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Biostratigraphic Correlation of Elikah Formation in Zal Section (Northwestern Iran) with Ruteh and Type Sections in Alborz Mountains Based on Conodonts

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Abstract

Conodonts are the most important fossil remains from the largest Phanerozoic extinction as well as the mass extinction of the late Paleozoic and could be used for exact dating during this period. Triassic deposits located in the Elikah Formation contain exposures in most of the Alborz sections as well as the Zal section in northwestern Iran. In this study, the Elikah Formation was investigated from a biostratigraphy point of view in the type section and Ruteh section of the Alborz Mountains and Zal section in the Jolfa region based on the existing conodonts. Biostratigraphy study of more than 300 samples taken from these three sections, resulted in the identification and introduction of the following conodont biozones: Taxone Range Zone *Hindeodus parvus* and *Pachycladina symmetrica – Pachycladina Oblique* Assemblage Zone in the type section, *Hindeodus parvus* Taxon Range Zone, *Hadrodontina – Pachycladina* Assemblage Zone and *Parachirognathus – Furnishius* Assemblage Zone in the Ruteh section and finally *Hindeodus parvus* Taxon Range Zone, *Isracicella staeschei* Taxon Range Zone and *Arachirognathus – Furnishius* Assemblage Zone in the Zal section. These biozones indicate that the Elikah Formation, in the three previously defined sections, is Early Triassic (Griesbachian). Additionally, comparison of the biozones in these sections illustrates a biostratigraphic correlation of Early Triassic deposits in the Zal, Ruteh and type sections.

Keywords: *Elikah Formation, biostratigraphic correlation, Early Triassic, conodonts, mass extinction.*

1. Introduction

Different events and their causes in PTB are among the complicated subjects that take into consideration by the geologists all over the world. There are several researches on extinction causes, biostratigraphy and biozones sepration in the world on this boundary[1,2,3,4,5,6,7,8,9,10,11 and 12]. Different studies have been carried out by Iranian-Japanese Research Group (IJRG) on PTB in Iran since 1969 [13].In addition, several biostratigraphic studies investigated in Iran on this boundary after that [13,14,15,16,17,18,19,20,21,22,23,24,25 and 26]. In spite of widespread studies on PTB, systematic investigations on Triassic sediments (Elikah Formation), specially based on conodonts, have not been carried out. Triassic deposits well exposed as the Elikah Formation in the Albroz Mountains and northwest of Iran. In this study, Elikah Formation has been studied from biostratigraphic point of view emphasizing on its boundaries in the type section in Elikah valley, Zal section and Ruteh section in Fasham region with special reference to conodonts. Event stratigraphy issues like sudden appearance of stromatolites, spreading of volcanic phenomena in the Late Permian have been studied as well. Additional biostratigraphic and lithostratigraphic correlations between them and other sections of Iran carried out.

2. Geographical Situation of Sections

In Alborz, the Triassic deposits exhibit great spreading and in some places, show considerable thickness. The Lower-Middle Triassic rocks of Alborz are limestone-dolomite carbonate successions known as “the Elikah Formation”. Glaus [27] studied and introduced the type section of the Elikah Formation, measuring 295m thick, in the Nour Valley located 5km downstream of the village of Elikah. The Triassic deposits in the Jolfa region of northwestern Iran indicate well exposures. One of the most beautiful outcrops of the Permo-Triassic can be observed in the Zal section. The facies changes of the Triassic deposits in the Alborz region of central Iran are known as the Sorkh Shale and Shotori Formations. The Elikah Formation is correlated to the Khaneh Kat Formation of the High Zagros and the Kangan and Dashtak Formations of the Folded Zagros [28]. In this study, the type section of the Elikah Formation is located in the Nour Valley, 5km downstream of the village of Elikah. The Ruteh section is located 30 km northeast of Tehran (village of Ruteh,

Fasham County) at 35° 58′ 28" N, 51° 31′ 37" E. The Zal section is situated in northwestern Iran, 20km south of Jolfa (2km north of the village of Zal) at 45° 35′ N, 38° 43′58.2" E. (Fig.1). It should be noted that biostratigraphy and determination of the Triassic deposits and biozones have not systematically been carried out in the mentioned sections.

3. Methods and Sample Preparation

Three hundred samples were taken from the Elikah Formation in the type section, Ruteh and Zal sections and the type and lithological composition of each layer was analyzed. The approximate weight of each sample varied from 4 to 5 kg. Microfossils were extracted using 99.98% pure citric acid. After collection, the conodonts were examined using a stereomicroscope. The microfossil elements were imaged using a Scanning Electron Microscope (SEM) model KYKYEM 3900 M belonging to the Applied Research Center of the Geological Survey of Iran.

4. Lithostratigraphy

The lower portion of the Elikah Formation contains various thicknesses of thin-bedded limestone and marly limestone, intercalated with marl and thin dolomite in the type section and other parts of both the Alborz and Zal sections. Cream to light grey, thin bedding and an abundance of trace fossils in the Elikah Formation's lower portion distinguishes it from the thick-bedded dolomites of the upper portion. The most frequently found fossils include bivalves (*Claraia*), small gastropods and trace fossils. The presence of an abundance of trace fossils in the thin-bedded limestone of the Elikah's lower portion led to the informal naming of this portion as vermiculate limestone. The presence of trace fossil bearing limestone, known as vermiculate limestone, is present throughout Iran and its neighboring countries. Various sections of the Elikah Formation, introduced as an Acme Zone, date to the Early Triassic. The sudden appearance of stromatolites in the early Triassic layers marks a bio event. Their appearance at the base of the Triassic is due to the loss of creatures and feeder microorganisms such as gastropods during the late Paleozoic extinction.

The upper portion of the Elikah Formation is composed of light colored, thick-bedded, dense dolomite-limestone carbonates of varying thicknesses (up to 1000m). Known as Elikah dolomites, they are cliff forming in appearance and except for rarely occurring microscopic fossils, contain no index fossils.

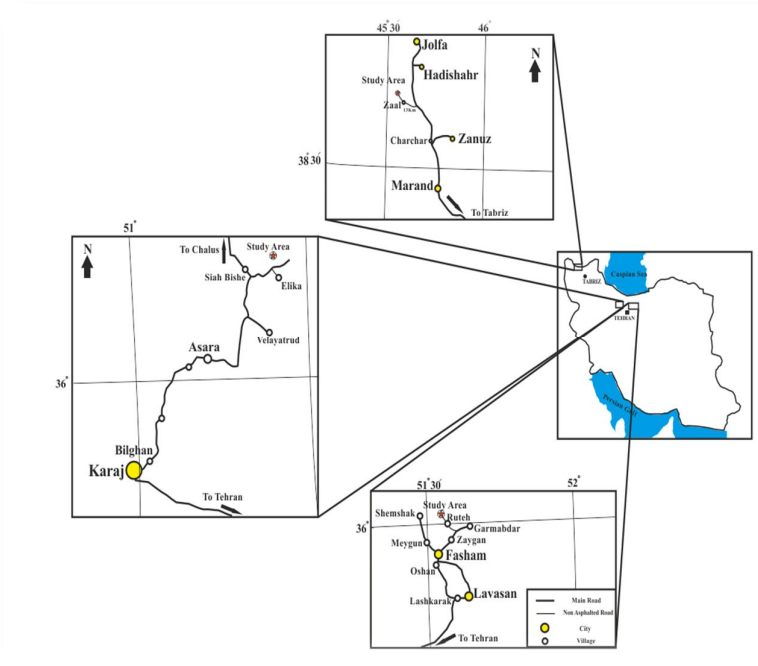

Fig 1: Location map of the studied section

4-1. Lithostratigraphy of Elikah Formation in Type Section

The Elikah Formation measures approximately 330m in the type section (Elikah Valley). It is composed of three carbonate units of alternating shale and thin to medium-bedded vermiculate limestone. The first unit contains 112m thick dolomite limestone while the second rock unit consists of alternating dolomitic

limestone and 100m thick, thin to medium-bedded dolomite. The third rock unit is comprised of alternating light to dark grey, thick to very thick-bedded, massive, cliff-forming dolomites. In the type section, the Elikah Formation rests on the chert-bearing limestone of the Nessen Formation by disconformity.

4-2. Lithostratigraphy of Elikah Formation in Ruteh Section

The thickness of the Elikah Formation in the Ruteh section is approximately 310m. It includes three carbonate rock units resting on the Nessen Formation by disconformity through a grey colored shale layer overlain by the Shemshak Formation through a gap. The first rock unit is 102m thick and includes alternations of thin to medium-bedded vermiculate limestone, thick-bedded to massive limestone containing dome stromalites and medium-bedded limestone containing bivalves and micro gastropod fossils.

The second rock unit is 85m thick and composed mainly of alternations of grey, medium-bedded to massive limestone. It contains storm deposits as well as sedimentary structures such as ripple marks. The third rock unit is 123m thick and includes alternations of thick to very thick-bedded, cliff-forming massive dolomite.

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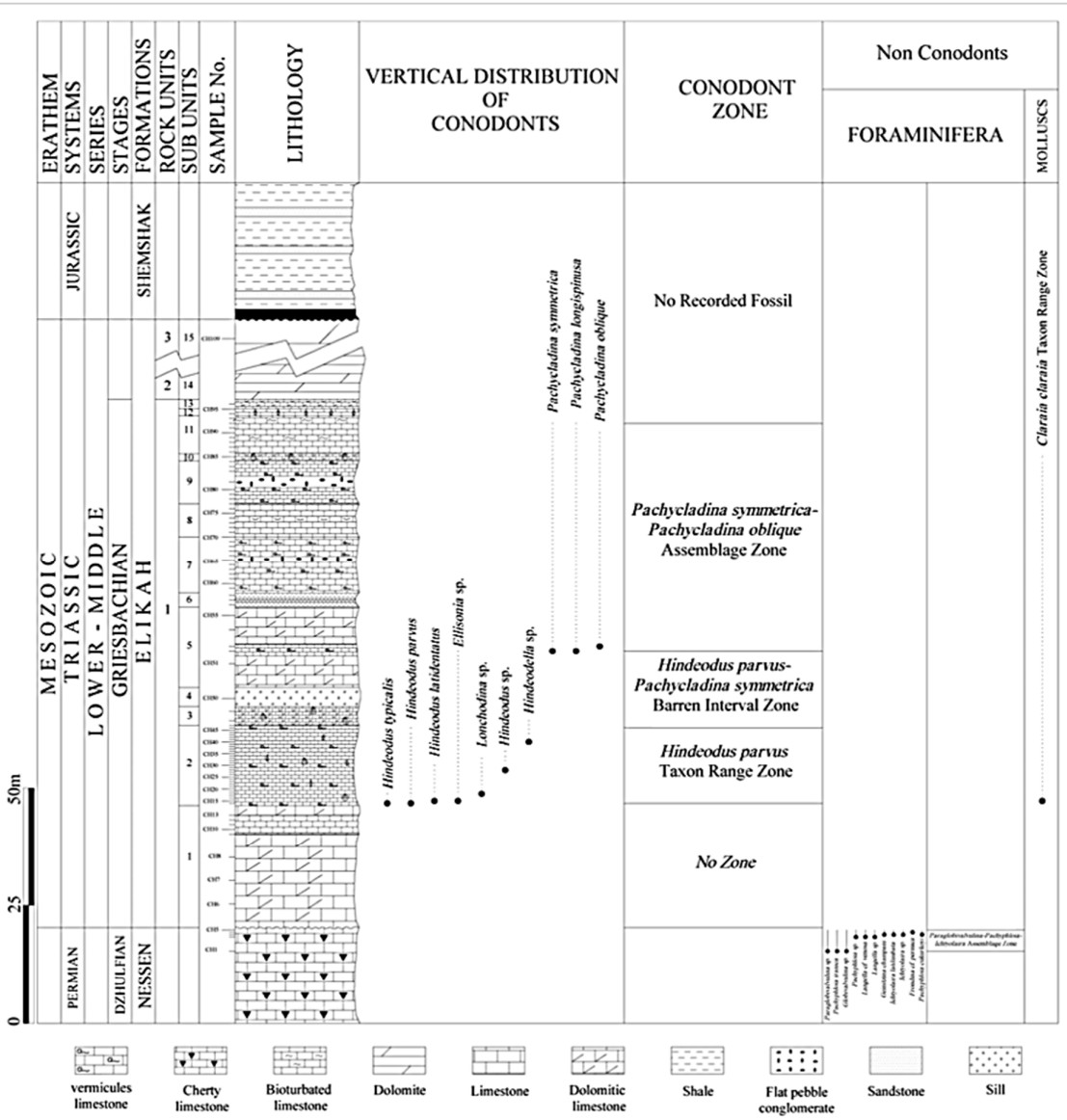

Fig 2. Conodonts and Non Conodonts vertical distribution of Elikah and Nessen Formations in Type section

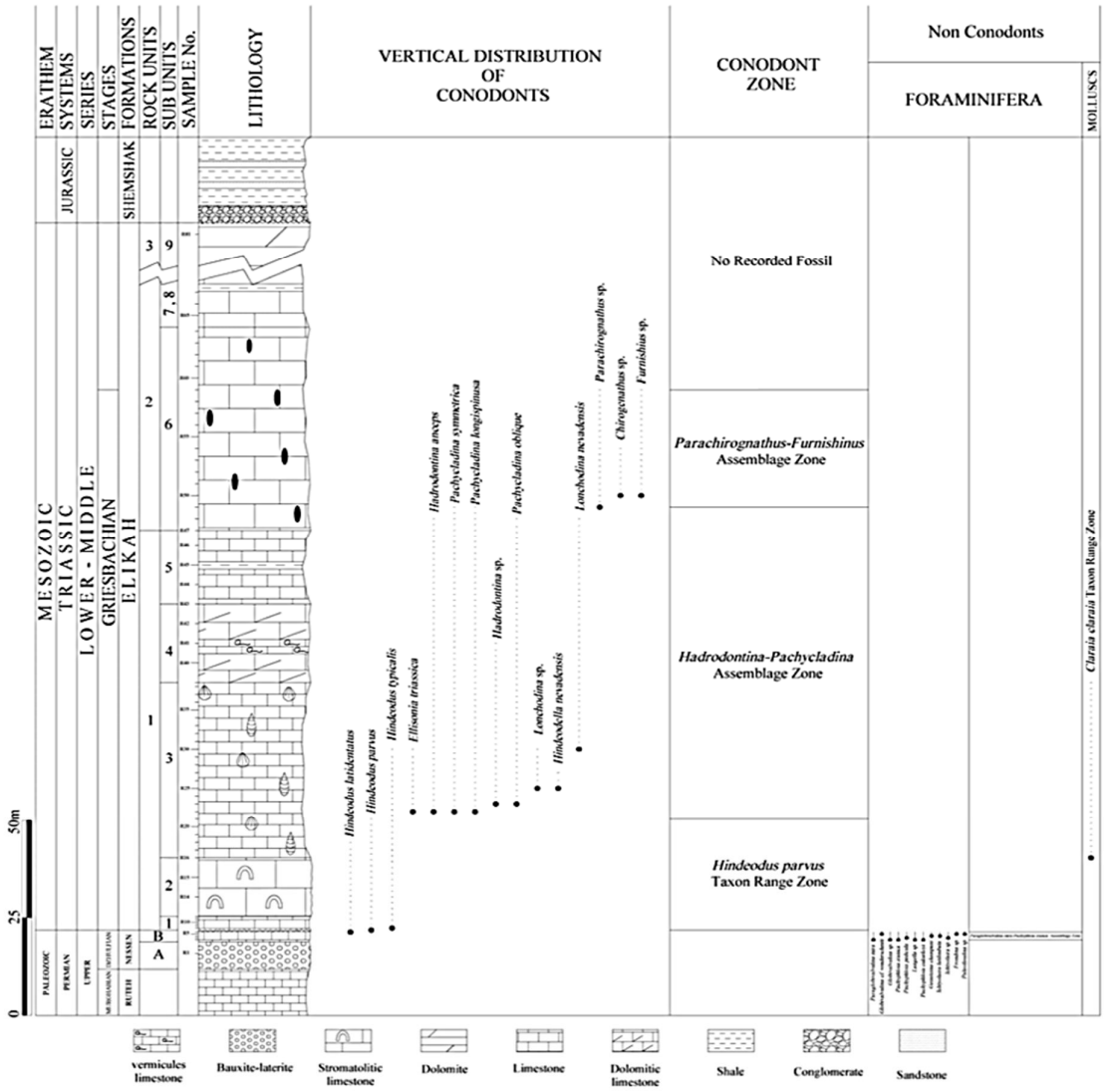

Fig. 3. Conodonts and Non Conodonts vertical distribution of Elikah and Nessen Formations in Ruteh section

4-3. Lithostratigraphy of Elikah Formation in Zal Section

The Elikah Formation in the Zal section, located in northwestern Iran, is one of the most complete sedimentary sections and marks a Permo-Triassic boundary in Iran. It includes three rock units and is approximately 950m thick. The first unit is 500m thick, includes alternations of pink, cream and grey, regular thin-bedded limestone containing abundant trace fossils (vermiculate limestone) and thin to medium-bedded limestone containing *Claraia* that rests concordantly on the Ali Bashi Formation. The second unit, 150m thick, includes altered cream to yellow dolomite and medium-bedded dolomitic limestone that gradually rests on Unit 1 of the Elikah Formation. The third unit of the Elikah Formation includes cliff-forming thick-bedded to massive dolomite 250m in thickness.

In the Zal section, the Elikah Formation rests, through a red colored shale layer, on the Ali Bashi Formation by disconformity. The main attributes of this disconformity and gap are the existence of a red colored, shale-clay layer at the top of the Dorashamian deposits containing saline or fresh water ostracods, changes in the water chemistry of two formations, the sudden appearance of stromatolites, the existence of fossil-bearing layers and shallow water benthic bivalves in the base of the Triassic. The Ali Bashi Formation is completely composed of a grey colored shale layer intercalated with marl, marl limestone and

grey colored limestone nodules in the 13m thick lower member (grey member).

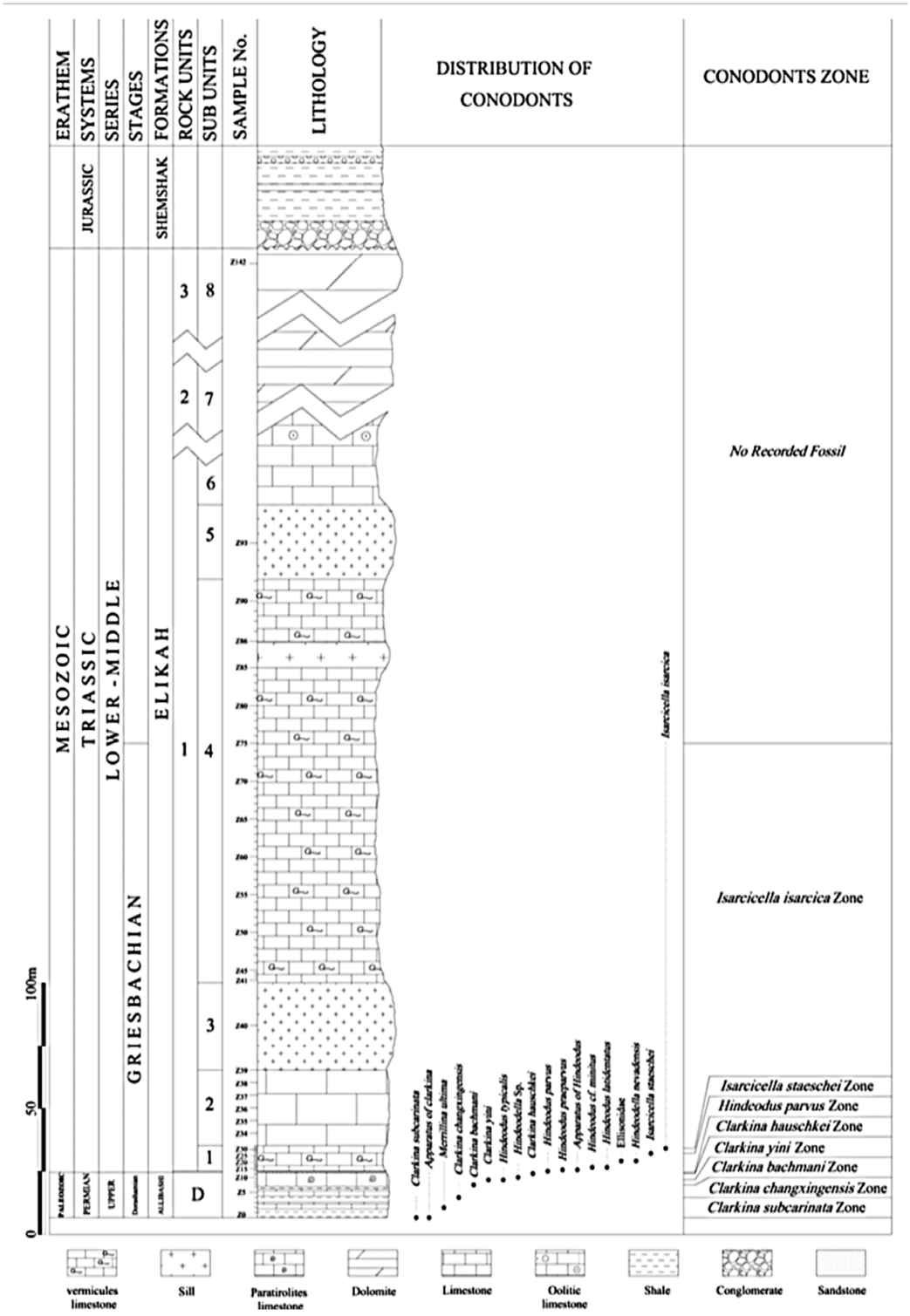

Fig 4. Conodonts and Non Conodonts vertical distribution of Elikah and Alibashi in Zal section

The upper portion is 5m thick and made up of a red colored carbonate unit that contains Pratirolites. The Elikah Formation is overlain by Jurassic units (Shemshak?), through disconformity, with a thin conglomerate deposit.

5. Biostratigraphy

The end of the Paleozoic and commencement of the Mesozoic were associated with a dramatic change in biodiversity and the mass extinction of species and generain in marine and continental environments. The greatest Phanerozoic extinction (mass extinction) resulted in the mass extinction of more than 96% of species, 83% of genera and 55% of families in marine environments [29, 30 and 31]. Except for conodonts, amonoids, a small number of mollusks and other remained groups that survived the mass extinction, there are very few fossils available to determine the exact age of this time. Therefore, the study of conodont elements fossils in this time range is of great importance because it will allow the determination of the exact date of Triassic sediments and clearly separate Triassic layers from the lower boundary (Permian) both in the world and Iran.

5-1. Biostratigraphy of Elikah Formation in Type Section (Central Alborz)

Biostratigraphy studies of 110 samples taken from the Elikah Formation type section of the Elikah Valley, resulted in the recognition and introduction of the following conodont elements:

Hindeodus parvus, Hindeodus latidentatus, Hindeodus typicalis, Pachycladina symmetrica,
Ellisonia sp., *Pachycladina* sp., *Pachycladina oblique, Pachycladina longispinusa, Lonchodina* sp., *parachirognathus* sp.

Based on these conodont elements, the conodont biozones recognized in the type section (Fig.2) are as follows (by age):

Hindeodus parvus Taxone Range Zone
Pachycladina symmetrica– Pachycladina oblique Assemblage Zone

Based on these defined biozones in the Elikah Formation type section, the lower parts of the Elikah Formation (First unit of Elikah Formation) are referred to as Griesbachian. Despite great efforts, no conodont elements were found in the dolomite portions of the formation (units 2, 3).

5-2. Biostratigraphy of Elikah Formation in Ruteh Section (Western Alborz)

The study of 90 samples taken from the Elikah Formation in the Ruteh section lead to the introduction of the following conodont elements:

Hindeodus parvus, Hindeodus typicalis, Pachycladina symmetrica, Pachycladina longispinosa, Pachycladina oblique, Parachirognathus sp., *Ellisonia* sp., *Lonchodina nevadensis, Hadrodontina anceps, Furnishius* sp., *Ellisonia triassica, Pachycladina* sp., *Hindeodella nevadensis , Ellisonia triassica* Sc element, *Hadrodontina* sp., *Hindeodus latidentatus, chirognathus* sp.

Based on these conodont elements, the conodont biozones introduced in the Elikah Formation, Ruteh section, (Fig.3) are as follows (by age from bottom to the top):

Hindeodu sparvus Taxon Range Zone
Hadrodontina –Pachycladina Assemblage Zone
Parachirognathus – Furnishius Assemblage Zone

Based on these biozones, the Elikah Formation is referred to as being Early Triassic (Griesbachian) in the Ruteh section.

5-3. Biostratigraphy of Elikah Formation in Zal Section

Studies done on 130 samples taken from the Elikah Formation in the Zal section resulted in the recognition of three conodont biozones referred to as Early Triassic (Griesbachian).

Hindeodus parvus, Hindeodus typicalis, Hindeodus latidentatus, Hindeodus sp., *Isarcicella isarcica, Hindeodella nevadensis, Hindeodella* sp.,*Merrillina ultima*

Based on these conodont elements, the conodont biozones recognized in the Zal section (Fig.3) are as follows (by age):

Hindeodus parvus Taxon Range Zone
Isracicella staeschei Taxon Range Zone
Isracicella isarcica Taxon Range Zone

Based on these biozones, the Elikah Formation is referred to as Sckythian (Griesbachian). In the Zal section, the upper rock units of the Elikah Formation have no conodont elements. Therefore, based on stratigraphical situation, the second and third rock units of the Elikah Formation are referred to as Early to Middle Triassic.

6. Stratigraphic Event

In this study, in addition to the defined conodont biozones, three types of stratigraphic events are introduced for the first time. A Late Permian volcanic chronostratigraphic event occurred that is evidenced through the existence of 2 million km3 of volcanic ash in Siberia, China and Iran. Additionally, there is evidence of volcanic alterations as both Buxite and latrite are observed in the Ruteh section. This stratigraphic phenomenon is known as the Dzhulfian age. The sudden appearance of stromatolite in the Early Triassic layers indicates a bio-event. Vermiculate limestone appeared widely throughout Iran as well as

neighboring countries in the Early Triassic in different sections of the Elikah Formation. This phenomenon is defined as an acme zone.

7. Biostratigraphy Correlation

In the studied sections, the global biozone *Hindeodus parvus* is correlated to other parts of the world, especially southern China. It indicates the commencement of the Triassic and is considered an index species for recognizing the Permo-Triassic boundary worldwide. The *Isracicella isarcica* biozone, also considered a global biozone, is reported from all over the world in places such as southern China, Tibet, Pakistan, Kashmir, India, Italy, Austria, the western United States, Australia and Canada. This biozone was reported in the upper portion of the *H.parvus* Zone in the Zal section (this study) and other sections of northwestern (Jolfa, Alibashi Mountains) and central Iran [32, 33 and 34].

The conodont element *Isracicella isarcica* was not found in the central Alborz sections of this study (Ruteh section and type section in the Elikah Valley). Instead, *Pachycladina* species were found in the upper portion of the *Hideodus parvus* Zone resulting in the determination of the *Pachycladina symmetrica–Pachycladina Oblique* Assemblage Zone in the type section of the Nour Valley as well as the *Hadrodontina –Pachycladina* Assemblage Zone and *Parachirognathus – Furnishius* Assemblage Zone in the Ruteh section. These biozones are assemblage zones of the Elikah Formation, equivalent to the *Isarcicella isarcicar* biozone and are referred to as Griesbachian.

Based on the described biozones of the Elikah Formation, it is referred to as being Early Triassic (Griesbachian) in the Zal, Ruteh and type sections and indicates a correlation of the biozones in the three mentioned sections. These biozones of Early Triassic deposits in Iran are greatly concordant to those in southern China (Table 1).

Table 1: Biostratigraphic Correlation of Elikah Formation in Zal, Ruteh and Type sections with other sections in Iran based on conodonts

<table>
<tr><th>Series</th><th>Zal Section This Study</th><th>Type Section This Study</th><th>Rutheh Section This Study</th><th>Till Abad Section (Haghparast. 2012)</th><th>Sibestan Section (Haghighat. 2007)</th><th>Shahmirzad Section (Safaee, 2000)</th></tr>
<tr><td rowspan="5">Griesbachian</td><td></td><td></td><td>Parachirognathus – Furnishius Assemblage Zone</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Isarcicella isarcica Taxon Range Zone</td><td rowspan="3">pachycladina symmetrica - Pachycladina oblique Assemblage Zone</td><td rowspan="3">Hadrodontina – Pachycladina Assemblage Zone</td><td>Hadrodontina anceps Taxon Range Zone</td><td rowspan="2">Pachycladina symmetrica-pachycladina oblique Assemblage Zone</td><td rowspan="3">Isarcicella isarcica Taxon Range Zone</td></tr>
<tr><td>Pachycladina longispinosa-pachycladina symmetrica Assemblage Zone</td></tr>
<tr><td>I. isarcica staeschei Taxon Range Zone</td><td>I. isarcica Taxon Range Zone</td><td rowspan="2">Hindeodus parvus-Isarcicella isarcica Assemblage Zone</td></tr>
<tr><td>Hindeodus parvus Taxon Range Zone</td><td>H. parvus Taxon Range Zone</td><td>H. parvus Taxon Range Zone</td><td>H. parvus Taxon Range Zone</td><td>Hindeodus parvus Taxon Range Zone</td></tr>
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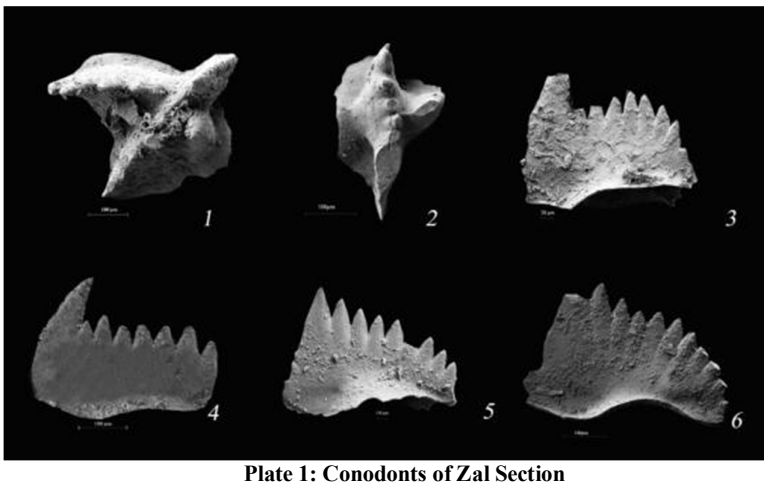

Plate 1: Conodonts of Zal Section
1. Isarcicella isarcica,2. *Isarcicella staeschei*, 3-5.*Hindeodus parvus*, 6.*Hindeodus latidentatus*

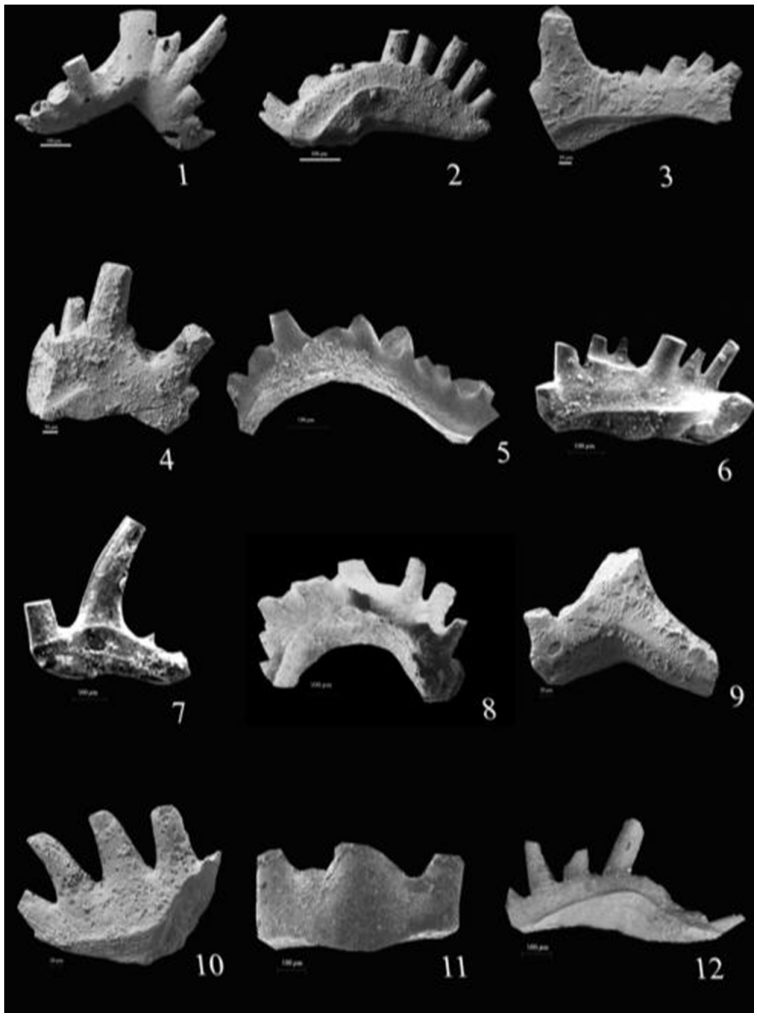

Plate 2: Conodonts of Rutheh Section
1. Lonchodina sp., 2. Pachycladina symmetrica, 3. Indet. Hindeodelliform element, 4. Pachycladina cf. longispinosa, 5. Ellisoniatriassica, 6. chirognathussp.,7. Pachycladina oblique, 8. Hadrodontina anceps, 9. Ellisonia sp.,10. Parchycladina sp., *11. Pachycladina oblique, 12. Hadrodontina* sp.*, pb element*

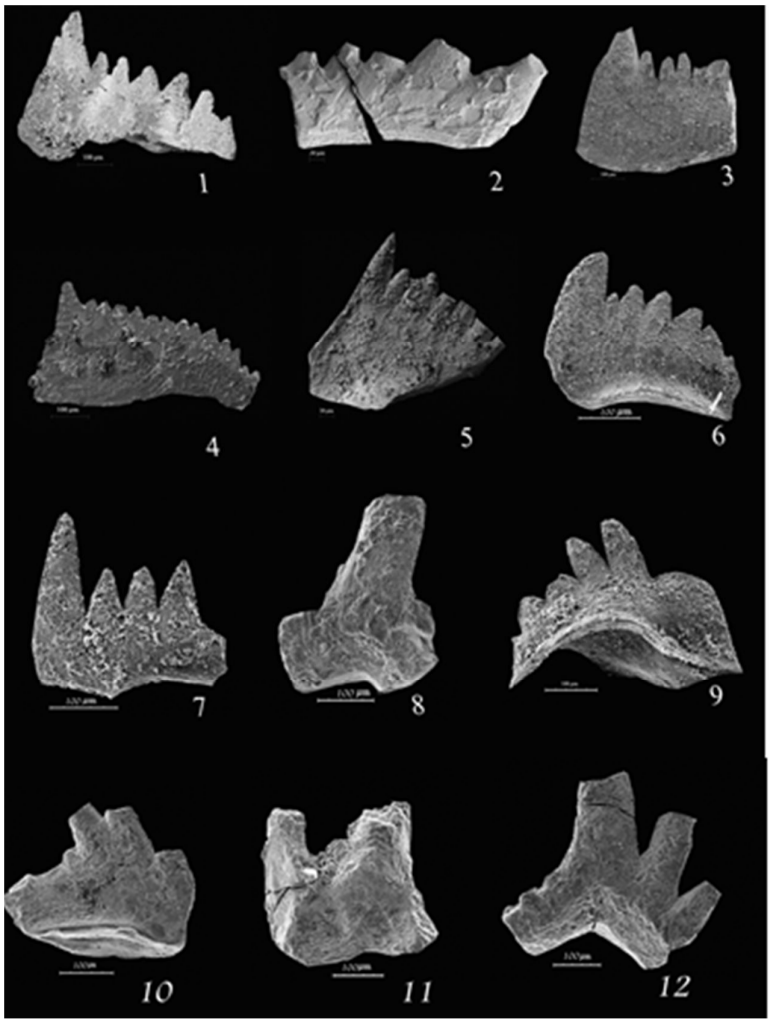

Plate 3: Conodonts of Type Section

1. Hindeodus latidentatus,.2. Ellisonia sp., pb element, 3. Hindeodusparvus, 4. Hindeodustypicalis, 5. Hindeodussp., 6. Hindeodusparvus, 7. Hindeodusparvus, 8. Pachycladina cf. oblique (broken), 9. Pachycladina sp.,10. Pachycladina sp., (broken), 11, 12. Pachycladina cf. symmetrica (broken)

8. Conclusions

Considering the spreading of the conodont elements and biozones of the Elikah Formation, it is referred to as Early Triassic (Griesbachian) in the Zal, Ruteh and type sections and indicates a correlation of the biozones in the three mentioned sections. These biozones of Early Triassic deposits in Iran are greatly concordant to the biozones of southern China. The dolomitic rock units of the Elikah Formation contain no conodont elements in any of the three sections. Therefore, based on stratigraphical situation, the second and third rock units of the Elikah Formation are considered Early to Middle Triassic.

The color alteration index of the conodont elements in the Zal section is 3. According to the CAI global standard, this number indicates a temperature range of between 110-200°C (heavy oil to wet gas capability). The color alteration index of the Triassic conodont elements in the Ruteh and type sections is 4. According to the CAI global standard, this number indicates a temperature range of between190-300°C. This temperature illustrates a dry gas stage or the absence of any hydrocarbon.

In the Zal section, the Elikah Formation rests on the Ali Bashi Formation by an apparent continuity that, in fact, is an erosional gap (disconformity). Some researchers believe that the existence of Parathirolites-bearing layers (dorashamian deposits) in Jolfa and Zal along with their absence in Alborz (Ruteh and type sections in this study) is an indication of continuous sedimentation in Jolfa and disconformity in Alborz. Existing evidence in the Zal section including: the

existence of a red colored shale-clay layer at the top of Dorashamian deposits that contains saline or fresh water ostracods, a negative shift in C^{13}, changes in the water chemistry of two formations, the sudden appearance of stromatolites, the existence of fossil-bearing layers (vermiculate limestone) and shallow water benthic bivalves in the base of the Triassic, supports the occurrence of a bioevent in the world, boundary of the Elikah and Ali Bashi Formations, despite the apparent continuity, is considered to be accompanied by a stratigraphical gap.

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