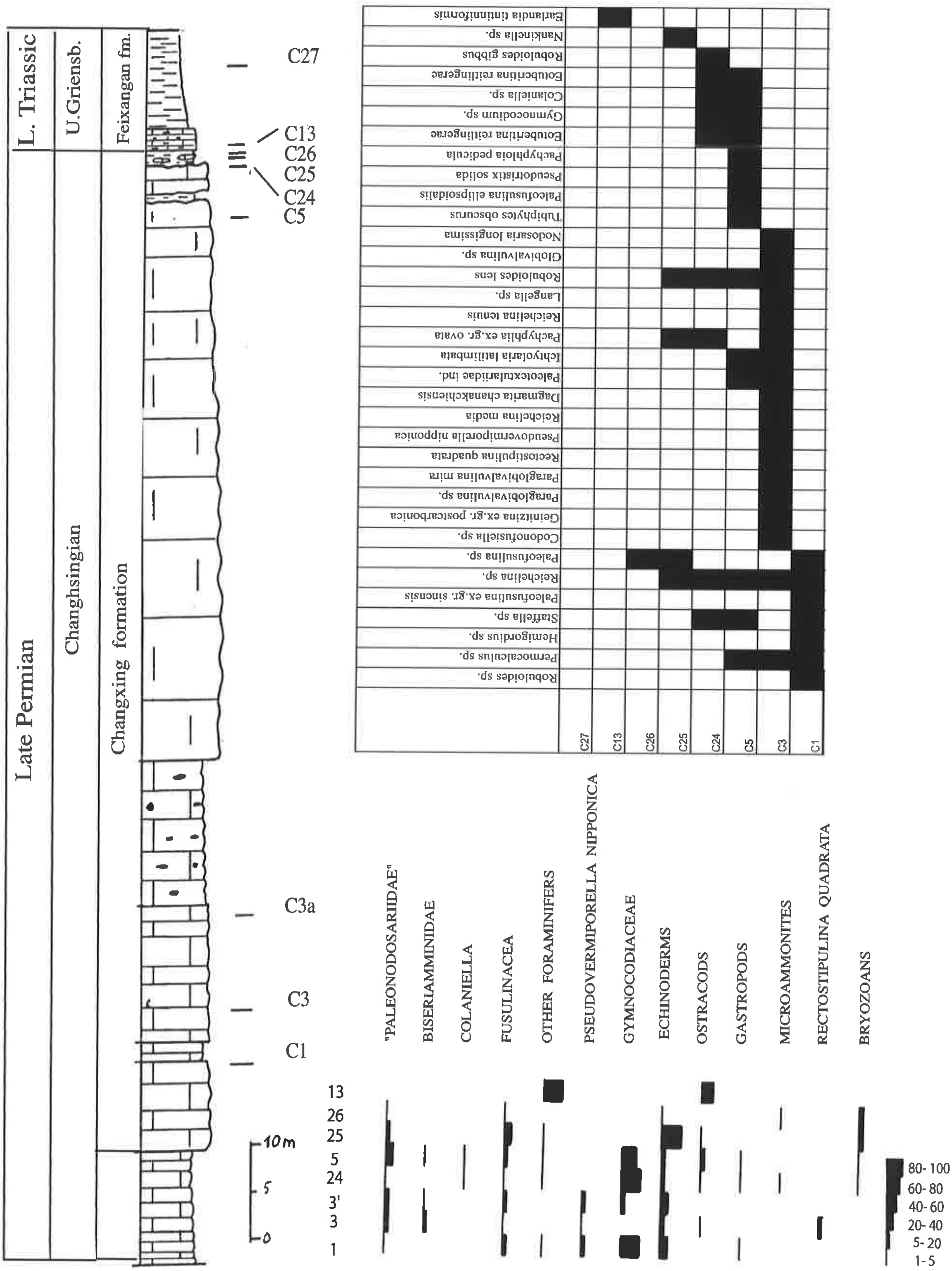


Fig. 1.8.3 Langfenya section : log, faunal inventory and estimation (%) table of the main bioclasts.

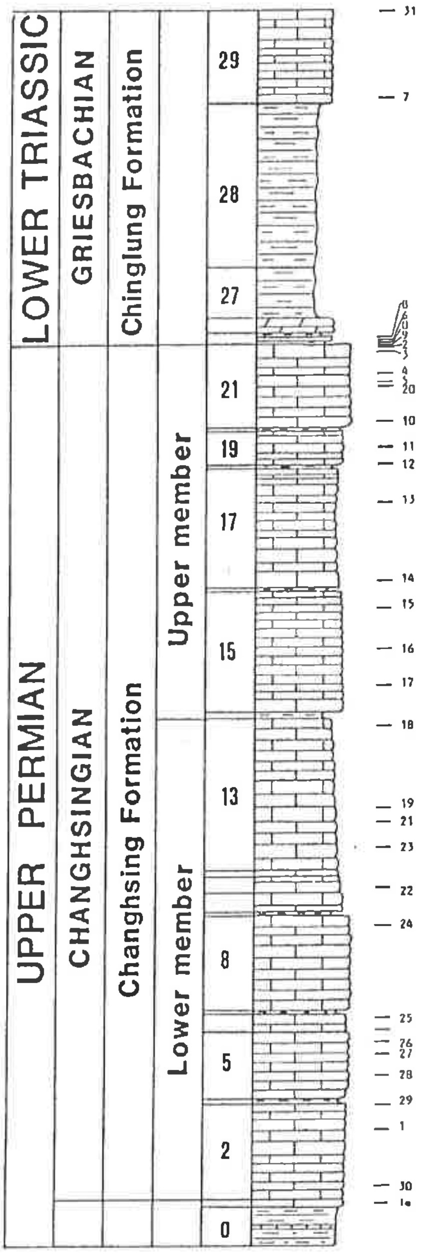


Fig. 1.8.4 : Meishan section
(Baud et al., 1989)

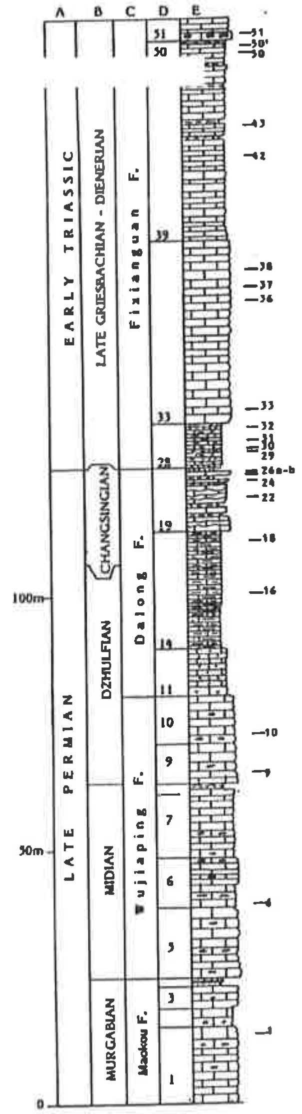


Fig. 1.8.5 : Shangsi section
(Baud et al., 1989)

Shangsi

	Eotuberitina reitlingerae	Paleotextulariidae ind.	Cribrogenenrina sp.	Pachyphloia ex gr. ovata	Paraglobivalvulina sp.	Neoendothyra sp.	Hemigordius sp.	Boultonia willisi	Gymnocodium sp.	Nankinella sp.	Tetrataxis sp.	Geinitzina ex gr. postcarbonica	Dagmarita chanakchiensis	Globivalvulina sp.	Ichtyolaria latilimbata	Codonofusiella sp.	Reichelina sp.	Paraglobivalvulina mira	Pseudovermiporella nipponica	Schubertella sp.	Staffella sp.	Paleofusulina sp.	Nodosaria sp.
22						■	■																■
18																							
16																							
10					■				■			■	■		■	■					■	■	■
9									■	■							■	■	■	■	■		
6		■		■			■		■		■	■	■	■	■	■	■						
1	■	■	■	■	■	■	■	■	■	■													

Fig. 1.8.6 Faunal inventory of Shangsi section (South China).

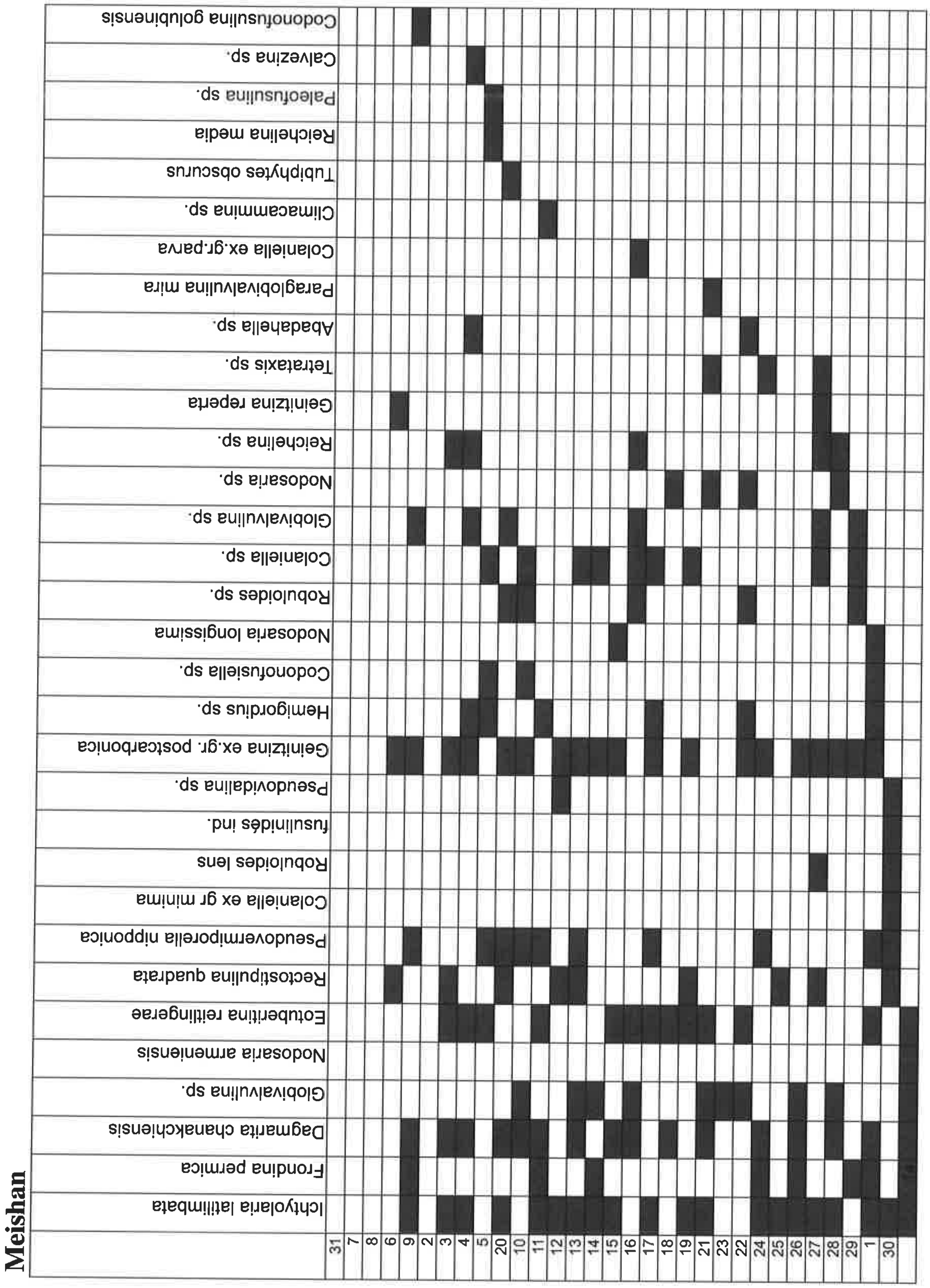


Fig. 1.8.7 Faunal inventory of Meishan section (South China).

Micropaleontological remarks on Permian deposits in South China

« Paleonodosariidae »
The index taxon *Colaniella* ex.gr. *parva* (COLANI) illustrates the Late Permian in South China, though individuals are not so numerous and often strongly recrystallized (Pl.13, fig. 3). Other taxa of this group often present dwarf forms, even just below the PTB.

Biseriamminidae
Only *Dagmarita*, *Globivalvulina* and *Paraglobivlavulina* are present in this group. *Paradagmarita* and *Paraglobivalvulinoides* are missing.
Globivalvulina and *Paraglobivalvulina* show often aberrant forms, especially in the Late Permian deposits of the Meishan section. We have already demonstrated that this phenomenon might point to a great stress disturbing usual environmental conditions (Jenny & Guex, 2005). This fact is observed in levels D13 and D17 in the section of Meishan, as well as in deposits of the Shangsi section.

Hemigordiopsidae
Few individuals and few species for this group, which also present dwarf forms.

Fusulinacea
Paleofusulina ex.gr. *sinensis* (SHENG) assigns a Changsinghsian age for the deposits of the Langfenya section (Pl. 13, fig. 6). Even though no section of this taxon was observed in our material from the Meishan section, it has been well studied by international scientists. We therefore don't need to add any comments.

Biofacies
Generally speaking, microfacies of our material of South China are very recrystallized. Bioclasts present often clear parallel orientation under microscopic observation.
In comparison with other areas such as Greece, faunal assemblages contain few in individuals (often dwarf forms as already noticed) as well as little diversity of species.

Plate 13

Fig. 1 : *Abadahella* sp., D4, Meishan section.

Fig. 2 : *Boultonia willisi* LEE, S1, Shangsi section.

Fig. 3 : *Colaniella* ex.gr. *parva* (COLANI), D 20, Meishan .

Fig. 4 : *Robuloides lens* REICHEL, C 25, Langfenya section.

Fig. 5 : *Paraglobivalvulina mira* var. *gracilis*, aberrant form, Wn 169, Wuchaping section.

Fig. 6 : *Paleofusulina* ex. gr. *sinensis* SHENG, C 1, Langfenya section.

Fig. 7 : Microfacies, S 9, Shangsi section.(a) *Nanlingella* sp., (b) *Paleofusulina* sp.

Fig. 8 : *Reichelina* sp.,C 25, Langfenya section.

Fig. 9 : *Earlandia tintinniformis* (MISIK), C 13, Langfenya section.

scale : Fig. 4, 9 = 100 µm
Fig. 1, 2, 3, 5, 6, 7, 8 = 500 µm

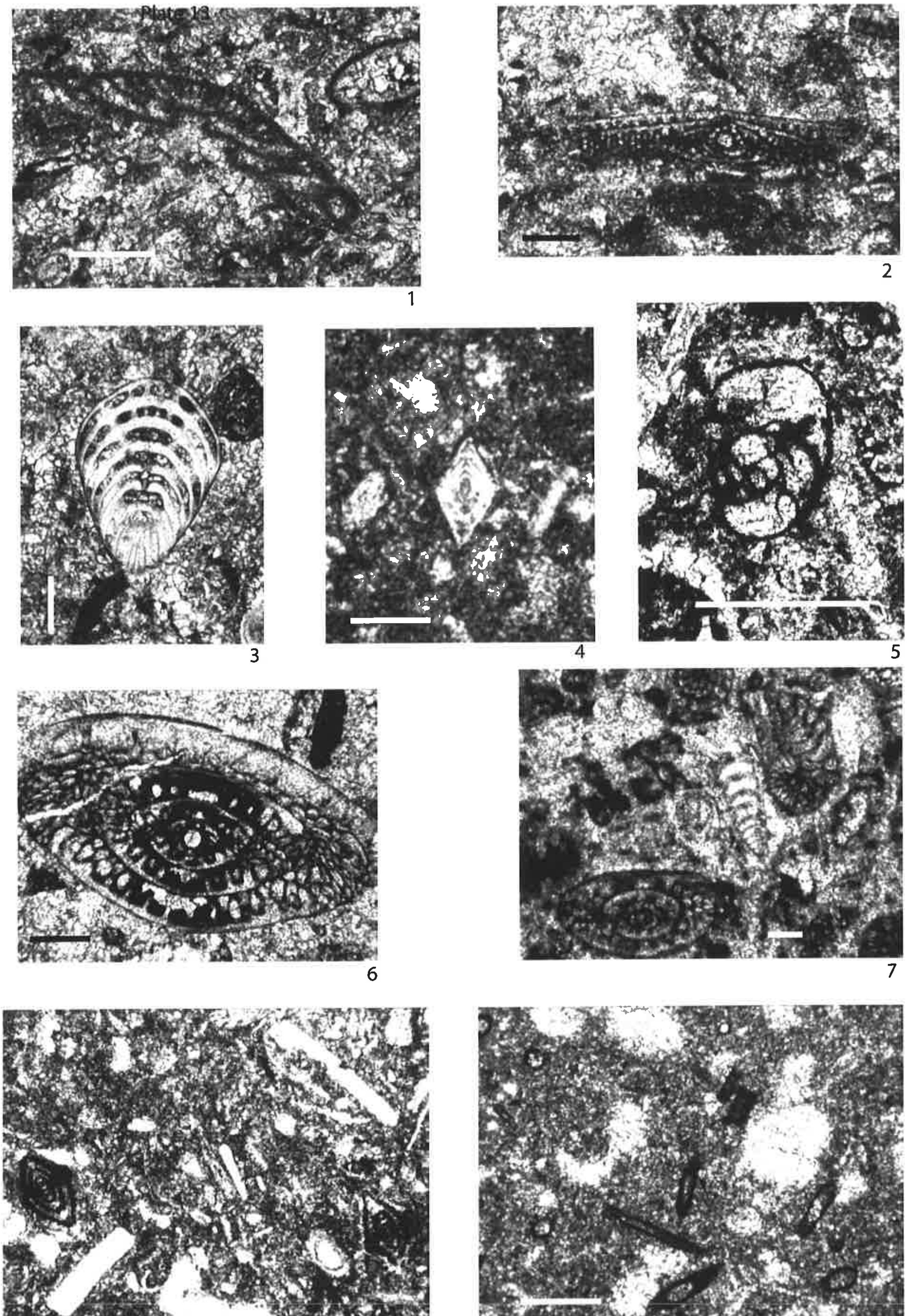


Plate 13

1. 9 Conclusions

This inventory allows us to make some remarks and interpretations on the different observed groups and taxa of Permian foraminifers.

"Paleonodosariidae"
Individuals of this group are present in each area from the Early Permian to the Upper Late Permian in the Tethyan realm.
No other species than Colaniella (COLANI) show a sufficient evolutive trend to be used in precise biozonation.
Nevertheless, inviduals of this group have the particularity of developing dwarf forms in the Upper Late Permian deposits. "Paleonodosariids" share this feature with the taxon Hemigordius. Dwarf forms seem to represent a Permian relict fauna, often in assocation with ostracods and/ or bivalves.
Estimation tables of the different bioclasts, especially in Southern Alps and South China reveals that dwarf forms characterizes the last typical Permian foraminifers (see Jenny and Guex, 2005 for more details). Recent studies (Abramovitch & Keller, 2003) show that dwarf forms could be due to a warm event or an increase in temperature of the sea water.
The presence of Cyclogyra in the Upper Late Permian deposits tends to go unoticed because of its small size.

Biseriamminidae
We noticed that taxa of this group evolve rapidely and have a large paleogeographical spread.
Once again, we insist on the great evolutionary trend of the *Globivalvulina-Paraglobivalvulina-Paraglobivalvulinoides* series (Jenny-Deshusses, 1983, 1988, 2002). This trend allows reliable biozonation, even when the usual foraminifers index -the fusulinids- are missing.
Furthermore, we have already shown (Jenny & Guex, 2005) that this series gives us an indication of the great environmental stress during the Late Permian before the PTB by developing aberrant forms.
All the taxa of this group have been observed in almost each area in the Tethyan realm. The large number of individuals of the taxon *Paragmarita* LYS & MARCOUX in the deposits from the Taurus Belt in Turkey should be stressed. This gives a typical Late Permian biofacies in this area.

Hemigordiopsidae
In contrary to the genus *Hemigordiopsis* which presents a characteristic coiling, the genus *Hemigordius* shows many different types of coiling more or less similar to a ball of wool. In thin sections, this king of coiling gives many different variations of figure, too many to establish clear different species. Therefore we decided to call these sections *Hemigordius* ssp.
For the same reason, we think that this group is not helpful for biostratigraphy, except *Hemigordiopsis* REICHEL and *Shanita* BRONNIMANN, WHITAKER & ZANINETTI. Both taxa are locally helpful in Late Permian age assignment (Jenny &Stampfli, 2000).
Some biofacies are characterized by numerous individuals of the genus Hemigordius, especially in the Middle Permian Marmari Formation in Hydra Island in Greece and in the Middle Permian deposits of Chios Island in Greece. We think, that it gives evidence for a restricted environment. The presence of numerous individuals of *Hemigordius* can thus help for environmental interpretation, more than for biostratigraphy.

Fusulinacea
We almost always observed numerous Staffellidae in restricted biofacies characterized by Hemigordius ssp.
We exposed our difficulties in finding well-oriented sections of index taxa belonging to the Fusulinacea group and stress once again the need for a major review of this group.
The maps presented in Part 3 illustrate well the features that the different taxa of this group characterize the different studied area.
Even though the genus Reichelina ERK has a long stratigraphical range, this taxon is often the last one of this group present in the Upper Late Permian deposits (Greece, Salt Range Pakistan for example). This is not very useful for age assignment, but reveals a large tolerance in different environmental conditions except for dolomite.

In conclusion:

- the main general evolutionary trend for the Permian foraminifers is the increase in the test evolution (Jenny, 2002).
- "Paleonodosariidae" and the Hemigordiopsidae present dwarf forms in the Upper Late Permian deposits, and are thus considered as relicted fauna, occuring after the disappearance of larger taxa such as *Hemigordiopsis*, *Paraglobivlavulina* and *Paraglobivalvulinoides* and of fusulinids.
- three taxa of the Biseriamminidae offer a very good evolutionary trend to offset the rareness or the absence of fusulinids: the *Globivlavulina-Paraglobivalvulina-Paraglobivalvulinoides* series.
- this series is followed by the apparition before the PTB of some individuals with aberrant forms, indication of great stress in their environment conditions (Jenny & Guex, 2005).
- in each area studied some charateristic sequences of foraminifers and calcareous algae associations can be defined, enabling good local biostratigraphy. But benthic Permian foraminifers are probably better indicators for environmental conditions and variations. These faunal associations are very useful for paleogeographic reconstructions (Part 3). In this instance, indicating the genera names is precise enough, especially for fusulinids.
- to obtain a reliable global biostratigraphy, it is necessary to reduce the number of used taxa and to avoid a too important and useless splitting of species.

2. Biostratigraphy

by Catherine Jenny and Jean Guex

2.1 Introduction

After the inventory, data were to numerous for reliable biostratigraphic correlations. Moreover, the absence of fusulinids in the studied sections as age index could not help for biostratigraphic correlations. Furthermore, some defined biostratigraphically section presented special and numerous differences in paleontologic contents with other well-defined biostratigraphically section. It seems moreover that there was a strong endemism. We thus tried mathematically to deciphere some useful biostratigraphic trends.

2.2 Method

The Biograph program known as Unitary Association Method (UAS) is a deterministic mathematical model designed to construct concurrent range zones. The method was described in detail in Savary and Guex (1999). The method establish discrete sequences of interval of species coexistence by making cyclic relationships between determined taxa in different biostratigraphical sequences and is able to process numerous data. The observed inter-species coexistences are compiled in a species-species matrix and then organized by a permutation of rows and columns to allow the appearance of sets of mutually coexisting species. From this reorganized matrix, it is possible to extract maximal sets of intersecting species ranges and represent them in a table called UA range chart. This chart is used to go back to the data and assign relative age or determine coexistence range zones to the fossiliferous beds of the studied lithological sections.

Biograph Computer Program is a powerful tool to obtain results when coorelations are difficult and particularly when taxa are not in constant stratigraphical position with each other, as it was frequent in our studies. This program tested with success other fossil groups like ammonites, radiolarians or diatoms.

In pratical terms, after the biostrtigraphic inventory (see Part 1), the most important taxa are choosed and numbered. We keep 157 taxa from our inventory, named 1 to 157 (Table 2.1). It was necessary to be restrictive to guarantee success for the analysis. In this sense oversplitting make choice more difficult. The second step is to number every levels in every lithological sections from 1 to X. Every level correspond to a sample. For example, in the Rudbarak section (Alborz Mountains, Iran) the lower sample n. 354 is the level 1, the upper sample n. 305 is the level 50, in stratigraphical order.

Finally the stratigraphical range of every taxa is determined and codified in every lithological section. We insist on the necessity of homogeny in the namings of species and repeat that it is certainly one of the most important advantage of our inventory.

At the time of processing, ten years ago, the calculation capacity of computer was at he limit to process all the data together. We tried however but the Biograph Program discriminated only four biozones with difficulty and more, reduced the 157 chosen species to only 71 !

We thus processed data area by area and obtain different biozones quite precise in stratigraphical succession.

List of foraminifers used in biograph programm :

1 Eotuberitina reitlingerae
2 Earlandia sp.
3 Lasiodiscus sp.
4 Climacamina valvulinoides
5 Deckerella sp.
6 Geinitzina sp.
7 Geinitzina gr, postcarbonica
8 Geinitzina primitiva
9 Geinitzina reperta
10 Geinitzina uralica
11 Langella sp.
12 Langella ocarina
13 Nodosaria armeniensis
14 Nodosaria longissima
15 Nodosaria postgeinitzi
16 Pseudolangella fragilis
17 Pseudotristix solida
18 Protonodosaria proceraformis
19 Pachyphloia sp.
20 Pachyphloia iranica
21 Frondina permica
22 Iflchtyolaria latilimbata
23 Robuloides gibbus
24 Robuloides lens
25 Dagmarita chanakchiensis
26 Globivalvulina sp.
27 Globivalvulina vonderschmitti
28 Paraglobivalvulina gracilis
29 Paraglobivalvulina mira
30 Paradagmarita monodi
31 Agathammina sp.
32 Cyclogyra mahajeri
33 Hemigordius sp.
34 Hemigordius permicus
35 Hemigordius reicheli
36 Pseudovermiporella nipponica
37 Neoendothyra parva
38 Neoendothyra reicheli
39 Codonofusiella inigua
40 Codonofusiella ex gr, kwangsiana
41 Codonofusiella sphaerica
42 Nankinella sp.
43 Reichelina cribroseptata
44 Schubertella sp.
45 Staffella sp.
46 Glomospira sp.
47 Gymnocodium sp.
48 Gymnocodium bellerophontis
49 Mizzia sp.
50 Tubiphytes obscurus
51 Rectostipulina guadrata
52 Rectocornuspira kahlori
53 Meandrospira sp.
54 Codonofusiella sp.
55 Reichelina sp.
56 Tetrataxis gr. conica
57 Baisalina pulchra
58 Atractyliopsis sp.
59 Mizzia cornuta
60 Mizzia velebitana
61 Earlandia tintinniformis
62 Pachyphlia gr. ovata
63 Calcitornella sp.
64 Hemigordius ovatus
65 Epimastopora sp.
66 Globivalvulina bulloides
67 Spirorbis. phlyctaena
68 Dasycladacées ind.
69 Climacammina elegans
70 Climacammina moelleri
71 Ccribrogenerina sumatrana
72 Paleotextularia sp.
73 Pseudovidalina ornata
74 Calvezina ottomana
75 Langella acantha
76 Langella conica
77 Langella perforata
78 Pachyphloia pedicula
79 Paleonubecularia sp.
80 Robuloides acutus
81 Neoendothyra sp.
82 Neoendothyra bronnimanni
83 Codonofusiella nana
84 Rugosofusulina truncata
85 Minojapanella sp.
86 Permocalculus sp.
87 Partisania sp.
88 Hemigordius padangensis
89 Planinvoluta sp.
90 Nankinella orbicularia
91 Staffella zisonghzengensis
92 Staffella sphaerica
93 Abadahella sp.
94 Colaniella ex gr minima
95 Colaniella ex gr lepida
96 Colaniella ex gr parva
97
98 Tetrataxis gr planulata
99 Colaniella sp.
100 Louisettita elegantissima-
101 Nodosaria sagitta
102 Boultonia willisi
103 Undgarella uralica
104 Globivalvulina graeca
105 Multidiscus sp.
106 Cancellina sp.
107 Gyroporella sp.
108 Tuberitina collosa
109 Neoschwagerina craticulifera
110 Neoschwagerina margaritae
111 Rausserella sp.
112 Chusenella tieni
113 Globivalvulina praegracilis
114 Pseudodoliolina sp.
115 Koivaella permiensis
116 Pseudoschwagerina sp.
117 Paleofusulina sp.
118 Paleofusulina gr. sinensis
119 Paleofusulina gr. minima
120 Paraglobivalvulina sp.
121 Paradoxiella sp.
122 Climacammina sphaerica
123 Globivalvulina kantharensis
124 Langella çukurkoyi
125 Dunbarula sp.
126 Paradagmarita sp.
127 Verbeekina sp.
128 Praesumatrina sp.
129 Climacammina sp.
130 Imperiella afghanensis
131 Lanchichites elegans
132 Geinitzina chapmani
133 Nanlingella sp.
134 Hemigordiopsis renzi
135 Schwagerina sp.
136 Pseudofusulina sp.
137 Anthracoporella spectabilis
138 Kahlerina sp.
139 Spiroplectammina sp.
140 Monodiexodina sp.
141 Endothyra sp.
142 Paraglobivalvulinoides septulifer
143 Codonofusulina golubinensis
144 Cyanophycées
145 Bradyina major
146 Pseudoreichelina sp.
147 Paleofusulina prisca
148 Paleofusulina fusiformis
149 Permocalculus plumosus
150 Codonofusiella schubertelloides
151 Sphaerulina sp.
152 Parafusulina multiseptata
153 Parafusulina ondulata
154 Polydiexodina afghanensis
155 Eopolydiexodina megasphaerica
156 Yangchenia sp.
157 Triticites montiparus
158 Shanita amosi

2.3 Conclusions

The luck of convincing global correlations by the Biograph Program is probably due to the strong controll on late Permian benthic fauna by environmental features like depth, marine currents, sea level, topography of sea bed, etc. As you wil read in part 3, the paleogeographic repartitions of chosen index taxa show that carbonate platforms were strongly reduced and parcelled out at the end of Permian time. This could partly explain the different faunal associations as isolated populations.

Oversplitting of taxa is probably a second problem in this time span. We should never forget that micropaleontology is above all a tool for the geology.

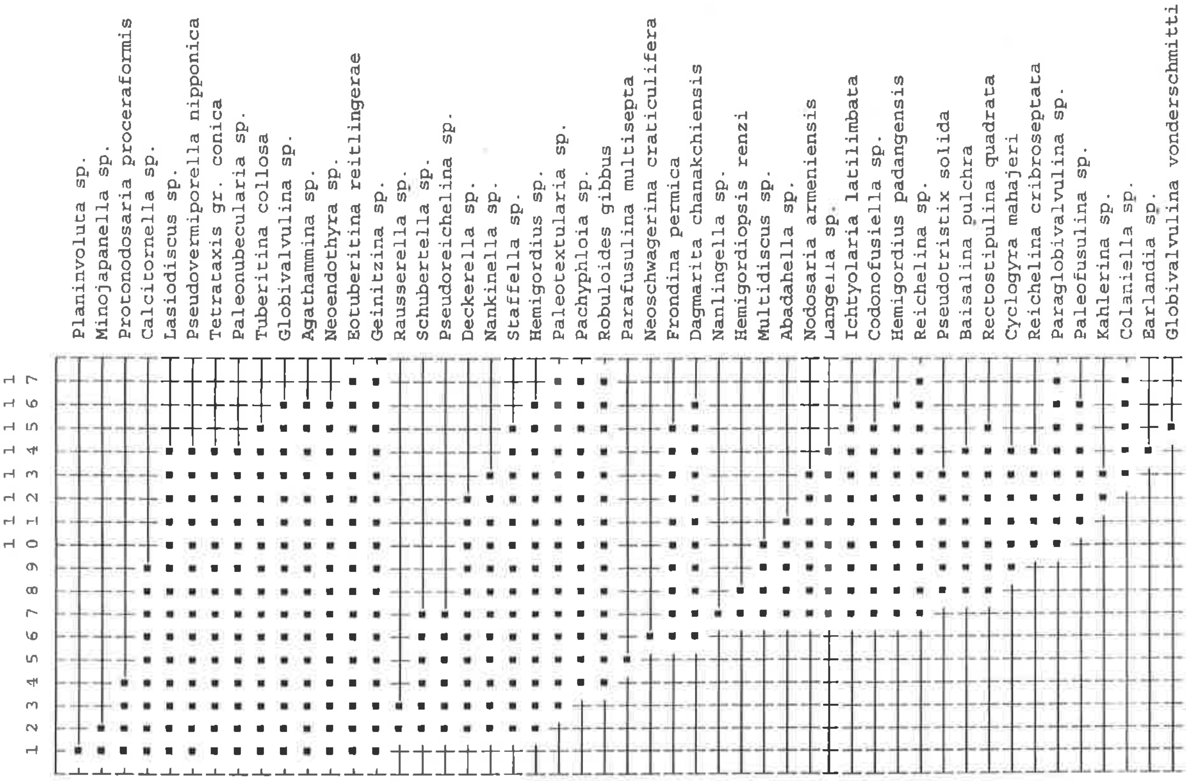


Fig 2.1 Range chart of Permian foraminifera and calcareous alagae in Greece compued by means of Biograph Program (Savary & Guex, 1999).

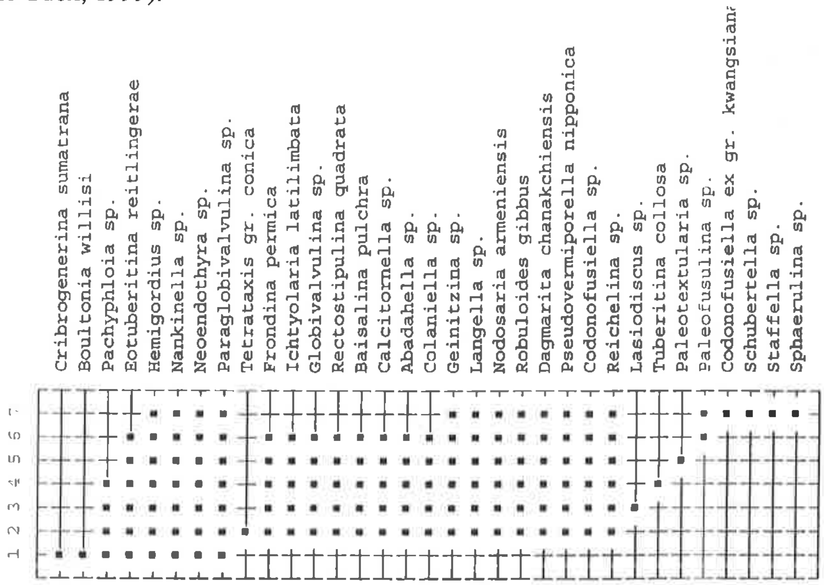


Fig 2.2 Range chart of Permian foraminifera and calcareous alagae in South China compued by means of Biograph Program (Savary & Guex, 1999).

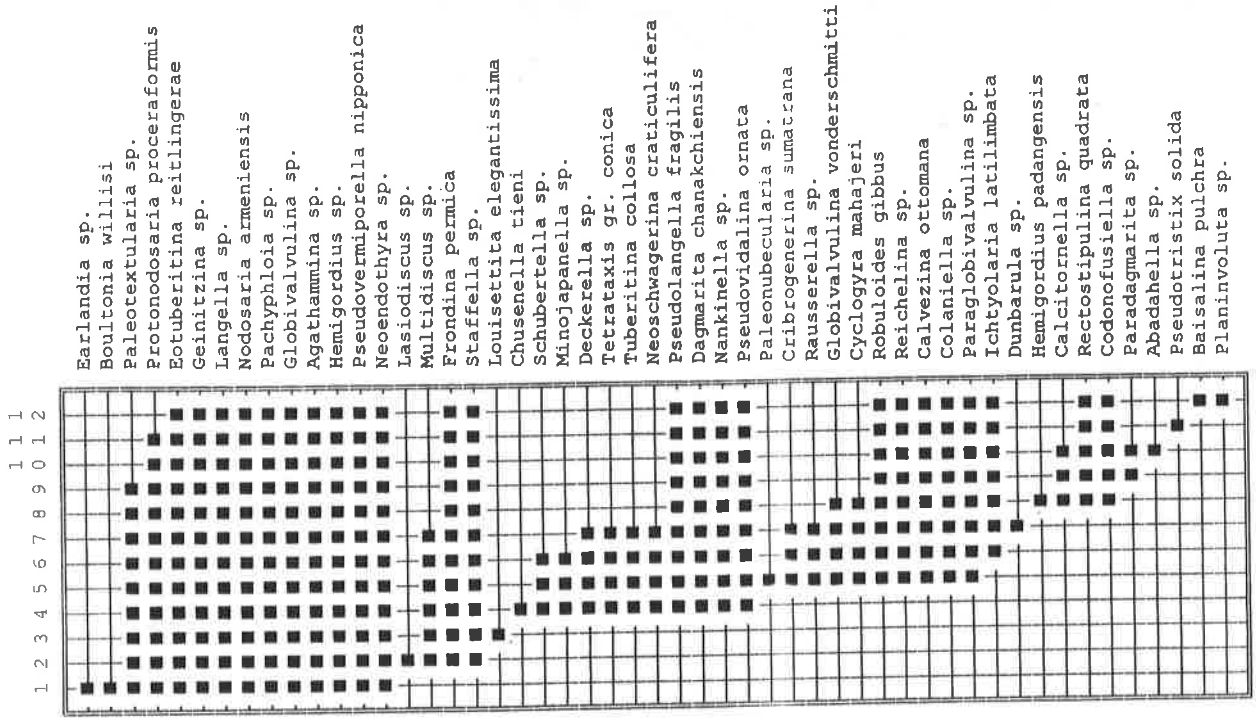


Fig 2.3 Range chart of Permian foraminifera and calcareous alagae in Iran compued by means of Biograph Program (Savary & Guex, 1999).

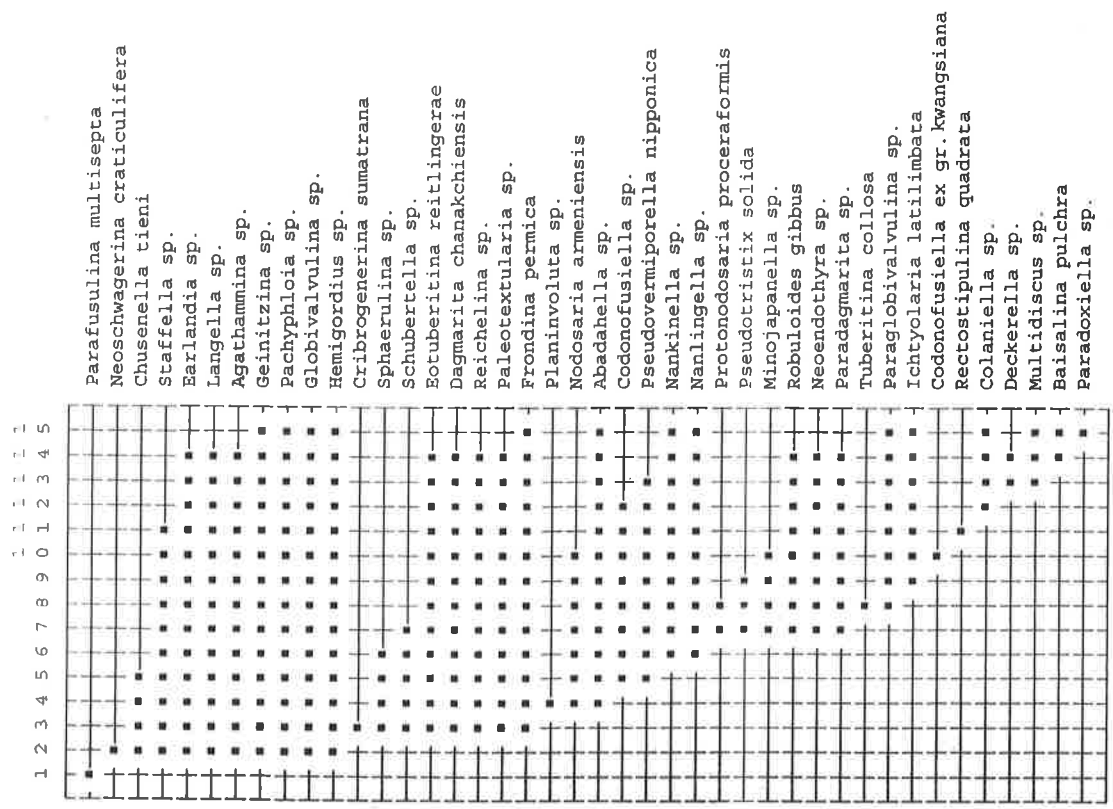


Fig 2.1 Range chart of Permian foraminifera and calcareous alagae in the Salt Range, Pakistan compued by means of Biograph Program (Savary & Guex, 1999).

Part 3. Paleogeography of theTethyan realm

3.1 Introduction

The present inventory of benthic taxa of foraminifers and calcareous algae on more than 3500 thin sections, representing twelve regions around the Permian Tethyan realm is a rich source for correlations.
We have seen in the previous chapter the difficulties in making global correlations in the Late and Middle Permian of the Tethys realm. Fusulinids, regarded as the more important group of benthic foraminifers are in some areas missing or rare. Sometimes the index taxas have not been found in the deposits, then other foraminifers like nodosarids, Biseriammindae, Hemigordiopsidae or calcareous algae are present. Our inventory showed great differences between the studied areas. A possible explanation of these discrepancies could be due to peculiar paleogeographic conditions related either to paleoclimate or continental drift or a combination of both.

In order to test paleogeographic differences in the faunal associations and potential endemism, we replace part of our data-base, completed with information from the literature (Altner, 1980; Aw et al., 1977; Baghbani, 1992; Kobayashi, 1996; 2003; Kotlyar et al., 1989; Leven 1967; Leven and Okay 1998; Lin et al., 1990; Lys, 1986; Nguyen, 1979; Vachard 1980) on different well-constrained geodynamic reconstruction (Jenny and Stampfli, 2000). A single micropaleontologist did the compilation, which guarantee homogeneity in the taxonomic determinations. On the base of our inventory, we decided to use only genus and not to consider species in order to assure large-scale correlations.
Our database was too poor during the Early Permian to make a consequent paleogeographic reconstruction. Moreover it seems that the Early Permian does not show much paleogeographic differentiation. In contrary, the Middle Permian sees the opening of Neotethys and the drifting of the Cimmerian continents, accompanied also by a change of climate around Gondwana. The main biostratigraphic criteria to separate Middle to Late Permian maps is the appearance of Paraglobivalvulina mira (Reitlinger) in the Late Permian. This taxa participates of a phylogenic trend and it has a large paleogeographic distribution.
Each map (Fig. 3.1, 3.2) presents the distribution of nine taxas, chosen because of their respective biostratigraphic importance observed in the inventory and literature.

This study brings an original way of investigating the significance of these taxa in terms of biostratigraphy and paleogeography, but it does not solve the problems of biostratigraphic correlations. However, this is an essential complement of the faunal inventory.

3.2 Maps

Some remarks on the maps reconstruction are necessary. There is still some confusion about what Tethys existed at what time (e.g. Sengör 1985). A consensus exists, however, regarding the presence of a mainly Paleozoic ocean north of the Cimmerian continent(s) - the Paleotethys, a younger Late Paleozoic-Mesozoic ocean located south of this continent - the Neotethys, and finally a Middle Jurassic ocean - the Alpine Tethys (Favre & Stampfli 1992; Stampfli & Marchant 1997), an extension of the central Atlantic, which broke through the Pangea supercontinent. These three oceanic realms form the Tethyan domain s.l. extending from Morocco to the Far-East (Sengör & Hsü 1984), to which one has to add oceanic back-arc basins developed along the Eurasian margin in Triassic and Jurassic times (e.g. Meliata- Maliac, Pindos, Küre, Vardar; Stampfli and Borel, 2002, 2004).

The first geodynamically correct definition of the main Tethyan oceans, based on extensive field work in the Middle-East, was given by Stöcklin (1974) who recognised a Late Paleozoic?-Triassic oceanic realm cutting through the epi-Baikalian (Panafrican-Gondwanan) platform and separating the Iranian plate from Arabia, that he called Neotethys and another older oceanic realm separating the Iranian epi-Baikalian (Panafrican) domain from the Variscan Turan domain to the north that he called Paleotethys (Stöcklin 1968, 1974, 1981).
Following this proposal, we started an investigation of the eastern Alborz range (Stampfli 1978) and effectively defined it as a potential southern margin of Stöcklin's Paleotethys Ocean. The opening of this Paleozoic Ocean was placed in Silurian-Early Devonian time. At the same time the ophiolites of Mashhad were recognised as most likely pertaining to the Paleotethys suture (see the review of Ruttner 1993, concerning these ophiolites).
The drifting of the Irano-Afghan block from Gondwana to Laurasia was then clearly recognised and constrained by the evolution of the microflora of the Iranian block from a Gondwana affinity in Carboniferous time (Coquel et al. 1977; Chateauneuf & Stampfli 1979) to a Eurasian affinity in Late Triassic time (Corsin & Stampfli 1977). The Eocimmerian orogeny was also defined in Iran at that time as a result of the closing Paleotethys and Middle Triassic collision of the Iranian block with the Eurasian Turan block (Stampfli 1978).
This concept was later on extended further west (Turkey) and East (Tibet, Far-east) by Sengör who defined the Cimmerian block as a ribbon-like micro-continent separating Neotethys from Paleotethys (Sengör 1979; Sengör 1984; Sengör & Hsü 1984), he also defined at the same time the Cimmerian deformation as non-Hercynian or post Hercynian.

New reconstruction models were derived recently (Stampfli & Borel, 2002; 2004) to reassess new plate tectonic concepts developed in the Tethyan realm, based mainly on the review of the geohistory and subsidence patterns of the involved plate margins (e.g. Stampfli, 2000; Stampfli et al. 1991 and 2001; Stampfli & Marchant 1997).

3.3 Conclusions

As conclusion, we propose the following observations:

- The Late Permian genus Paleofusulina seems to be confined to the Paleotethys realm, and especially to its northern margin.
- The genus Colaniella never occurs in the equatorial part of the Cimmerian blocks during the end of the Permian. Otherwise this taxa shows a more widespread repartition than Paleofusulina.
- For these reasons, we wonder if Paleofusulina can keep its prevalent importance as index foraminifera for the Late Permian biostratigraphic correlations. Colaniella has a better geographical range during the Late Permian and could be considered as an important fossil index.
- The Biseriamminids family, except the genus Paradagmarita, presents real good value for paleogeography and biostratigraphy in the Tethyan realm, when fususlinids are missing or in complement of them. In this family, the Globivalvulina- Paraglobivalvulina-Paragobivalvulinoides show a widespread repartition in addition of a good phylogeny trend, which is the main feature for a good fossil index. Even more, taxa of this

Late Middle Permian (Late Guadalupian)

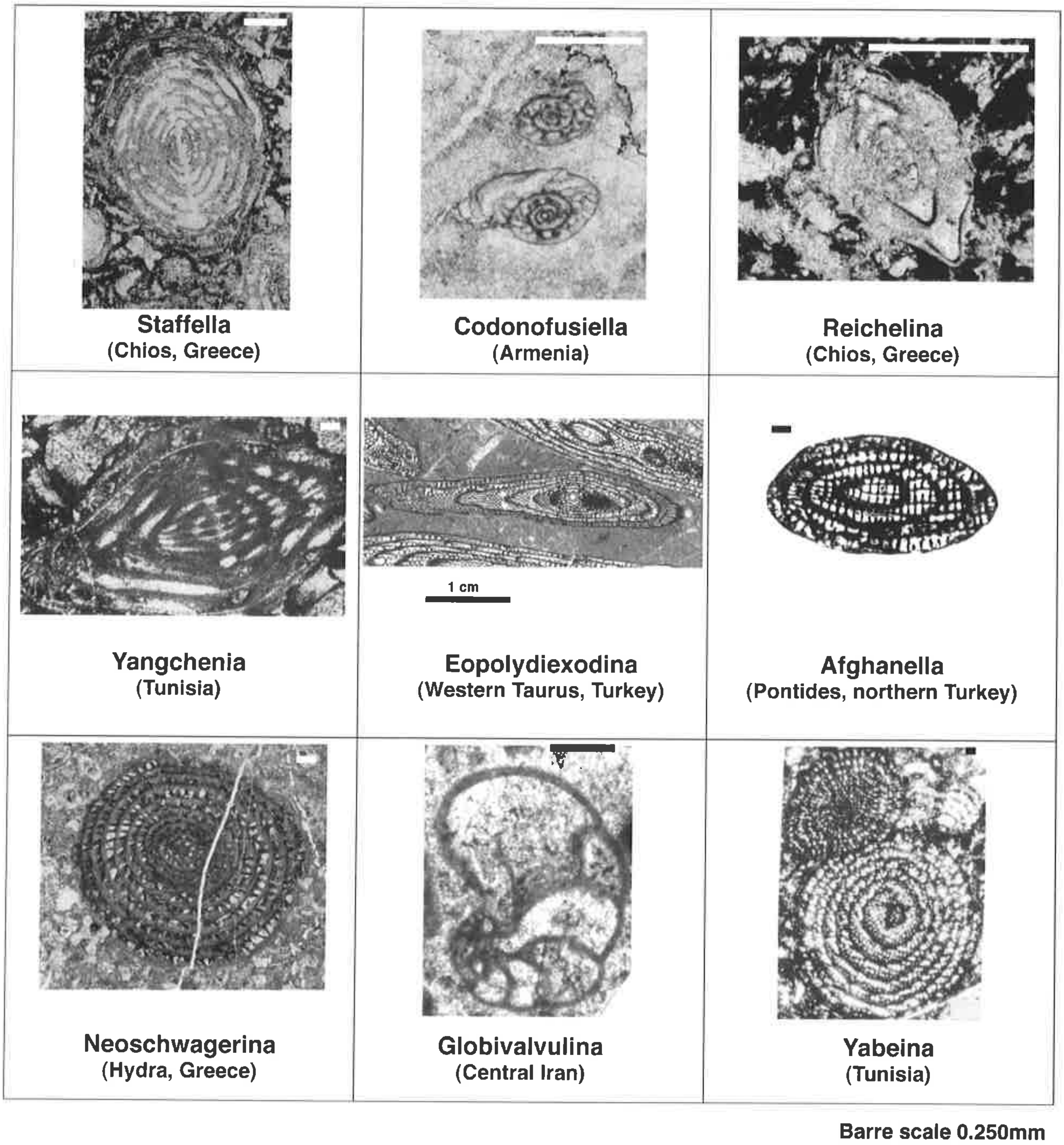
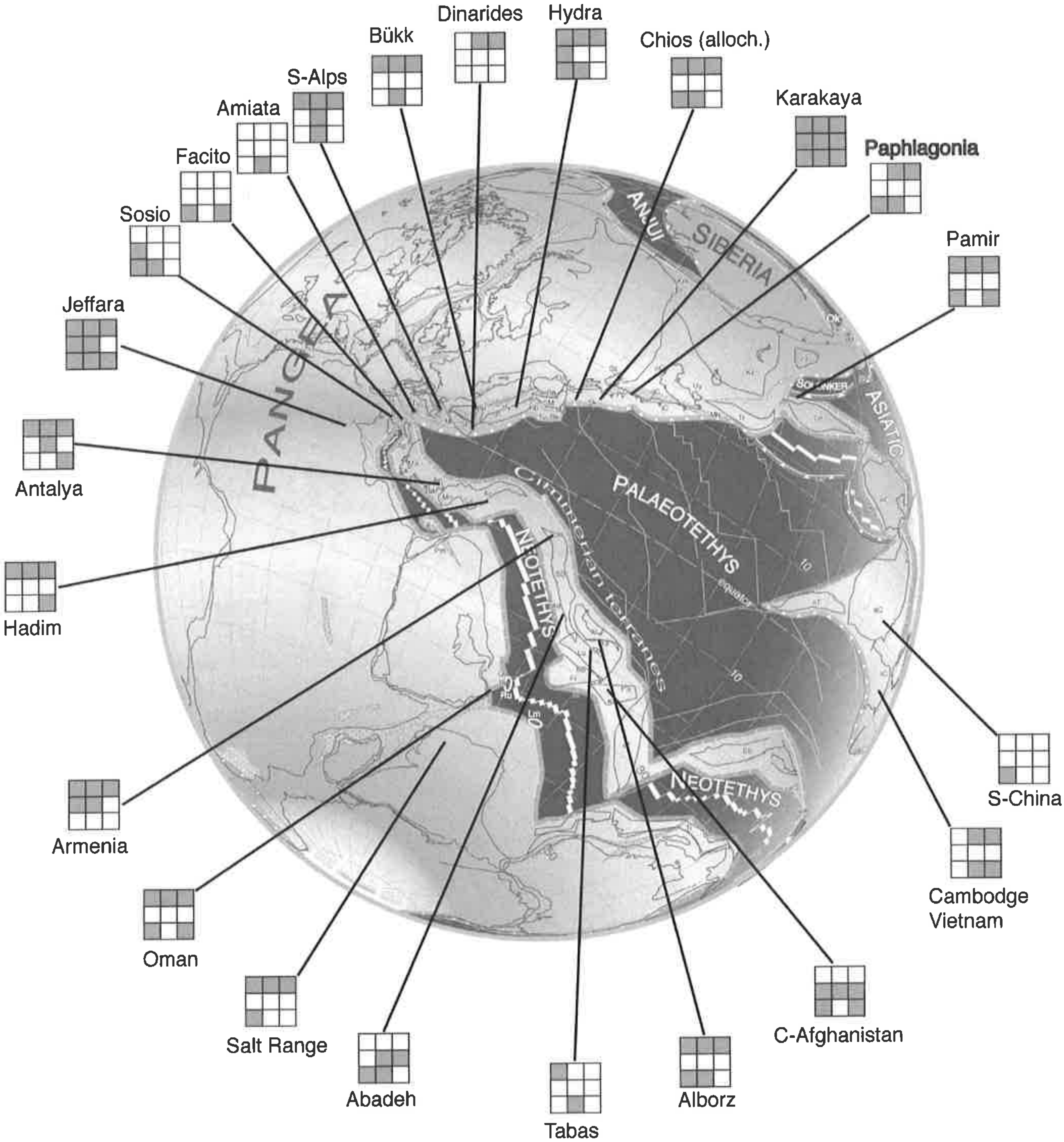
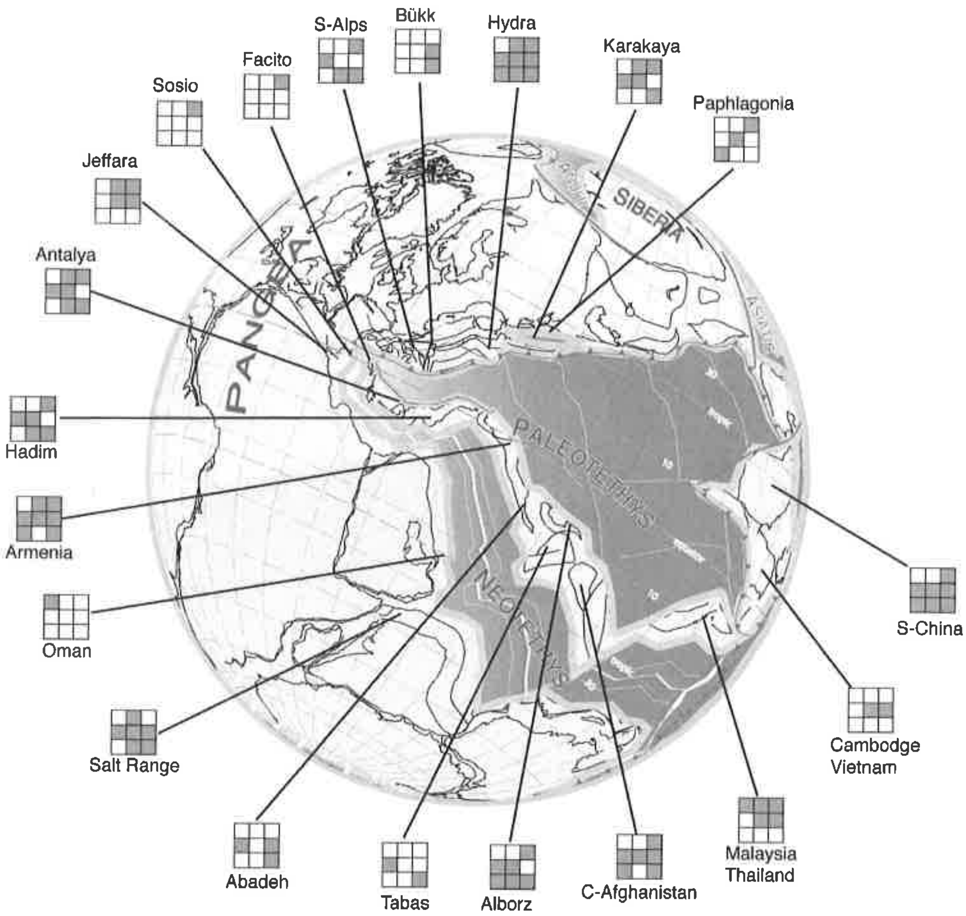
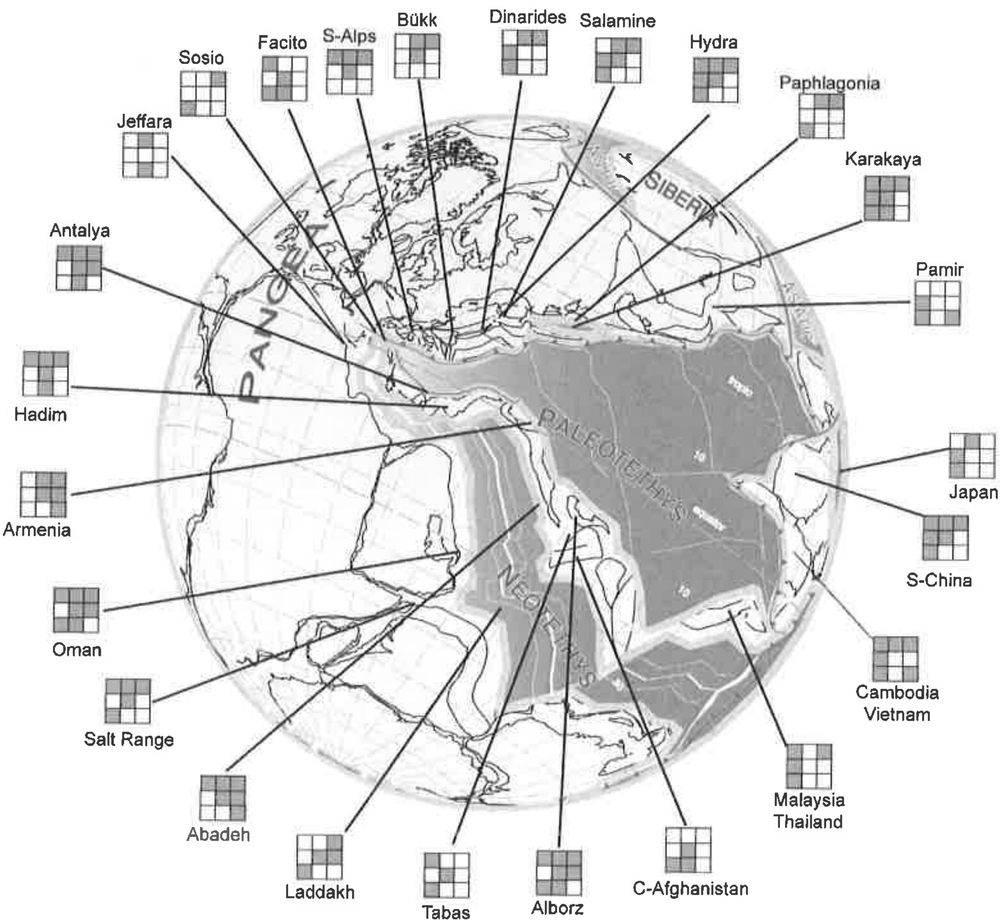


Fig 3.1 Distribution of foraminifers of the Tethyan realm in Late Middle Permian (Guadalupian). Grey squares on each geographic location indicate the presence of the above corresponding taxa.
See main text for references.


Dinarides
Hydra
Bükk
Chios (alloch.)
S-Alps
Amiata
Karakaya
Paphlagonia
Facito
Sosio
Pamir
Jeffara
Antalya
Hadim
Armenia
Oman
Salt Range
Abadeh
Tabas
Alborz
C-Afghanistan
S-China
Cambodge
Vietnam
PANGEA
SIBERIA
ASIATIC
PALAEOTETHYS
Cimmerian terranes
NEOTETHYS
NEOTETHYS

Late Permian (Lopingian)





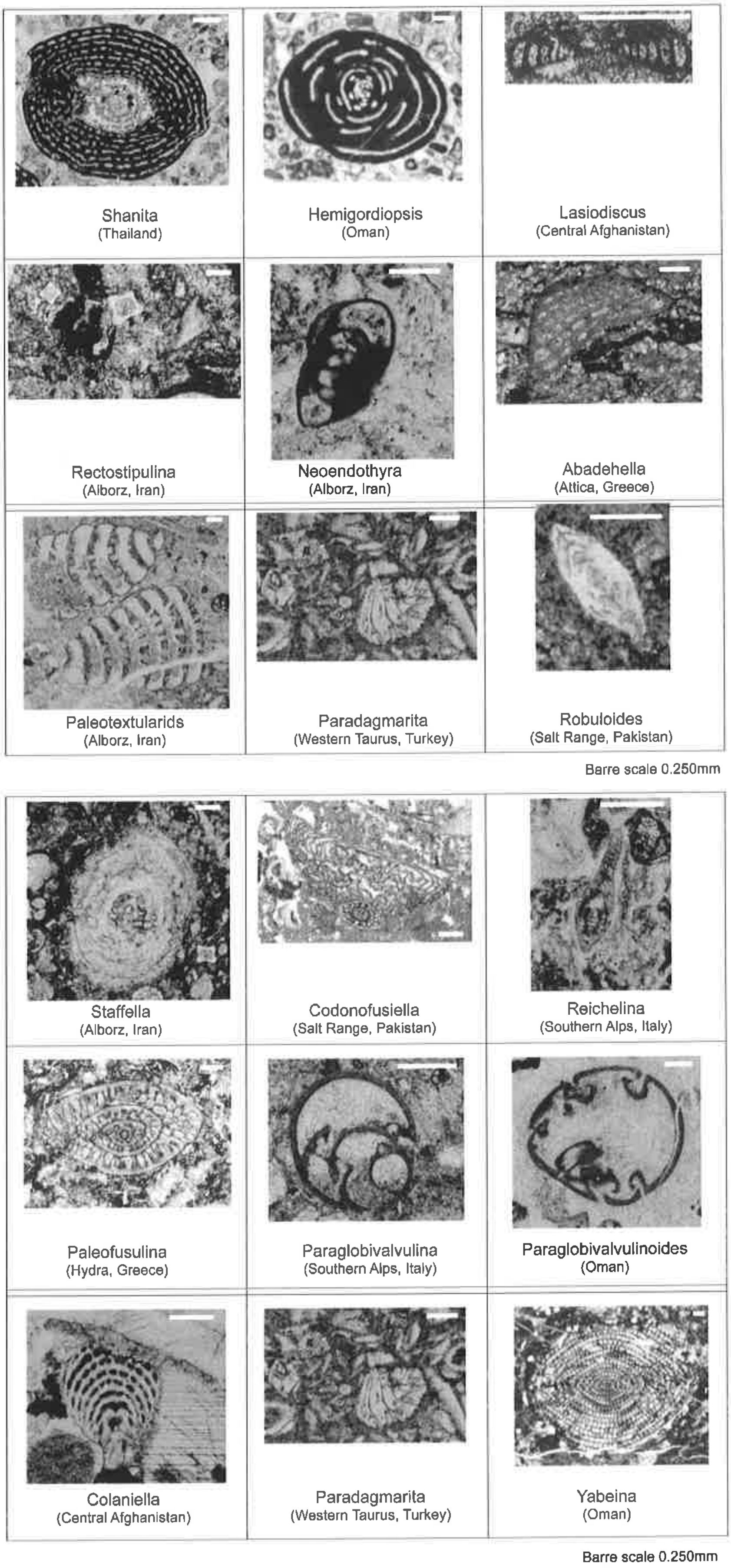


Fig 3.2 Distribution of foraminifers of the Tethyan realm in Late Permian (Lopingian). Grey squares on each geographic location indicate the presence of the above corresponding taxa. See main text for references.

family offer well-documented data in almost all Permian deposits, and in different environmental conditions. At least, Globivalvulina and Paraglobivalvulina can reveal important disturbance in their environmental conditions by developing aberrant forms, as we locally observed below the Permo-Triassic Boundary (PTB) (Jenny & Guex, 2005).

These paleogeographic reconstructions confirm the strong endemism of foraminifers in the Middle and Late Permian, perhaps due to the opening of the Neotethys and the possible reorganisation of current at this time.
This strong endemism leads us to consider Permian faunal associations in their local composition and in coherent stratigraphic sequences to build up local biostratigraphy. At this condition the determination at species level can be used. This allows correlations and /or comparisons between definite areas but not global correlations. As an example, Codonofusiella ex.gr. kwangsiana SHENG is present in Late Permian deposits of Armenia and in the Salt Range (Pakistan) and allows a correlation only between these two areas. In all the studied areas it is possible to describe such associations and to use them for local precise biostratigraphy. Regarding the faunal associations, we can keep one or more taxa, which characterise each area. As an example the genus Paradagmarita is typical for the Taurus Belt deposits (Turkey) because of the great number of individuals. The Staffella-Hemigordius association is typical for the Marmari Formation (Murgabian) of Hydra Island deposits (Greece). There are many such examples.

Paleogeographic reconstructions give no definite answer to the problematic of the migration of taxa around the Tethyan oceans during Permian times. However, it seems that climatic belts could play a major role in this distribution. But to answer to this question, we still need to learn more on evolutionary trends in Permian foraminifers.

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