

Ministry of
Mines & Metals

 GEOLOGICAL SURVEY OF IRAN

With cooperation of
Deputy Ministry of Projects & Planning



GEOLOGY OF IRAN

Biostratigraphy and Paleo-biogeography of some Paleozoic rocks at Zagros and Alborz mountains

M. Ghavidel-syooki

Editor-in-chief:

A. Hushmand-zadeh

1994

GEOLOGY OF IRAN

18 Biostratigraphy ... Paleozoic ...

18

QE
۷-۲
۱۳۹۸
۱۳۷۳



TREATISE ON THE

GEOLOGY OF IRAN

**Biostratigraphy and Paleo-biogeography
of some Paleozoic rocks
at Zagros and Alborz mountains**

M. Ghavidel-syooki

Editor-in-chief: A. Hushmandzadeh

1994

Contents

Introduction	1
Objectives of study	2
Preparation Techniques	4
Microscopic Techniques	5
Sample collection and the field studies	5
Field work No.1 Kuh-e-Ozom in Kopeh-Dagh region	7
Field work No.2 Khoshyeilagh area in eastern Alborz	9
Paleontological History of Khoshyeilagh formation	10
Field work No.3 Hassanakdar area	10
Faraghan formation in Zagros basin	11
Biostratigraphic Zonation	16
Biostratigraphy of Paleozoic sequence in the Hassanakdar area	17
Acritarch assemblage zone I	18
Acritarch assemblage zone II	18
Acritarch assemblage zone III	19
Acritarch and spore assemblage zone IV	19
Acritarch and spore assemblage zone V	20
Pollen assemblage zone VI	21
Analysis of Palynological data in the Khoshyeilagh area	22
Acritarch and spore assemblage zone I	22
Acritarch and spore assemblage zone II	23
Acritarch and spore assemblage zone III	23
Acritarch and spore assemblage zone IV	24
Acritarch and spore assemblage zone V	25
Biostratigraphy of Padeha and Khoshyeilagh formations in Kuh-e-Ozom, Kopeh-Dagh region	26
Acritarch and spore assemblage zone I	26
Acritarch and spore assemblage zone II	27
Acritarch and spore assemblage zone III	30
Acritarch and spore assemblage zone IV	31

Biostratigraphy of Faraghan formation in Zagros basin	32
Assemblage zone I	33
Spore assemblage zone II	33
Assemblage zone III	34
Assemblage zone IV	35
Assemblage zone V	37
Discussion on Paleogeography and Paleoecology	38
Plate 1	48
Plate 2	50
Plate 3	52
Plate 4	54
Plate 5	56
Plate 6	58
Plate 7	60
Plate 8	62
Plate 9	64
Plate 10	66
Plate 11	68
Plate 12	70
Plate 13	72
Plate 14	74
Plate 15	76
Plate 16	78
Plate 17	80
Plate 18	82
Alphabetical arrangement and worldwide records of the encountered Acritarch taxa	85
Alphabetical arrangement and worldwide records of Spore taxa	105
Alphabetical arrangement and worldwide records of Pollen graint taxa	130
References	145

IN THE NAME OF GOD

Treatise on the Geology of Iran

Although almost over a century from now, organised geological studies have been carried out in Iran and lot of data generated, no appropriate compilation is available on the geology of Iran. This is because of the scattered nature of data and related informations available with individuals at various related organisations. This situation has allowed influence of personal views and interests to dominate over true scientific spirit in geological teachings, which has deviated, scientists and experts of various branches of this field of science, from the correct path. On the other hand due to the lack of accurate, standard and complete informations reflecting the realities, some irregularities have crept in the chalking out of the official scheme of schedules. In the mean while, there has always been a sense of fear that with passage of time there will be the danger of loosing the data that are available with the individuals.

Because of these reasons, the necessity of compilation of the available data in the form of comprehensive monographs, was felt very strongly. However, it was realised practically that the gap in informations was much more than that was thought in the beginning and it called for a more detailed research and correct teachings. In this regard, the bureau of Treatise on the Geology of Iran has started extensive collaborations with various universities and research centres, both nationally and internationally to overcome the above difficulties. In the course of development

towards achieving our goals, this organisation has signed and concluded successfully as many as fifty contracts with experts in the following six fields of geology:

- 1- Stratigraphy
- 2- Metallogeny and Economic Geology
- 3- Geodynamics
- 4- Metamorphism
- 5- Magmatism
- 6- Geomorphology

Based on the informations collected on the above fields, the editing headquarter in consultation with the Central Book Council, has decided to carry out the publications in two phases. In the first phase separate books will be published under the authors names with little editing, followed by compilation of comprehensive books monographs on the geology of Iran in the second phase. Following titles are already published:

Stratigraphy of Zagros, Palaeozoic Stratigraphy of Iran, History of Geology and Mining in Iran, Coal of Iran, An overview on the Neogene-Quaternary Stratigraphy of Iran, Biostratigraphy of Permian Sediments of Zagros, Industrial Earths of Iran, Talc of Iran, Sodium Sulfate of Iran, Sulphur of Iran, Feldspars of Iran, Geology of the Kopeh Dagh, Mineral and Termal Waters of Iran, Oligocene-Miocene-Pliocene, Seas and Lakes of Iran.

This bureau has also prepared the following maps, which are in proof print stage:

- 1- Magmatic Rocks of Iran, Scale 1:2,500,000
- 2- Tectonic Map of Middle East, Scale 1:5,000,000
- 3- Mineral Distribution Map of Iran, Scale 1:1,000,000
- 4- Mineral Maps of Tehran and Saveh Quadrangles, Scale 1:250,000
- 5- Tectonic Map of Iran, Scale 1:1,000,000
- 6- Seismotectonic Map of Iran, Scale 1:1,000,000
- 7- Oro-hydrographic Map of Iran, Scale 1:1,000,000

8- Magmatic Mape of Iran , Scale 1:1,000,000

9- Geomorphologic Mape of Iran, Scale 1:1,000,000

10- Climatologic Mape of Iran ,Scale 1:2,000,000

This book is of the T.G.I. publication series which has been prepared, almost long ago, by Dr. Ghavidel- syooki.

He is an expert, as well as a research fellow on the Palynology field of study in the N.I.O.C. and for many years he's been involving in researching and preparing materials of this field. By having done so he's added a lot of new findings to the Geological Data- Set of Iran.

Dr.Emad-Eddin Kavari has been in charge of compilation and scientific editing of this book.

T.G.I., hereby,would like to acknowledge their efforts and express its gratitude to them.

Editor - in - chief

A. Hushmand-zadeh

Introduction

This research work presents the results of palynological investigations of some paleozoic sedimentary rocks in Iran. The treated Paleozoic sediments are from Lower Ordovician, Upper Devonian and Lower Permian. The studied samples are from Alborz-Ranges, an area in Kopeh-Dagh Region and a section from south east Iran in the Zagros Basin. In this study the treated rock units are called Padeha , Khoshyeilagh, Geirud, Dorud and Faraghan formations. Locations of the sampling sections have been selected in the critical areas. As the Faraghan Formation with wide distribution along the southeast margin of the Iranian Plate which thrust on the Arabian Shield. The Padeha and Khoshyeilagh formations have been measured and sampled twice from two different localities. One locality site is in Kuh-e-Ozom at the Kopeh-Dagh Region and the next site is in the eastern part of the Alborz Ranges. By understanding the palynological data of these two rock units the paleogeography and age relationships of north eastern parts of Iran are cleared.

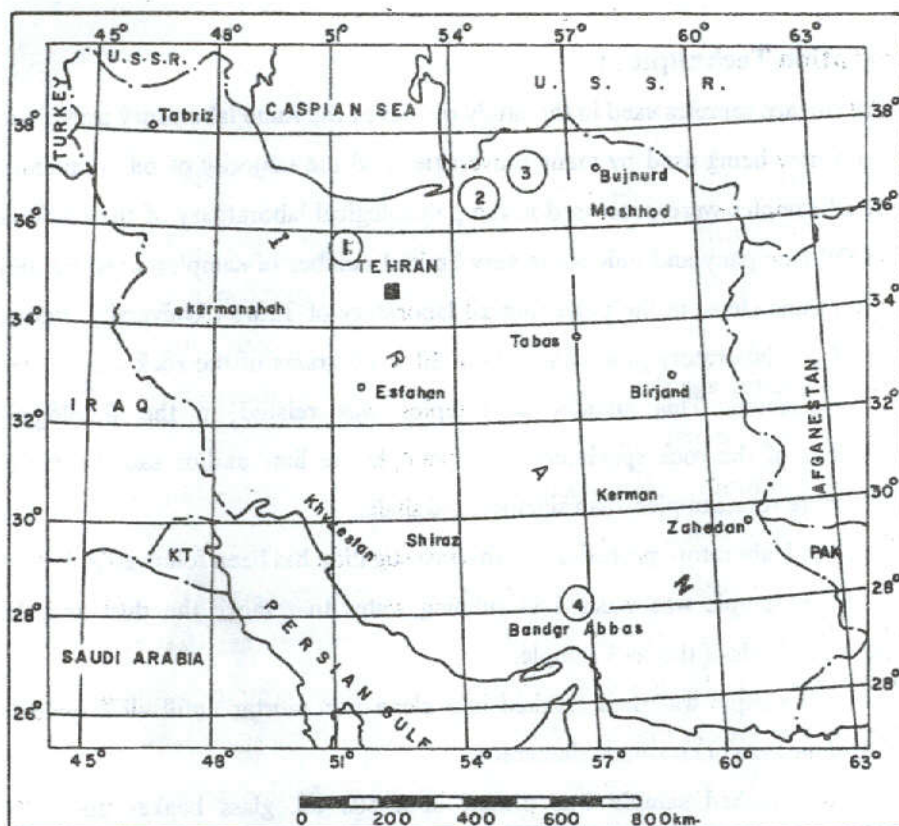
A total of 556 surface samples were analysed and studied in this investigation. From these samples about 290 of them are from Padeha and Khoshyeilagh formations that they have been sampled twice at two different locations. From the remaining samples 129 of them are from a section at the Hassanakdar area in southern part of Alborz that covers Lashkarak, Geirud and Dorud formations. The last 137 samples are from the Faraghan formation in the Zagros basin.

In this study, only the stratigraphic values of genera and species of the encountered palynomorphs are credited and the palynological treatments are arranged in alphabetic names, thus no attempt has been made to the proper natural

taxonomic classifications for the listed and or illustrated palynomorph taxa. Before explanation and establishing the palynological biozones, the field works and lithological characteristics of the studied rock units are also discussed.

Objectives of study :

This research shows the fact that sometimes a very little part of sedimentary rocks containing an assemblage of the palynomorph taxa with good preservation, that are suitable for age determination , paleogeographic relationship of the rocks, especially when no macrofossils or other microfossils are present. As the Padeha formation was known as the unfossiliferous rock unit it was interesting to present a documentary age values for this unit. Also re-evaluation of the given age values for some of the mentioned Paleozoic formations were in mind during this research. It was also desirable to find out diagnostic palynomorph taxa for the studied sedimentary rocks, and subdivide the formations into finer biostratigraphic zones. By this research it is obvious that palynology is an useful tool for age determination and interpretation of different sedimentary environments. Expansion of the palynological information for the country, has been another objective in this research since the data in this respect are very limited. Furthermore additional objectives are summarized as follows: Identify and illustrate the important palynomorph species of the mentioned rock units in the paleozoic Era. Interpret the different paleo-environments represented by the plant microfossils in Koppe-Dagh, Alborz and the Zagros areas. Resolving the stratigraphic problems of age and correlation of the Padeha, Khoshyeilagh and Faraghan formations. Determination of the index palynomorph species for relationships of Kopeh-Dagh Region to north and central Alborz, and Zagros areas as well as Gondwana and Laurasia supercontinents. It is hoped that the established biozones can be helpful in age determinations, correlation and the interpretation of sedimentary environments of the country and resulted in further palynological studies in various part of Iran.



INDEX MAP OF IRAN AND
LOCATION OF STUDIED AREAS

LEGENED

- 1: Hassanakdar
- 2: Khoshyeilagh
- 3: Kuh-e-Ozom
- 4: Kuh-e-Faraghan

Preparation Techniques :

All surface samples used in this study received the same laboratory treatments which are now being used by many universities and the majority of oil companies. Almost all samples were processed in the palynological laboratory of the National Iranian Oil Company and only some very limited number of samples were treated, under the same steps, in the palynological laboratory of Tehran University. Before starting of any laboratory procedures about 30 to 60 grams of the rock sample was randomly selected. This amount of samples was related to the lithological compositions of the rock specimens, For example the limy and/or sandy samples required more rock samples, than siltstone and shale.

The used laboratory procedure, in this investigation has been followed as below:

- 1- Each sample was washed in running water to remove the dust and the unwanted materials of the rock sample.
- 2- Each sample was then crushed in a clean iron mortar until all fragments were less than 1.cm in maximum dimension.
- 3- The crushed sample was placed in a 500 ml. glass beaker and 10% Hydrochloric acid was added until the sample was covered. After 24 hours, the sample was repeatedly washed with distilled water and using the centrifuge to remove any trace of the Hydrochloric acid.
- 4- The washed sample was placed in a plastic beaker and treated by 48% of Hydrofluoric acid. After 24 or 48 hours the sample was washed by a series of distilled water to remove the dissolved silicate and extra hydrofluoric acid.
- 5- Each sample was then sieved by 15 or 20 micrometers plastic screen. After sieving, the organic fractions were placed in a glass beaker and treated by 10% of hot Hydrochloric acid and washed repeatedly.
- 6- About 30 ml. of saturated zinc bromide ($Zn Br_2 + H_2O$) or zinc chlorite ($ZnCl_2 + H_2O$) with specific gravity 1.95 was added to the residues of each samples in order to separate the inorganic material from the organic residue.

7- The organic residue was diluted and mixed with distilled water immediately after agitation, three drops were taken by pipette and put on a clean-cover slip and mixed with Polyvinyl Alcohol. The cover slip was placed on a hot plate and then inverted on a clean-glass of microscopic slide. Three slides were prepared from each sample. Each prepared slide bearing the same code and numbering policy of the National Iranian Company, and all the slides of this study have been stored in paleontological section of the N.I.O.C.

Microscopic Techniques

During this research, the Leitz Orthomat microscope was used for all observations and photography. The coordinates of location of each palynomorph were recorded, using the coordinates from the calibrated mechanical stage. The different palynomorph taxa were photographed using the Leitz Orthomat automatic microscope camera system. Kodak panatomic X film (32 ASA/16 DIN) was used. The developing processes and printings were done by existing facilities of the Geological laboratories of the National Iranian Oil Company.

Identification of various palynomorph species were accomplished by comparison of the specimens with those described and illustrated in the most available literatures of the Paleozoic Era. Quantitative evaluation of each productive sample was made on systematic traverses of the slide. The palynomorph taxa were counted until a total of 500 specimens (100 specimens for Hassanakdar area) was attained, the relative percent for each genus and species was calculated based on the total number of each species or genus to the total grain counts. Quantitative sign for abundance is as follows: very rare <1%, rare 1-3% common 3-7% and abundant >7% .

Sample collection and the field studies :

For this research work, collection of samples required a systematic field observations at different localities. The main emphasis has been achieved for the good

sample collections from the Padeha and Khoshyeilagh formations. As the Padeha unit with its wide geographic distribution has been recorded unfossiliferous at the type section. In 1989, author analyzed some samples which had been collected from the Padeha and Koshyeilagh formations of Kuh-e-Ozom by Afshar-harb. Surprisingly the samples revealed that both rock units were productive and contained well-preserved palynomorph taxa (N.I.O.C.Paleont Note No.37). It was interesting to see that based on the encountered spore and acritarch species, the age of Late Devonian could be proposed for these two formations. This age value was different from what it has been previously assigned for these two units. At the same time the obtained preliminary results encouraged the author to collect a new set of samples and also a more detailed meticulous palynological studies of these formations. For this reason the author decided to collect new samples from Kuh-e-Ozom in the Kopeh-Dagh region and the Khoshyeilagh area in the eastern part of the Alborz Ranges.

Prior to the method of sampling and field procedures, a short discussion on the lithological compositions and the geographic distribution of the Padeha formation seems to be required. This unit was named after the village of Padeha in the Ozbak-Kuh Mountain in eastern Iran (Ruttner, Nabavi and Hajian 1968). This rock unit is composed of unfossiliferous multi-colored shales, sandstones, dolomites and evaporites. The Padeha formation is 492 meters thick in the type section, consisting of alternation sandstones, dolomites and two thick gypsum zones in the middle and close to the top. This rock unit has conformable contact with Niur formation of Silurian below and Sibzar dolomites of Devonian on the top.

The Padeha formation has been traced in Derengal Mountains of northern Tabas city with a thickness of 730 meters, consisting of sandstones, shales, dolomites and no gypsum. This rock unit has also been reported from west of Ravar city which is marked by two gypsum zones (Stocklin 1961). Also, the Padeha formation in northern and southern mountain of Yazd city is composed of alternating sandstones

and dolomites. In Kerman area this formation is exposed, and consisting of sandstones, shales, dolomites and gypsum. The Padeha in both Yazd and Kerman areas has disconformable contact with lower Paleozoic strata (Cambrian or Silurian) below and gradational contact upward with fossiliferous Devonian deposits. In all the above-mentioned areas no fossils have been recorded from the Padeha formation and the Early Devonian age has been inferred from the stratigraphic position at the type locality.

Field work No.1, Kuh-e-Ozom in Kopeh-Dagh region :

A total of 100 surface samples were collected from the Padeha and Khoshyelagh formations in this area in 1989. The area is located north eastern Jajarm town, approximately 50 Km. of southern Bejnurd . The author measured and sampled two stratigraphic sections in the Kopeh-Dagh Region which are in Kuh-e-Ozom and Robat-e-Gharabil. The total thickness of paleozoic sequence is 858 meters which is divided into Padeha formation (340m.), Khoshyelagh formation (209m.) and the Mobarak limestone (319m.).

Padeha formation at the type locality in Ozbak-Kuh consists of 492m. of well bedded sandy dolomites, sandstones and gypsum, in the Boz-Kuh areas reported by Alavi Naini, it consists of 413 meters of mainly sandstones and dolomites (G.S.I. report No.23). In Kopeh-Dagh Region, this formation is only exposed in southwest central part near the Jajarm and Robat-e-Gharabil. Padeha formation in Kuh-e-Ozom is lithologically more similar to the type section at Ozbak-Kuh than to the section of Boz-Kuh. In Jajarm area the lower part of Padeha formation is not exposed and cut by a fault. But lower part of this unit is exposed in Kuh-e-Ghelli, approximately 60 km away. In general, four lithological members are recognizable in the Padeha formation and from base to the top are:

1- Clastic member: This member is exposed in Kuh-e-Ghelli but not in Kuh-e-Ozom. This member is 200 meters thick and consists of purple-reddish brown

shales and sandy siltstone. This member is also present in Robat-e-Gharabil where represents 100 meters reddish brown sandstone and purple shales. The thickness of this member in Ozbak-Kuh is 205 meters composing of sandy dolomites, sandstones and shales (fig.1).

2- Lower evaporite member: This member at Kuh-e-Ozom consists of 239 meters of thick bedded gypsum which is alternated with subordinates green-gray shales and black dolomites. The member northwards becomes thin at Robat-e-Gharabil and is composed of 85 meters dark-gray gypsiferous shales. This member in Ozbak-Kuh is 70 meters thick and consists of gypsum and subordinates of thin bedded dark shales and greenish gray sandstones.

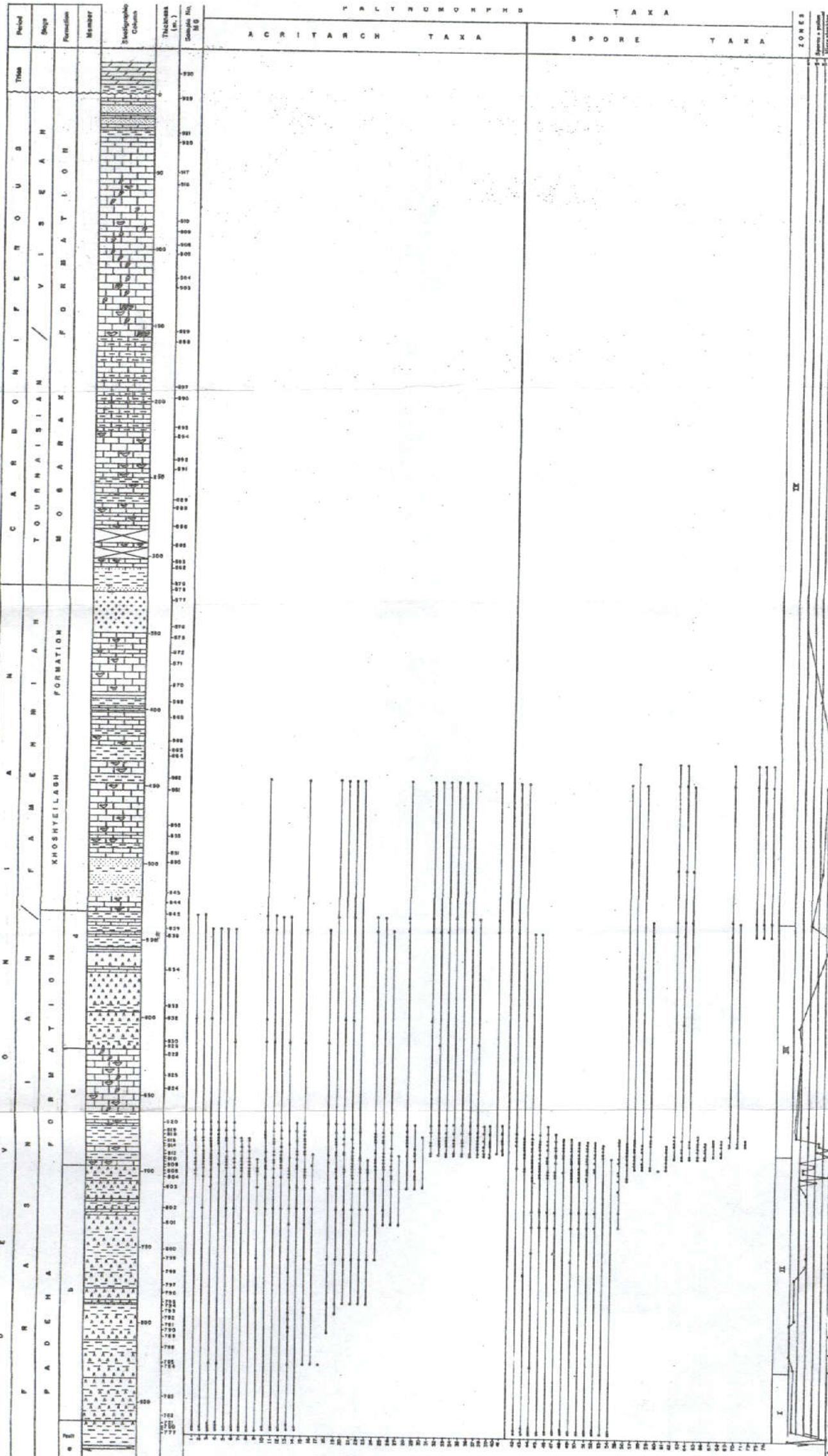
3- Carbonate member: This member in Kuh-e-Ozom is 49 meters, consisting of dolomites and fossiliferous corallian limestones. This member becomes thin, around 15 meters towards Robat-e-Gharabil. This member composed of 120 meters sandstones and dolomites in the type section of Ozbak-Kuh.

4- Upper evaporite member: In Kuh-e-Ozom, this member consists of 89 meters of gypsum and thin bedded dark gray shales. In Robat-e-Gharabil, it is about 20 meters of shales, siltstones and a few beds of gypsum. This member in the type locality of the Padeha formation in Ozbak-Kuh is represented by 80 meters of medium bedded gypsum and dolomites.

It is believed that the best development of Padeha formation is present at Kuh-e-Ozom, Where it is 340 meters thick and also the carbonatic member of this unit is fossiliferous, containing corals and brachiopods (Fig. 1). The fauna has been studied by Ahmadzadeh-Heravi(1975) and he has suggested the age of Late-early Devonian for this member of the Padeha formation.

Khoshyeilagh formation is only 209 meters thick in Kuh-e-Ozum. It is composed of alternating thinly bedded grayish argillaceous limestones and thick beds of dark bioclastic limestone. Very thin shaly layers are parting the limestone beds.

The underlying formation is Mobarak Limestone with the thickness of 319



LIST OF PALYNOMORPH SPECIES

Number	Species Name	Local Name
1	Varychium	europeum
2	Dovernaysphaera	tauricogulata
3	Gorgoniasphaeridium	condensum
4	Gorgoniasphaeridium	disiectum
5	Polydrysium	decaurum
6	Cymatiosphaera	spicigera
7	Chomatritetes	volagenae
8	Chomatritetes	bischoense
9	Cymatiosphaera	adolocherata
10	Cymatiosphaera	perimembrata
11	Helosphaeridium	paucata nov. sp.
12	Helosphaeridium	deminatum
13	Dicellaophora	remota
14	Vibrysphaera	conica nov. sp.
15	Multiplicisphaeridium	ramusculum
16	Populogabata	annulata
17	Multiplicisphaeridium	ampliatum
18	Michrystridium	caeratum
19	Varychium	laevi
20	Varychium	dowdii
21	Helosphaeridium	sp.
22	Cymatiosphaera	subtrita
23	Cymatiosphaera	craticula
24	Novifusa	exilis
25	Dovernaysphaera	tesellata
26	Saharidic	lusca
27	Dicellaophora	sp.
28	Stellinum	oculostriatum
29	Synsphaeridium	catenarium
30	Gen. nov.	
31	Gorgoniasphaeridium	ohense
32	Stellinum	comptum
33	Stellinum	protuberans
34	Unellium	winslowae
35	Unellium	piriform
36	Varychium	parvum
37	Multiplicisphaeridium	ampliatum
38	Dictyodiscus	confragus
39	Gneculocella	paucata
40	Deltacoma	intonsum
41	Tunisphaeridium	flaccidum
42	Rotetriletes	arata
43	Geminispora	fibribreata
44	Geminispora	leucurata
45	Emphosporites	rotatus
46	Dictyodiscus	sphaericus
47	Emphosporites	annulatus
48	Colytosporites	distictus
49	Reticulotriletes	rotundus
50	Reticulotriletes	rotundus
51	Reticulotriletes	rotundus
52	Reticulotriletes	rotundus
53	Rugulatisporites	pychellii
54	Cyclogranisporites	ionica nov. sp.
55	Apiculatisporites	rotundus
56	Ancyrospora	adolocherata
57	Calyptosporites	longi
58	Grandispora	proximocavata
59	Apiculatisporites	granulata
60	Apiculatisporites	sp.
61	Dibellisporites	turriculatus
62	Hystericosporites	porrectus
63	Retispore	lepidophyte
64	Ancyrospora	capitata
65	Gneculocella	kernickii
66	Apiculatisporites	sp.
67	Camazonotriletes	parvus
68	Camazonotriletes	laevigatus
69	Cymbasporites	cyathus
70	Laevigatisporites	sp.
71	Dicellaophora	macronotus
72	Vallatisporites	verrucosus
73	Vallatisporites	vallatus
74	Hymnozotriletes	explanatus

LEGEND

- Sandstone
- Shale
- Evaporite
- Dolomite
- Limestone
- Brachiopod
- Coral
- Igneous rock
- Discontinuity
- Fault
- Covered interval

NATIONAL IRANIAN OIL COMPANY
EXPLORATION AND PRODUCTION

Fig. 1
STRATIGRAPHIC DISTRIBUTION OF
PALYNOMORPHS IN PADEMA & KOSH YEILAGH
FORMATIONS AT KUM-E OZOM AREA

Author: M. Ghavami Boushi | Date: August 1962
Drawn by: M. Jahanlou | Scale: 1:50000

meters in Kuh-e-Ozom. The samples of this unit have not been processed and studied by the author. But Stepanov (1967) has proposed the age of Lower Carboniferous to this unit for its brachiopod assemblages.

Field works No.2 Khoshyeilagh area in eastern Alborz :

The area of the second field studies is called Khoshyeilagh which located in southern of the Caspian Sea, near the village of Tilabad, approximately 70 Km of Shahrud city and 50 Km. of Shahpasand (Azad-Shahr) town. The paleozoic sequence of this area has been measured, sampled and studied by many geologists and as well the paleontologists. In Khoshyielagh area, the Padeha formation is 275 meters thick and overlies the Soltan-Maidan formation (Ordovician or Silurian) with a nonconformable contact. The Padeha formation comprises of heterogenous conglomerate, coarse to medium grained white sandstones, sandy limestones, dolomites and purple shales which are intercalated with dark gray shales. The Padeha formation of the type section in Ozbak-Kuh is somehow different from this unit in the Khoshyeilagh area as the gypsum members of the middle and the top are absent in this formational unit. Padeha formation is also unfossiliferous in this area and the age of lower Devonian has been assigned on the base of its stratigraphic position. Khoshyeilagh formation with a thickness of 1300 meters overlies the Padeha formation. This unit has been divided into 17 members. The 14 meters of the basal conglomerate changes into the siltstone, alternations of fossiliferous argillaceous limestones, dark grayish and sandstones. The Khoshyielagh formation is underlain by micritic limestones of the Mobarak formation. Both the upper and lower contacts of this unit are conformable and gradational(fig.2).

Khoshyeilagh formation was introduced, from Khoshyielagh village in eastern Alborz Range, by H.Bozorgnia, A.Artinmehr, A.Bayat and M.Mohajer, in 1970. According to these geologists, the Khoshyeilagh village is one of the few places where highly fossiliferous Devonian strata are found in the Alborz Ranges. They believe

that the Geirud formation which has been introduced as the type locality of Devonian in Jajrud Valley should be replaced by the Khoshyeilagh formation. Because it has a greater thickness and a better developed geology than the Geirud formation of Jajrud Valley. Moreover, this unit ranges from Middle to Upper Devonian whereas the Geirud formation only covers the Upper Devonian deposits. About 200 samples have been collected from these two rock units during the field observation of the Khoshyeilagh area (Fig. 2).

Paleontological History of Khoshyeilagh formation :

Based on the brachiopod collections, Miss D. Brice has proposed the age of Middle-Upper Devonian for Khoshyeilagh formation (1977-1978). However, she revised her previous works and suggested the age of Upper Devonian (1985). Ghods (1982), based on the coral species has suggested the age of Givetian-Frasnian to this unit. Also Khoshyeilagh formation has been studied for its microfossil contents by F. Bozorgnia (1973) and he suggested Givetian-Upper Devonian for this rock unit. B. Hamdi and P. Janvier (1981) studied the conodonts of both Padeha and Khoshyeilagh formations and suggested Lower-Upper Devonian for these two units. A. Ashori based on conodonts of the basal part of Khoshyeilagh formation (members 1 and 2), proposed the Eifelian age for these members (1981). In addition the palynological investigations have been also achieved to this formation: M. Ghavidel-Syooki has studied the dark shale samples of this unit and suggested Late-middle Upper Devonian (1976). Coquel et al., (1977) have studied some samples from Khoshyeilagh formation (members 6-17) and have suggested the Late Frasnian-Famennian age for this rock unit.

Field works No.3. Hassanakdar area :

This area is located approximately 60 km. of northern Karadj city. The Paleozoic sequence includes seven rock units from base to the top which are Lalun, Mila, Lashkarak, Geirud and Dorud-Nessen formations. These rock units are well

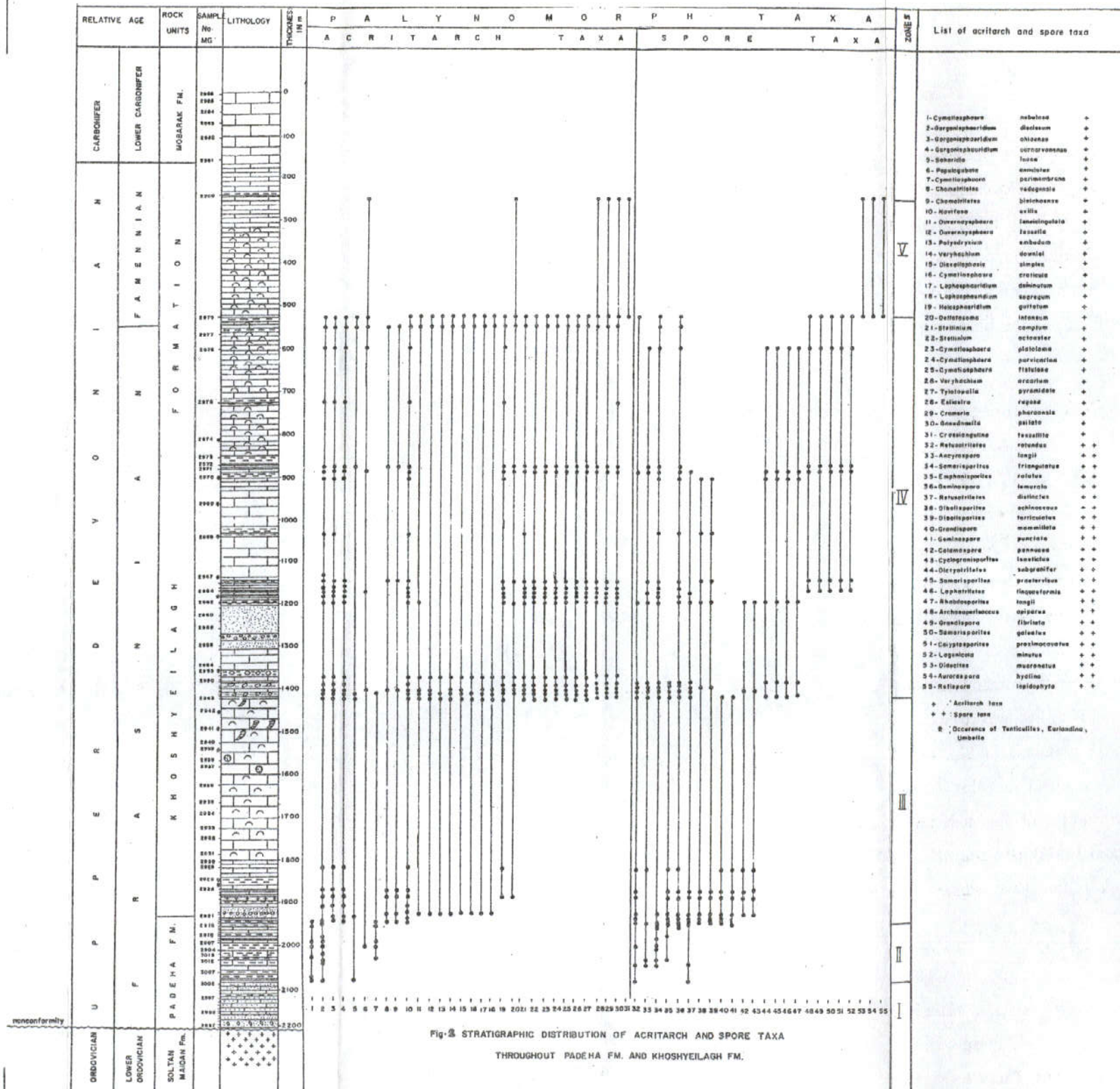


Fig. 2 STRATIGRAPHIC DISTRIBUTION OF ACRTARCH AND SPORE TAXA THROUGHOUT PADEHA FM. AND KHOSHYEILAGH FM.

exposed along the road of Karadj-Chalus near the Hassanakdar village which its name is derived. From the above mentioned formations only three rock units were selected for sampling and their palynomorph contents. These rock units are Lashkarak, Geirud and the Dorud formations. The field work was carried out by authorian 1991, when a section for the three named formations was measured and sampled. Thickness of this stratigraphic sequence is about 435 meters, that 35 out of 435 meters is from Lashkarak and the rest belongs to the Geirud and Dorud formations (Fig. 3).

The Lashkarak formation has distinct sedimentary facies which is easily separatable from the underlying formation of Mila and the Overlying Geirud Formation. The Lashkarak unit consists of dark-gray, silty shale and intercalation of igneous rocks in the middle part, this rock unit has been studied palynologically and it was assigned to the lower Ordovician age by Vanguestaine (1973). The Geirud formation was introduced by Asserto (1963) and comprises of black, silty shales and sandy limestones with small brachiopods and corals. The age of this formation has been the subject of major controversy, for instance Dedual (1967) has assigned it to the Silurian-Devonian. Likewise, based on brachiopod species Rivier (1934), Asserto (1963), Guetani (1965), Samani(1972), Bozorgnia (1973) suggested Upper Devonian and Lorenz (1964) the Upper Devonian-Lower Carboniferous ages. The palynomorph taxa has also been studied by Kimyai (1979) and he has suggested Middle Devonian-early Late Devonian age for this unit.

A total of 129 surface samples from the Lashkarak, Geirud and Dorud formations were collected for palynological studies in Hassanakdar area by the author (1991).

Faraghan Formation in Zagros basin :

The Faraghan formation was named after the best developed and the most accessible outcrop sections at Kuh-e-Faraghan by Sazabo and Kheradpir in 1978.

Before this study, the formation used to be called "Carboniferous sandstones" or the "Permo-Carboniferous sandstones". This rock unit has a wide distribution in the Zagros basin, and it is exposed along Ushtran-Kuh, Zard-Kuh, Kuh-e-Dinar, Kuh-e-Gahkum, Kuh-e-Surmeh and Kuh-e-Faraghan. The thickness of this formation varies from place to place as it is described in below:

In Ushtran-Kuh, the Faraghan formation is made of brownish-red, weathered white, coarse grained sandstone, that is poorly exposed and it is only 30 meters thick (Harrison, 1931). In Zard-Kuh area, this rock unit has an exposure of 100 meters thick, and it is composed of white, thin bedded sandstones (Kheradpir and Setudehnia, 1972; Ghavidel-Syooki, 1989). In Chal-i-Sheh area the Faraghan formation has a thickness of about 500 meters (Harrison, 1930; Szabo et al., 1976; Ghavidel-Syooki 1982). At one horizon in Chal-i-Sheh, this unit contains abundant remains of *Sigillaria persica* (Seward, 1932). This plant species should indicate an age not older than Westphalian or Lower Permian for Faraghan formation, as suggested by Seward (fig.4).

In Kuh-e-Dinar area, the thickness is diminished to a few meters of white sandstones with a dark brown, ferruginous weathered surface, which is usually present at the base of the cliffs of the Permian carbonates (Setudehnia, 1976). In Kuh-e-Gahkum, the Faraghan formation consists of white, current-bedded sandstones approximately 240 meters in thickness, with 27 meters of thin bedded ochrious limestone in the middle parts of the section (Mc Quillan, 1962; Szabo, 1977; Ghavidel-syooki 1984). In Kuh-e-Surmeh, the upper portion of Faraghan formation is obscured, and only its lower portion, with thickness of 100 meters, is exposed. The lithology consists of white, pebbly, current-bedded, friable, hematitic sandstones. McGugan (1949) has reported a number of the plant casts at the middle part of the Surmeh section and Douglas (1950) has identified them as a Carboniferous morphotype of Equisetaceae.

In Kuh-e-Faraghan, the Faraghan formation is composed of white to dark gray,

fine to medium-grained sandstones with dark shale intercalations and minor limestone in the middle part of the section. In Kuh-e-Faraghan, thickness of this rock unit has been measured by different geologists and the measurements range from 207.2 meters by Mcquillan in 1962 300 meters by Mollazal in 1963, 311 meters by Nicol and Kheradpir in 1972, and 230 meters by Ghavidel-Syooki in 1984. The discrepancies may be due to a combination of several factors such as precise locality of measurement, interpretation of dip, faults, base, top, etc. The upper contact of Faraghan formation is gradational with Upper Permian carbonates of Dalan formation at all outcrop sections, except for Kuh-e-Surmeh that this contact is obscured. This gradational contact with permian carbonates is clearly noticed in two surface sections of Kuh-e-Faraghan (the stratigraphic sections concerning this research) by a transition from interbedded sandstones and limestone beds and by the sandy character of the lowermost carbonates of the Dalan formation. The lower contact of the Faraghan Formation is marked by an unconformity where the lowermost beds overlying Cambrian to Silurian sediments (Szabo and Kheradpir 1978). The Faraghan Formation overlies the Cambrian at Kuh-e-Dinar, Kuh-e-Gereh, the Ordovician at Zard-Kuh, Chal-i-Sheh, Kuh-e-Surmeh and the Silurian shales in the Faraghan-Gahkum areas. In Kuh-e-Surmeh this unconformity is marked by a coarse, quartz conglomerate which lies on a barren dolomitic recrystallized limestone with a 10 degree angular unconformity. However, in Faraghan-Gahkum areas the lowest contact with the Silurian shales appears to be a disconformity than an angular unconformity. This well marked angular break has been associated with erosional activity that removed more than 1100 meters of Cambrian-Ordovician beds at Kuh-e-Dinar and Kuh-e-Gereh in the Zagros Basin. This erosional period might have been simultaneous with the Caledonian Orogenic activities at the Zagros Basin. Similar observations were suggested in the Golpaygan area by Thiele et al. (1968), who postulated similar movements for the Central Iranian Basin.

The source area for the Faraghan clastics may have been the acidic basement complex of the Arabian Shield. However, there is another alternative in that much of the sand in the Faraghan formation could have been derived from Kuh-e-Dinar and Kuh-e-Gereh in the Zagros Basin. The latter possibility is based on permian subcrop map of the Zagros Basin which has been prepared by Szabo and Kheradpir (1978).

The Faraghan formation lacks marine fossils. The age of this rock unit has been the subject of controversy for a long time. Most of the geologists, however, assigned the Faraghan formation to the Permo-Carboniferous period (Setudehnia, 1976) and some into the Permian period. The age assignment of Faraghan has been based on Seward's work (1932) in the Chal-i-Sheh area about 500 Kilometers away from the type section of this unit. After the publication of Seward's the geologists accepted his proposal age, the Carboniferous for the Faraghan formation (proposed age is also recorded in the "Stratigraphic Lexicon of Iran). Szabo and Kheradpir (1978) reviewed Seward's paper and suggested the lower Permian age for the Faraghan formation. They believed that the oldest dated Permian beds are not older than Artinskian stage. Furthermore, they do not accept that unconformity is present between Faraghan Formation and the Permian carbonates in the Zagros Basin. However they suggested that a break should only be present at the very base of the Faraghan Formation.

To find out reality, the author decided to focus on palynological characteristics of the Faraghan formation in the Faraghan and Gahkum areas. The research was carried out on both surface sections (which were measured and sampled by other geologists Mollazal in 1962 and Kheradpir Nicol in 1972) or cutting samples which were obtained from the oil wells (Finu-1, Namak-1, Sefidar Naura-1, Anjir-1, Kuh-e-Siah-1, Dalan-1 and 2). Fortunately, both surface and subsurface samples were rich in palynomorphs and they made it possible to determine the exact age span of the Faraghan formation. By the preliminary studies, it was decided for more detailed palynological works on the Faraghan formation. Therefore the author measured and

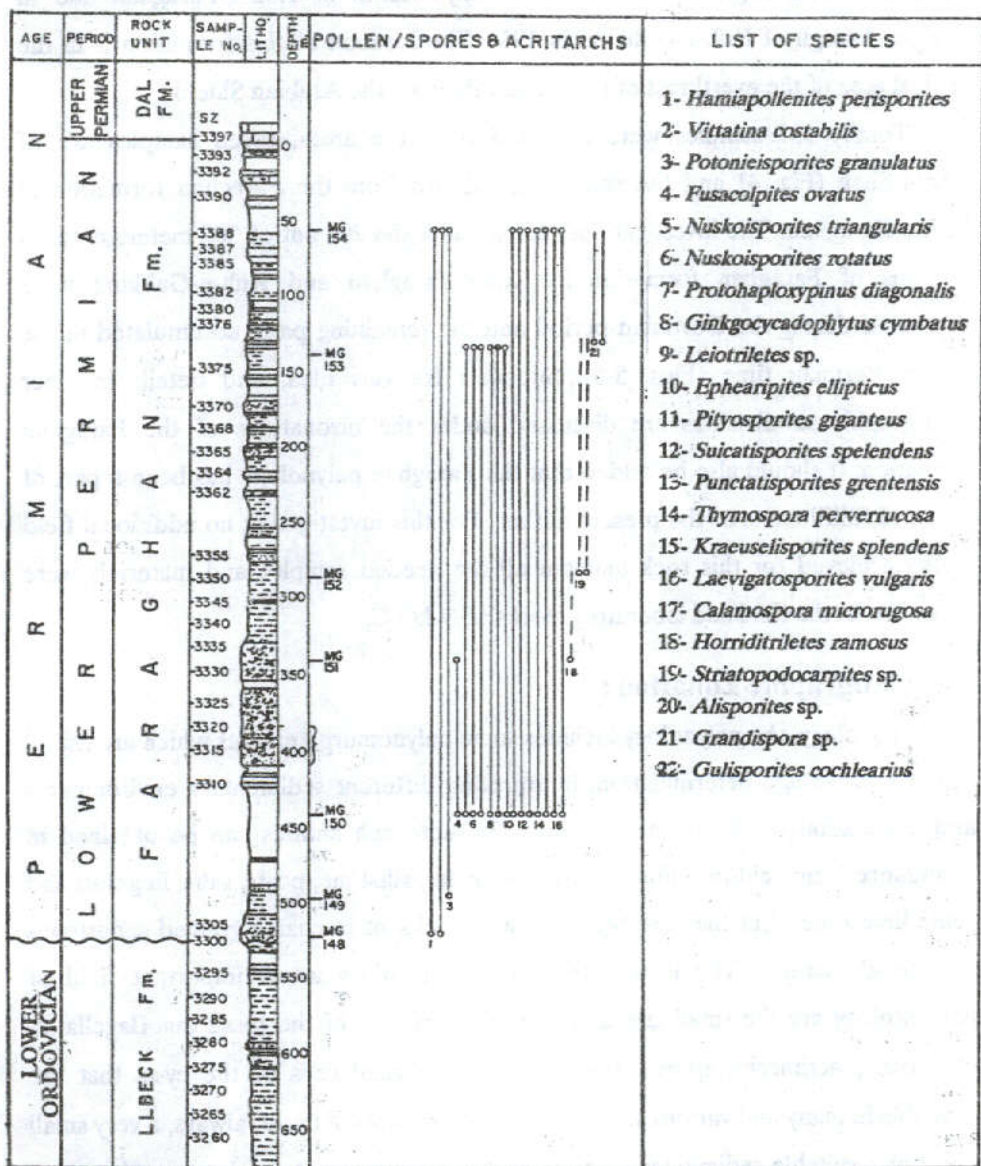


Fig.4 : Stratigraphic distribution of pollen and spores of the Faraghan formation in Chal-i-Sheh area(After Szabo, Rask & Khosravi1977)