The Triassic of Aghdarband (AqDarband), NE-Iran, and its Pre-Triassic Frame				Editor: Anton W. Ruttner
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Geodynamic Significance of Recent Discoveries of Ophiolites and Late Paleozoic Rocks in NE-Iran (Including Kopet Dagh)

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With 7 Figures

NE-Iran
Khorasan
Aghdarband
Mashad
Fariman
Torbat-e-Jam
Devonian
Carboniferous
Permian ophiolites
Scythian
Kimmerian orogeny

Contents

Zusammenfassung

Geländearbeiten eines Teams des Geological Survey of Iran (1985–1988) im nördlichen Bereich des Blattes Torbat-e-Jam (Quadrangle Map of Iran, 1 : 250.000) erbrachten neue, zusätzliche Ergebnisse, die hier mitgeteilt werden, soweit sie für das Gebiet von Aghdarband von Bedeutung sind.

- Nördlich der Trias von Aghdarband ist eine Gesteinsfolge aufgeschlossen, die nicht nur Ober-Devon (Frasnian, Fammenian), sondern auch Unter-Karbon (Tournaisian) umfaßt. Diese Gesteinsfolge entspricht der Geirud-Formation und dem Mobarak Limestone des zentralen Alborz, bzw. dem oberen Teil der Koshyeilagh-Formation des östlichen Alborz.
- 50 Kilometer südwestlich von Aghdarband treten ozeanische Sedimentgesteine und Vulkanite unter ihrer jurassischen Bedeckung zutage. Es sind schwach metamorphe Schiefer, feinsandige Turbidite, Radiolarite und rote kieselige Schiefer, die zusammen mit spilitischen Diabasen (z. T. mit Pillow-Strukturen), Andesiten und ultrabasischen Gesteinen die Mashhad-Fariman-Torbatjam-Depression an deren Nordost-Seite der ganzen Länge nach begleiten. Der Metamorphosegrad nimmt in dieser Zone gegen Südosten ab. Es können zwei tektonische Einheiten unterschieden werden. In der tieferen Einheit sind größere und kleinere Körper von spätigem Kalk in die ozeanischen Gesteine eingeschlossen; in ihnen wurde eine Mikrofauna des Unter-Perms nachgewiesen. Sowohl die Deformation wie die Metamorphose der Gesteine dieser Zone wird der Kimmerischen Orogenese zugeordnet. In der SW-Ecke des Erosionsfensters von Aghdarband (Darreh Anjir, etwa 15 km SE des Ortes Aghdarband) sind ophiolitische Gesteine von Mélange-Charakter aufgeschlossen. Dort wurde in einem Kalk-Block eine Mikrofauna des Ober-Perm gefunden.

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- Eine mächtige Schichtfolge bestehend aus roten (und grünen) Schiefertonen, Sandsteinen und Konglomeraten – vorläufig Qara Gheitan-Formation genannt – ist südlich des engeren Gebiets von Aghdarband aufgeschlossen. Kalkgerölle mit Mikrofaunen des Karbons und Ober-Perms einerseits und die Überlagerung durch den Sefid Kuh-Kalk des Ober-Skyths andererseits weisen auf ein Unter-Skyth-Alter dieser Schichtfolge.
- Unserer Auffassung nach ist der Kopet Dagh der extreme NW-Rand der Epibaikalischen Afro-Arabischen paläozoischen Plattform; wir können keinen Hinweis auf eine herzynische Orogenese erkennen, wie sie für die Turan-Platte bezeichnend ist.

Abstract

New findings were obtained during a mapping campaign carried out recently (1985–1988) by a team of the Geological Survey of Iran in the northern part of the Torbat-e-Jam Quadrangle Map. These findings are reported and discussed here as far as they are relevant to the Aghdarband area:

- The rocks exposed to the north of the Triassic of Aghdarband ("Northern Frame") comprise a sequence from the Upper Devonian (Upper Frasnian) to the Lower Carboniferous (Tournaisian). This sequence corresponds to the Geirud Formation and Mobarak Limestone (Central Alborz Mountains), and to upper parts of the Khoshyeilagh Formation (Eastern Alborz Mountains), respectively.
- Oceanic sedimentary and volcanic rocks outcrop below their Jurassic coverbeds 50 kilometers southwest of Aghdarband along the north-eastern side of the Mashhad–Fariman–Torbatjam depression. Metamorphosed shales and siltstones – the latter showing turbidity features –, radiolarites and radiolarian red shales are exposed at the whole length between Mashhad and the Afghan border, together with spilitic diabase – partly showing pillow structures – and andesite as well as with ultrabasic rocks. The grade of metamorphism decreases from Mashhad towards southeast. Two structural units can be distinguished. Bodies consisting of sparry limestone interposed in the lower unit yielded an Early Permian microfauna. Ophiolitic rocks of mélange character are exposed in the southwestern corner of the erosional Window of Aghdarband, 15 km WSW of the village Aghdarband (Darreh Anjir). There, a limestone block yielded a microfauna of Late Permian age.
- A thick sequence consisting of red (and green) shales, sandstones and conglomerates, informally named Qara Gheitan Formation, is exposed in the area to the south of the Aghdarband area. Its Early Scythian age is indicated by limestone pebbles containing microfaunas of Carboniferous and Late Permian age, and by its position below the Late Scythian Sefid Kuh Limestone Formation. Basal parts of the Qara Gheitan Formation rest transgressively on ultrabasic rocks at Darreh Anjir.
- Both the deformation and the metamorphism in the zone situated to the north of the Fariman-Torbatjam lineament is attributed to the Kimmerian orogeny.
- We consider Kopet Dagh to be the extreme NW-margin of the epi-Baikalian Afro-Arabian Paleozoic Platform, and we can not find any evidence of a Hercynian Orogeny as it is defined with regard to the Turan Plate.

1. Introduction and Review of Previous Work

Pre-Liassic rocks from the Aghdarband region were reported for the first time by K. T. GOLDSCHMID (1956). Lithologically, these rocks are different from those of the Paleozoic platform of Iran. J. STÖCKLIN (1973) considered this area to be a part of epi-Hercynian substratum (Tectonic Map of Iran, G. S. I.) and later (1977), in his proposed classification, included Kopet Dagh in the "Northern Domain" situated at the southern edge of the Hercynian Turan block of Central Asia. A. W. RUTTNER (1984) for the first time, undertook a detailed study of the area. The results were published in two preliminary papers (1983, 1984) and are presented now in this volume (including a geological map of the Aghdarband area 1:12.500) in which the stratigraphy of the Triassic rocks of the Aghdarband area is described in detail on the basis of intensive field work and paleontological studies.

In the above mentioned preliminary publications, RUTTNER described some occurrences of Upper Devonian rocks and he also attributed provisionally some marbles and crystalline limestones to the Precambrian, and concluded that the Triassic of Aghdarband unconformably overlies a Hercynian folded basement.

Systematic mapping by the Geological Survey of Iran for the preparation of Trobat-e-Jam Quadrangle (lat. 35°–36°, long. 60°–61° 30') on a scale of 1 : 250.000 was started in 1985 by the present writers. On the basis of recent findings, a different series of events in the pre-Bajocian geodynamics of the region can be proposed. A comprehensive report will be published after the compilation of all laboratory and field data. Meanwhile, at the encouragement of Dr. RUTTNER himself, we present a short summary of relevant findings and the corresponding conclusions. A preliminary geological map of the NE Khorasan province is presented (Fig. 1) while the Aghdarband area is shown separately as Fig. 2 which incorporates RUTTNER's map (1984). Our recent work has revealed the following facts:

2. The Pre-Triassic Rocks of Aghdarband

Exposures of rocks older than the Triassic were first reported by A. W. RUTTNER in 1983 from the "north and south frame" of the Aghdarband area. The former exposure, located to the south of Kashaf Rud, is a sequence of volcano-sediments, shale and carbonatic rocks. In the limestone intercalations, SCHÖNLAUB determined Upper Devonian conodonts (this Vol.). RUTTNER believed that this sequence unconformably overlies crystalline marble and limestone which were attributed provisionally to the Proterozoic or Early Paleozoic (Fig. 3).

Recent observations in different sections including Annabeh valley and north of Aghdarband have revealed

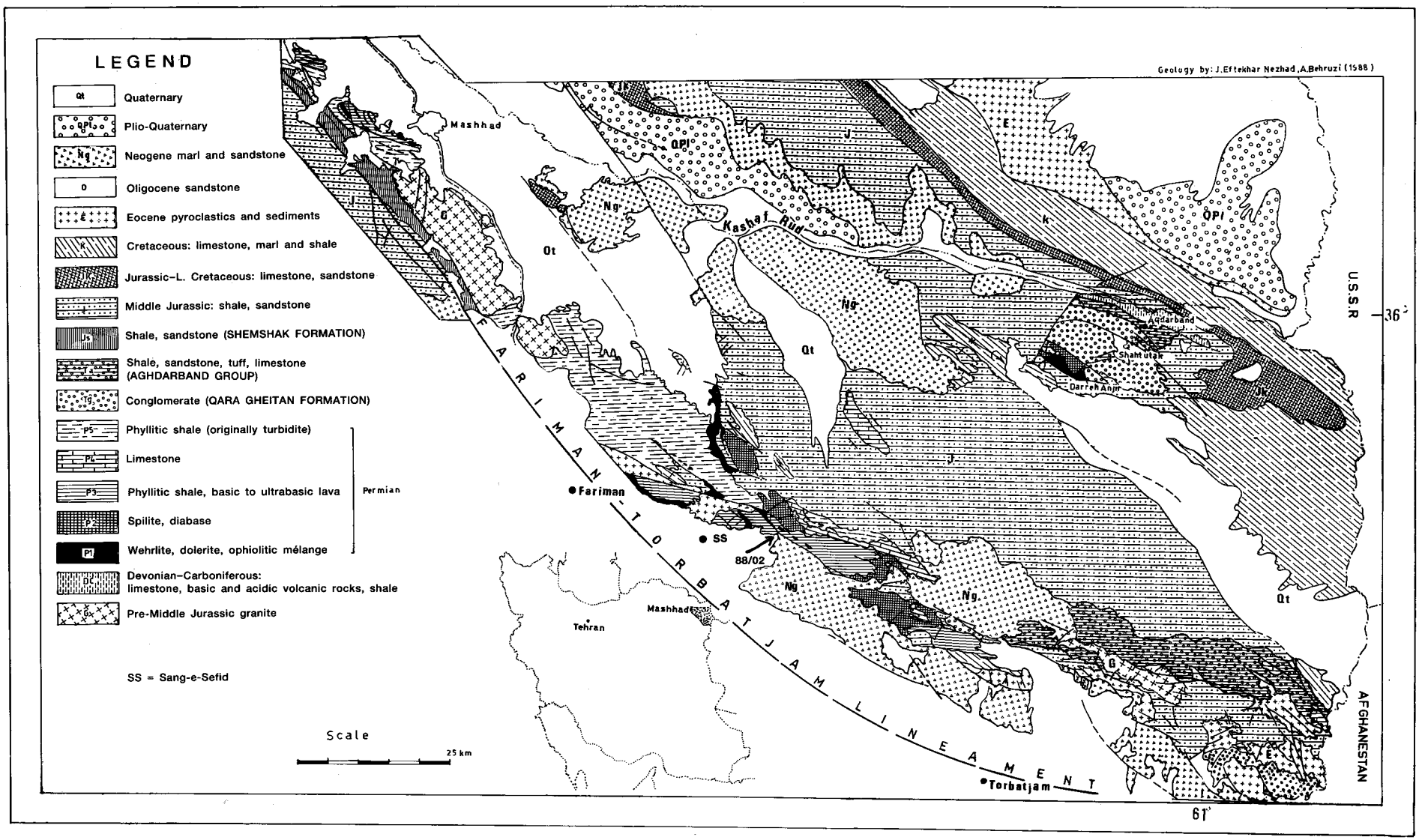
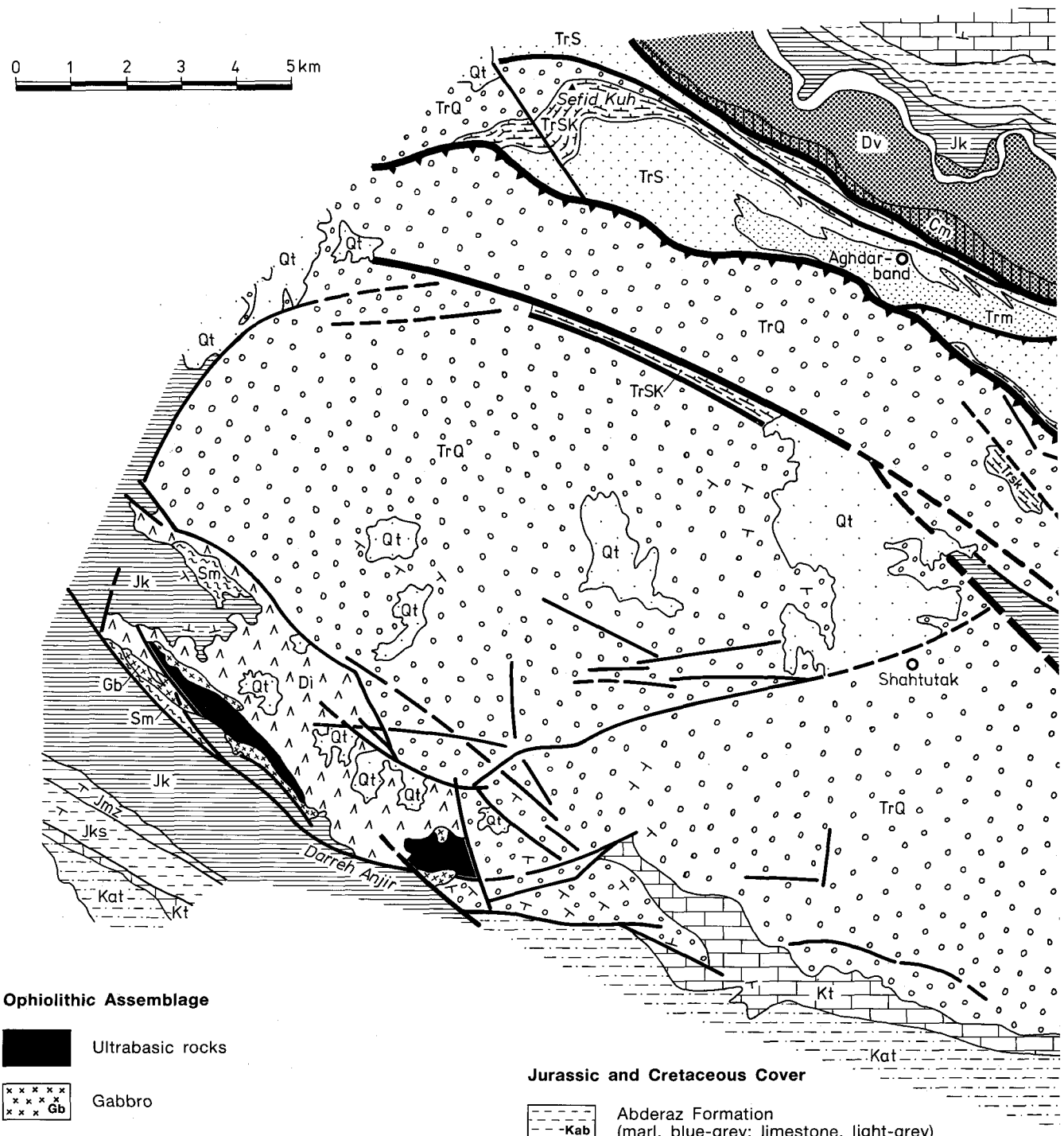


Fig. 1.
Preliminary geological map NE of Koresan



Ophiolithic Assemblage

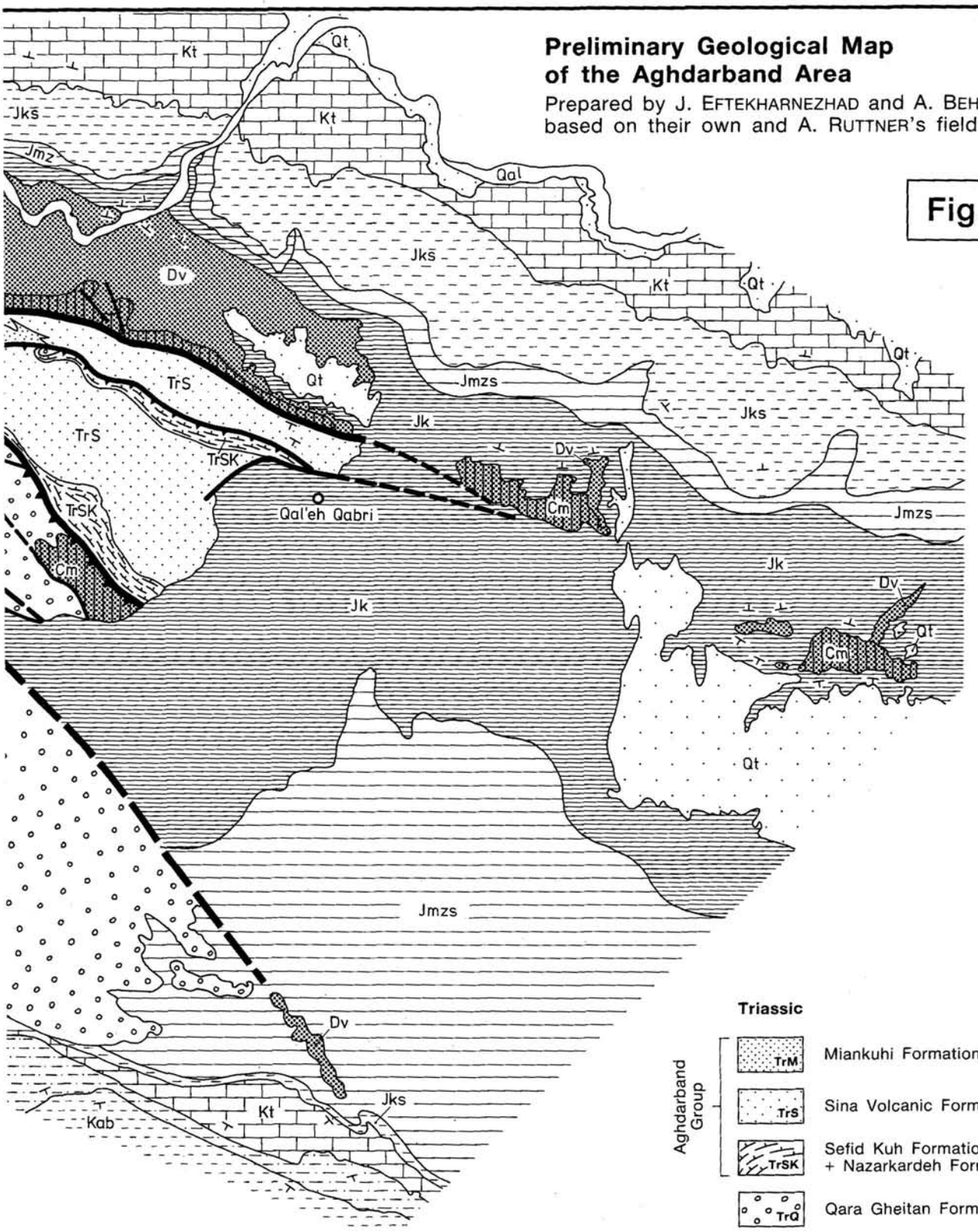
- Ultrabasic rocks
- Gb — Gabbro
- Sm — Phyllitic rocks and intercalated recrystallized limestone
- Di — Diabasic rocks subordinate tuffs, radiolarite, radiolarian chert, calcareous and radiolarian siltstone

Quaternary

- Qal — Alluvium
- Qt — Terraces, Loess

Jurassic and Cretaceous Cover

- Kab — Abderaz Formation (marl, blue-grey; limestone, light-grey)
- Kat — Atamir Formation (sandstone, shale)
- Kt — Tirgan Formation (limestone, light-grey)
- Jks — Shurijeh Formation (sandstone, red)
- Jmz — Mozduran Formation (limestone)
- Jmzs — Mozduran Formation (sandstone, conglomerate, grey)
- Jk — Kashafrud Formation (sandstone, shale, silt, dark grey)



Preliminary Geological Map of the Aghdarband Area

Prepared by J. EFTEKHARNEZHAD and A. BEHROOZI based on their own and A. RUTTNER's fieldwork.

Fig. 2

Triassic

Aghdarband Group

- TrM — Miankuhi Formation
- TrS — Sina Volcanic Formation
- TrSK — Sefid Kuh Formation + Nazarkardeh Formation
- TrQ — Qara Gheitan Formation

Paleozoic

- Cm — "Marble" and crystallized limestone, light-grey; conglomerate, tuffaceous cement (*Lower Carboniferous*; Mobarak Limestone)
- Dv — Volcaniclastics, limestone and shale intercalations (*U. Devonian*)

Graphik: J. Ruthner

facts some of which do not agree with RUTTNER's interpretations. Briefly, these are:

1) Several samples were taken from recrystallized limestone intercalations from RUTTNER's Upper Devonian rocks. In spite of the slight metamorphism B. HAMDI (G. S. I.) has determined the following foraminifera:
   Lunucammina sp.
   Archaesphaera sp.
   Saccaminopsis sp.
   Endothyra ? sp.
   as well as
   Algae
   Shell fragments
   Microgastropoda

   *

   Also, the samples were rich in conodonts and the following species were identified (B. HAMDI):
   Polygnathus sp.
   Polygnathus cf. *xylus* ZIEGLER & KLAPPER
   Polygnathus normalis MILLER & YOUNGQUIST
   Roudya sp.
   Prioniodina sp.
   Prioniodina Prona (HUDDLE)
   Ozarkodina sp.
   Polygnathellus sp.
   Bryantodus sp.
   Ligonodina sp.
   Camtognathus sp.
   Engr. *Neoprioniodus*.

   *

   The entire assemblage has been attributed to the upper Frasnian – lower Famennian by HAMDI. This age agrees with that found by SCHÖNLAUB.

2) A conglomerate layer occurs in the upper part of this sequence, composed of recrystallized limestone pebbles cemented by green tuffaceous material. RUTTNER believed that the conglomerate was at the base of the upper Devonian succession which unconformably overlies Proterozoic–Early Paleozoic marbles. Samples from the limestone pebbles of this conglomerate yielded the following microfauna (HAMDI):
   Lonchodina sp.
   Hindeodella sp.
   Polygnathus sp.
   Polygnathus cf. *webbi* STAUFFER
   Neoprioniodus sp.
   Prioniodina sp.
   Ligonodina sp.
   Fish tooth and crinoid stem segments

   *

   On the basis of the faunal assemblage HAMDI suggested a late Devonian–early Carboniferous age. In other words, it represents a transition from Devonian to Carboniferous. This indicates the conglomerate beds should be on the top of the Devonian sequence, which is contrary to RUTTNER's idea that the conglomerate lies at the base of the sequence.

3) In RUTTNER's structural section (Fig. 3) the conglomerate unconformably overlies the Proterozoic–Early Paleozoic marbles with an overturned contact. He suggests that the main deformation and crystallization of marbles was related to the Caledonian or Precambrian orogeny. These marbles are massive but, in the lowermost part, beds of grey recrystallized biomicritic limestones can be seen. Samples from these biomicritic limestones taken north of the Aghdarband village yielded the following fossils (HAMDI):
   Parathurammina sp.
   cf. *Saccaminopsis* sp.
   Earlandia sp.
   Chaesphaeva sp.
   Archaesphaera cf. *minina*
   Diplosphaerina sp.
   Lunucammina sp.
   Microgastropoda

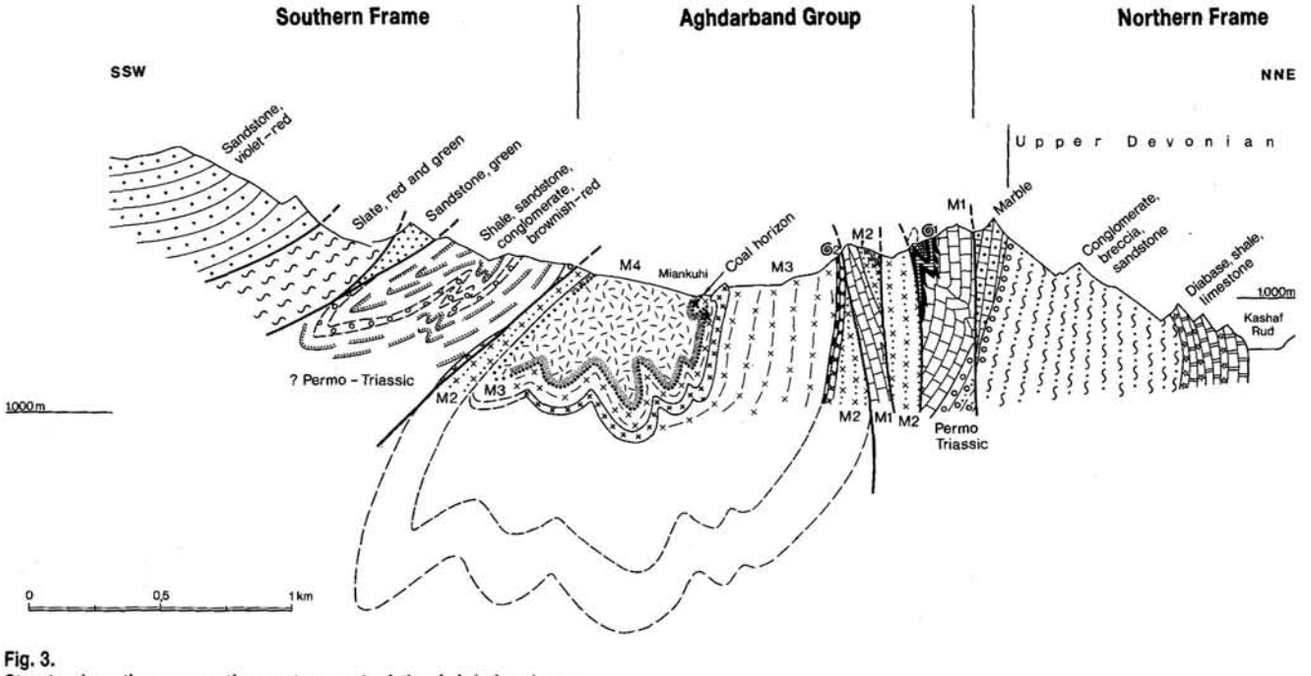


Fig. 3.
Structural section across the western part of the Aghdarband area.
After A.W. RUTTNER (1984).

HAMDI suggested a Lower Carboniferous (Tournaisian) age and believed it to be a transition bed from Upper Devonian (Famennian) to Lower Carboniferous. Several samples from the upper massive part of the marble (with a light colour) yielded the following foraminifera:

Paleotextularia sp.
Tolypammina sp.
Trochammina sp.
Lituotuba sp.
Archaesphaera sp.

and several other fossils such as:

Coral (colonial Rugose coral)
Crinoid stem segments
Microgastropoda
Ostracods (upper Paleozoic type)
Echinoid spines
Echinoderm stem segments
Fish teeth
Fish scale
Fish plate

One Sample yielded Holothurian sclerites. HAMDI proposed a Lower Carboniferous to Permian (?) age on the basis of the above mentioned fossils.

*

In general, the entire sequence including volcanisediments and the overlying marbles belongs to the Upper Devonian– Carboniferous. This can be correlated lithologically with similar rock sequences of the Geirud Formation (in the Central Alborz mountains) of the same age (R. ASSERETO & M.G. GAETANI, 1964). The lower part of the sequence which mainly consists of volcanisediments with limestone and shale intercalations can be correlated with the A-member, and the upper carbonatic unit with members B, C and D of the Geirud Formation. Or, the carbonate unit can be the equivalent of Mobarak Limestone in Central Alborz. The upper unit of Khoshyeilagh Formation and the Mobarak Limestone of eastern and central Alborz (F. BOZORGNIA, 1975) correspond to the lower and upper parts of this sequence respectivey. Also the whole sequence can be correlated with members 7 and 8 of HAMDI's section from the eastern part of the central Alborz (1981).

In eastern Alborz, the Kuh-e-Kurkhurd Quadrangle (lat. 37–38°, long. 55° 30'–57°; 1 : 250.000), M. SOHEILI (1981) has reported limestone similar to the upper carbonatic portion of this sequence from two localities south and south-west of Kopet-Dagh. These limestones have been correlated with the Mobarak limestone of Carboniferous age.

In addition, Devonian limestones of the Annabeh valley have shown traces of phosphorite which are similar to phosphatic horizons in the upper Devonian Member A of the Geirud Formation in Central Alborz (M. MOVAHHED, M. SAMIMI & R. GHASSEMIPUR, 1968; R. ASSERETO, 1969).

On the basis of these arguments, we conclude that the above mentioned marbles overlie Devonian–Carboniferous volcanisediments in a normal sequence. Further, these marbles are younger than any orogenic movements of Precambrian or Caledonian age in the Turan plate. Metamorphism and deformation is a local phenomenon as shown by the fact that the Carboniferous limestones are more affected than the Devonian rocks south of Kashaf Rud. We believe that the metamorphism of the Carboniferous marbles should be related to some younger orogeny which has also affected the lower Triassic limestones east of Aghdarband.

3. Permian Events

Significant differences become apparent when comparing the Permian sediments on either side of the NW–SE trending Fariman–Torbatjam depression which can be regarded as a major lineament. This is well reflected in the contrast between the lithology of Permian rocks in the NW trending mountain ranges on either side of this lineament.

During the early Permian, shallow marine carbonate with basal clastic sandstone were deposited in an epicontinental environment to the SW of the Fariman–Torbatjam depression. Similar environments prevailed in Central and North Iran. Northeast of the depression an oceanic trough had developed and oceanic volcano-sediments were accumulated in great thickness. Submarine basic and ultrabasic volcanics with intercalations of fine clastic rocks, carbonates, radiolarite and radiolarian red shale constitute the lower part of the sequence. Fine clastic sediments and phyllitic shale dominate the upper part (with a few intercalations of basic spilite and recrystallized limestone) which has a transitional contact with the lower part. Turbidity current features such as flow casts are common in the fine clastic rocks (Figs. 4). Pillow structure can be seen in spilitic diabase (Fig. 5) and andesite as well as in ultrabasic submarine flows (mainly wehrlite). Locally spilite and pillow breccia are cemented by radiolarian chert (Fig. 6). According to B. MAJIDI (1981) ultrabasic rocks of the lower sequence around Mashhad can be classified as magnesium-rich type of abyssal tholeiite. This complex is well exposed in the NW–SE trending range from Mashhad to the Afghan frontier with a gradual increase in the thickness of the carbonatic rocks towards the North and NW of Torbatjam.

The whole sequence was subjected to strong deformation and metamorphism. Around the Mashhad granite it is highly affected by dynamothermal metamorphism. It is rather difficult to find any evidence for the age of the original rock and the sequence was considered to be an exposure of Precambrian age. MAJDI (1981) recognized the above mentioned two lithostratigraphic units and correlated them with lithologically similar complexes in the Hindu Kush and Tian Shan. He also identified the Mashhad metamorphic rocks with the Hercynian chain and suggested that the northern Alborz mountains including the Binalud range west of Mashhad had originated during the Late Devonian–Early Carboniferous orogenic phase.

Regional study of the complex by present authors revealed some fundamental data which must be taken into account in any structural interpretation of the region. The grade of metamorphism considerably decreases from Mashhad to the southeast. East and SE of Fariman (Robat and Gandab villages) the intercalated limestone is slightly recrystallized and rather rich in well preserved microfaunas. Samples collected from a fossiliferous oncolitic sparite bed of the lower unit

Fig. 4.
Flow casts in sandy slates.
Tangel-e-Robat, W of Sang-e-Sefid.
Photo: A.W. RUTTNER.

Fig. 5.
Spilitic diabase with pillow structure.
Shahan Germab village, NE of Fariman.
Photo: J. EFTEKHARNEZHAD.

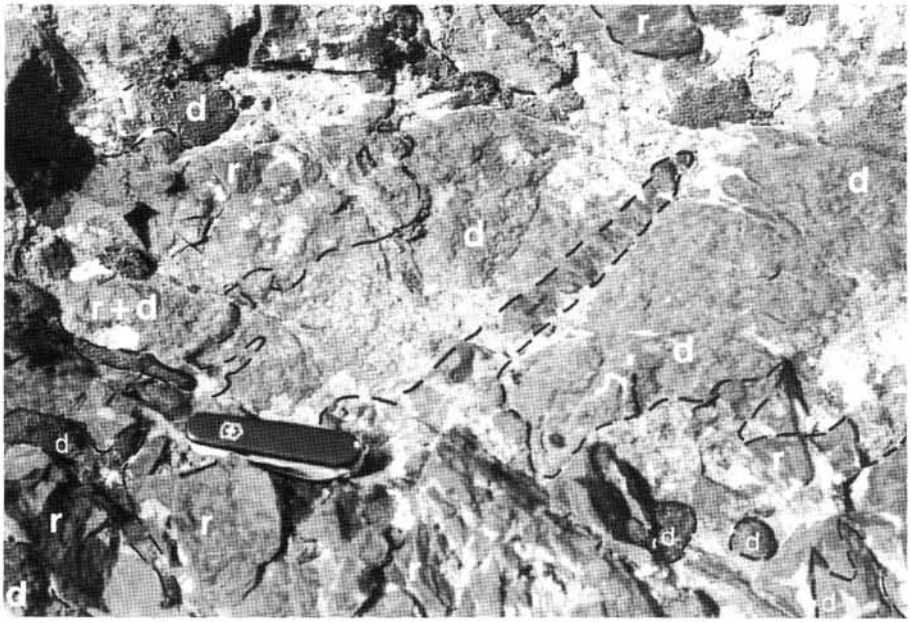


Fig. 6.
Reddish chert (r) and spilitic diabase (d).
Road to Shahan Gerab village, NE of Sang-e-Sefid.
Photo: A.W. RUTTNER.

which is intercalated within the basic, ultrabasic submarine flows and radiolarian shale have yielded the following fossils:

Girvanella permica PIA
Triticites sp.
Schwagerina sp.
Echinoid remains

F. BOZORGNIA determined their age as Asselian to Sakmarian.

Another sample of fossiliferous sparite in the upper level from the lower unit showed:

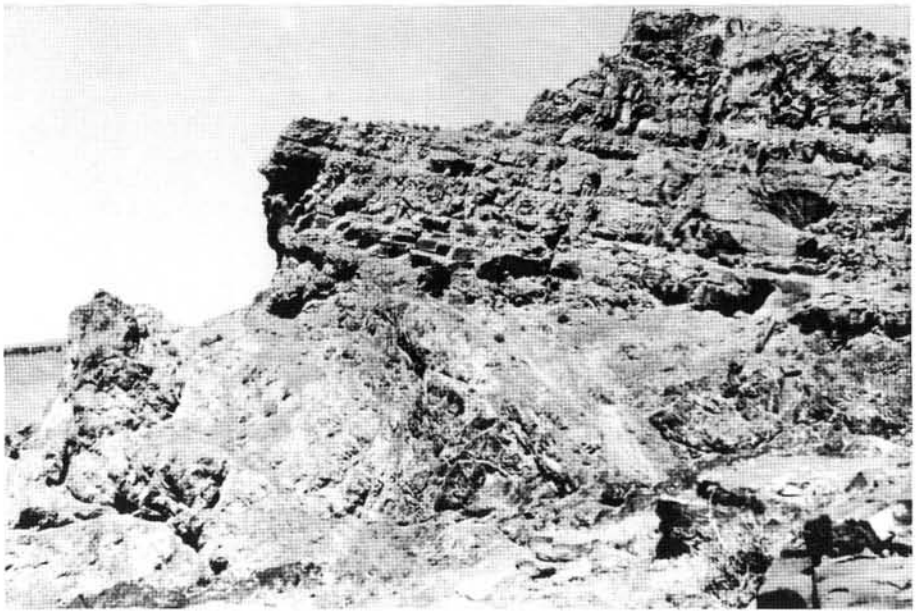
Eotuberina reitlingeri MIKBITRO-MUKLAY
Schwagerina sp.
Climacammina sp.
Geinitzina cf. *reporta* BIKOVA
Tetratanis conica EHRENBERG
Globivalvulina NONDER
Schwagerina schmiltu REICHEL
Condonofisulla sp.
Schubertella sp.

F. BOZORGNIA assigned them a Sakmarian to Murghabian age. Recently, a sample of true oceanic sedimentary rock, i.e. a reddish chert, has been found to contain pelagic conodonts of highest Permian age (cf. H. KOZUR & H. MOSTLER, this vol.). The whole sequence is strongly tectonized, and the total thickness for the lower unit is estimated to be 800 m.

The upper unit which is widely exposed around SE of Mashhad appears as a monotonous sericitic schist and graditionally changes to phyllite and slate NE of Fariman. The thickness of this unit is estimated to be more than 2000 m. There is no fossil evidence for the exact age of the upper unit, and judging from its stratigraphical position a Late Permian to very Early Triassic (?) age may be suggested.

Ophiolitic rocks crop out also about 40 kilometers farther to the North in the area of Darreh Anjir, which is situated about 20 kilometers to the SW of Aghdarband (cf. Fig. 2). There, these rocks are a ophiolitic melange mainly, consisting of diabasic rocks and – subordi-

Fig. 7.
Unconformity between Kashaf Rud Formation (Bajocian) and Permian ophiolitic melange.
Darreh Anjir, SW of Aghdarband.
Photo: J. EFTEKHARNEZHAD.



nately – of tuff, radiolarite, radiolarian chert, radiolarian siltstone, and calcareous siltstone. Besides this melange, there are also outcrops of ultrabasic rocks, gabbro, phyllitic shale, and recrystallized limestone. To the South, both these ophiolitic rocks of Darreh Anjir and those of Fariman are unconformably overlain by the Jurassic Kashafrud Formation (Fig. 7).

East of Cheshmeh Anjir – at the road to Mazrieh Shahtutak – an isolated block of limestone (biocalcarenite to calcirudite, in part pelmicrosparite) associated with ophiolitic mélange yielded the following microfossils:

Geinitzina cf. *chapmani* SCHUBERT var. *Longa* sul.
Geinitzina aff. *reperta* BIKOVA
Geinitzina sp.
Hemigordius sp.
Agathammina sp.
Reichelina sp.
Stafella sp.
Climecamina sp.
Ictyolaria sp.
Tuberitina sp.
Globivalvulina sp.
Paraglobivalvulina sp.
Macroporella sp.
Mizzia sp.
Vermiporella sp.
Dagmartia sp.
Agathammina sp.
Worm traces
Algal debris

F. KASHANI and F. BOZORGNIA assign this fauna to the Late Permian (Early Julfian).

4. Mesozoic Events

4.1. Triassic Rocks (Qara Gheitan Formation)

South of Aghdarband, extensive red and green exposures of shales, sandstones intercalated conglomerate, basic lavas and tuffs can be seen. RUTTNER has reported similar occurrences northwest of Aghdarband (south of Qara Gheitan village) and proposed the informal name Qara Gheitan Formation for this assemblage. However, this unit is better developed south and southwest of Aghdarband, and its extreme southern limit is defined by an apparently faulted contact with the ophiolitic rocks of Darreh Anjir. East of the Darreh Anjir village however, a normal transgressive contact with an ultrabasic and gabbroid rock (a component of ophiolitic melange) has been seen. Here the conglomerate with subrounded pebbles of basic-ultrabasic rocks, radiolarian chert (mainly derived from the underlying Ophiolitic Melange) constitute the basal part of the Qara Gheitan Formation.

At this northern limit this unit is thrust over rocks of the Aghdarband Group (Fig. 2) near Mazrieh-e-Shahtut (south-east of Aghdarband). The upper part of the Qara Gheitan Formation shows green tuffaceous facies which is apparently similar in lithology to Member 2 of the Aghdarband Formation (RUTTNER, 1983, 1984) or to the Sandstone Member of the Sina Formation (Aghdarband Group) respectively (RUTTNER, this vol.). This tuffaceous part transitionally changes to a vermicular limestone (carbonate facies) which has been named as Sefid Kuh Formation (this vol.).

It seems that the vermicular limestone occurs as a lens within the green tuffaceous part which is lithologically similar to the Sandstone Member of the Sina Formation.

The above-mentioned evidence indicates that the Qara Gheitan Formation underlies the Aghdarband Group with a transitional contact. There is no evidence of any disconformity between the two formations as suggested by RUTTNER. Several samples were taken from the limestone pebbles of intercalated conglomerate beds within the Qara Gheitan Formation from the south and southwest of the Aghdarband area. F. KASHANI has determined the following microforaminifera which indicate a Carboniferous age for the pebbles:

Tetrataxis cf. *hemisphaerica*
Lysella sp.
Pseudolituotubella cf. *tenuissima*
Eoparastafella cf. *simplex*
Septabrunsiina cf. *Kingirica*
Endothyra sp.
Tetrataxis planolata
Earlandia sp.
Archaediscus sp.
Septarunsiina sp.
Msitina sp.
Textularidae
Paleospiroplectammina sp.
Archaedisucs cf. *tchalussensis*
Diplosphaerina cf. *inaequalis*
Pseudolitutubella sp.
Crinoids
Gastropoda
Shell debris
Coral
Brachiopoda fragments

A single sample also yielded the following late Permian fossils:

Agathammina sp.
Agathammina cf. *pusilla*
Shell debris

All the above-mentioned evidence suggests post-Late Permian possibly Early Scythian age for the Qara Gheitan Formation.

4.2. Kimmerian Orogenic Event

A Kimmerian orogenic phase was responsible for the most intense deformation and other consequences in the NE Fariman–Torbatjam lineament in Early Jurassic time. The movement was succeeded by an important thermal flow and successive phases of granitic intrusion with contact metamorphism. The youngest sediments affected by metamorphism have been dated as Liassic (Shemshak Formation) in the Binalud Range west of Mashhad (A. AGHANABATI & M. SHAHRABI, 1987), where Rhaetian–Liassic metamorphic rocks are transgressively overlain by non-metamorphic Bajocian marine sediments. The underlying metamorphic and granitic rocks dominate the pebbles of the Bajocian basal conlgomerate. This is also well evidenced in the mountain ranges east of Fariman and north of Torbatjam along the border with Afghanistan. The effects of

Kimmerian events become more obvious north of Torbatjam where coal-bearing sediments i. e. Miankuhi Formation of the Aghdarband Group have been affected by dynamothermal metamorphism and related plutonism as already described from the Mashhad region. Here, the Kimmerian orogeny is also well documented by a pronounced unconformity between the base of the non-metamorphosed Bajocian Kashaf Rud Formation and the underlying upper Triassic metamorphic rocks. The associated granite intrusion has been dated at 153±5 Ma. by Y. GUILLOU (1978); this indicates a rather late (early Late Jurassic) consequence of this orogeny.

The metamorphism related to Kimmerian Orogeny is not restricted to the NE of Khorassan Province, but it has been reported from many localities in central Iran. The deformation, metamorphism and related plutonism were limited in extent, but quite pronounced in a narrow ring-shaped zone surrounding the eastern Lut and northern parts of the central desert (EFTEKHAR NEZHAD, 1980). Metamorphic rocks from Mashhad to the Afghan border constitute the NE portion of this zone. It is assumed that due to the Kimmerian folding and granitization, parts of the central Iran (Dasht Kavir and Lut Block) attained a considerable degree of stabilization.

5. Discussion and Conclusion

❶

Late Devonian–Carboniferous rocks of the Aghdarband area are lithologically similar to the well-known stratigraphically equivalent formations in central and eastern Alborz (Geirud Formation and Mobarak Limestone). It seems that the central and northern slopes of Alborz including Kopet Dagh constitute the narrow shelf margin of the Epi-Baikalian Afro-Arabian Platform. There are no evidences for the „Hercynian Orogeny" that took place strictly in the Late Paleozoic as it is defined in the Turan plate of Central Asia.

❷

Tensional tectonic forces affected the northern margin of the Afro-Arabian platform during the Early Permian. The magma was erupted as basic and ultrabasic flows in a tensional crustal setting and the subsiding trough took shape NE of the Fariman–Torbatjam lineament (widening towards the NE); this trough forms a great portion of the present Mesozoic substratum of Kopet Dagh. The process may have continued until the development of oceanic rift and appearance of true oceanic crust in the axial part (Dareh Anjir: south of Aghdarband), where ophiolitic rocks along with co-eval sedimentary rocks occur in a chaotic mixture as ophiolite melange. It can be also assumed that the ultramafic rocks of southern Aghdarband could be obducted mantle slabs of the upper mantle.

The possibility that the basic and ultrabasic rocks around Mashhad could be a relict of the Paleotethys which separated Gondwanaland from Angaraland in Paleozoic time was suggested by STÖCKLIN (1974). However, we consider these rocks to be Permian rift volcanics, and true ophiolitic complexes representing oceanic crust are exposed around southern Aghdarband.

The existence of an oceanic trough in SE Kopet Dagh (Dareh Anjir) also contradicts the idea that Aghdarband in the SE Kopet Dagh was a southern extension of the central Asian Hercynian basement as believed by many authors.

❸

The tensional stress terminated and was followed by compressional movements in the very Late Permian. Later, the separated blocks collided to produce an ophiolitic melange which was subsequently uplifted and exposed to erosion. Pebbles from the basal conglomerate of the Qara Gheitan Formation to the east of Dareh Anjir mostly consist of the underlying ophiolitic complex as well as radiolarian chert and carbonatic rocks of Permian age. Considering all these facts, the age of the Qara Gheitan Formation can be assigned to the pre-Late Scythian possibly Early Scythian.

❹

It is possible to find pebbles of Hercynian granite derived from the Turan Plate in the conglomeratic beds of the Qara Gheitan Formation, because the collision between the Afro-Arabian and Turan plates took place before the deposition of the Qara Gheitan Formation in the Early Triassic.

❺

The metamorphic rocks of NE Fariman-Torbatjam and Mashhad fall within the NE part of the narrow zone of metamorphic rocks (EFTEKHAR NEZHAD, 1980) which follow the trend of the Ophiolite Ring surrounding the Lut and central desert (STÖCKLIN, 1974). This ring-shaped zone is characterized by metamorphism related to the younger phenomenon of the Kimmerian orogeny (pre-Bajocian).

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