A review on Late Scythian to Middle Anisian Ammonoids from the Alam Formation in Nakhlah area, Central Iran

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Abstract

Introduction: The up to 1298 m thick, mainly turbiditic, siliciclastic Alam Formation consists of conspicuous carbonatic alternations at the lower part, and predominantly of a sequence of marine turbidities with frequent volcanic components at the middle and upper parts, deposited on a forearc side of an active margin in a continental shelf to slope setting.

Aim: The study and review of ammonoids collected from the Alam Formation and their paleobiogeographical relationships with other areas.

Material and Method: In the present study many ammonoids were collected and systematically studied from different levels of the Alam Formation and their paleobiogeographical distributions and relationships surveyed.


Conclusion: The mentioned ammonoids belong to a single bio-province at southern margin of Turan continent and have common faunas with the Nazarkardeh Formation in Aghdarband area (NE Iran). The paleobiogeographical relationships of Triassic ammonoids of the Nakhlah Group with other areas show the existence of a certain province in the southern margin of Eurasia from the eastern most to western most portion of Paleothetys Ocean. This distribution shows the bio-district distinction of Eurasia (in the north) from Gondwana (in the south) and also shows the boundary between Eurasia (at north) and Gondwana (at south) in northern Iran.

Keywords: Triassic, Ammonoidea, Alam Formation, Nakhlah, Central Iran.

Introduction

A very distinctive succession of Triassic sedimentary strata with a thickness of 2724 m is well exposed in the Nakhlah area of central Iran, covering an area between longitudes
53°.45’ N to 53°.54’ N and latitudes 30°.30’ E to 33°.37’E (Fig. 1). These strata have been first studied and named by Davoudzadeh and Seyed-Emami \(^1\) as the Nakhhlak Group including the Alam, Baqoroq and Ashin formations (Fig. 2) with Late Scythian to Carnian age.\(^{1-5}\)

The first research on the Anaraka area was carried out by Stahl.\(^6\) “Between 1929 and 1969” German geologists carried out some investigations concerning the economical geology in this region. Davoudzadeh and Seyed-Emami \(^1\) studied the stratigraphy and paleontology of the Triassic rocks of the Nakhhlak area. They studied a section with a thickness of 2549 meters and introduced the Nakhhlak Group, with three formations: the Alam, Baqoroq and Ashin formations as the Nakhhlak group with Late Scythian to Late Ladinian age. The ammonoids of the Nakhhlak Group have been studied by Tozer.\(^2\) Vaziri \(^3\) carried out the lithostratigraphical and biostratigraphical study of the Triassic rocks of the Nakhhlak area and described the sedimentary environments of these rocks. He also prepared a geological map of the Nakhhlak area on a 1:20,000 scale.

The comparison between the Triassic rocks of the Nakhhlak area and other Triassic rocks of the Iran Plate shows that there is no similarity between them, because the latter are essentially carbonates (dolomite, limestone, and dolomitic limestone). These rocks were deposited in shallow marine environments on the continental shelf, whereas the Triassic rocks of Nakhhlak (except for the Baqoroq Formation which represents continental environments) were deposited mostly in a continental slope and basinal environment, and are mainly composed of siliciclastic turbidites, in most cases mixed with volcaniclastic fragments. The only correlative Triassic succession to the Nakhhlak Group is Triassic succession of Aghdarband area \(^7, 8\) in northeastern Iran (Fig. 1).

Fig. 1- Location and geological map of the Nakhhlak area in central Iran (modified from Alavi et al.).\(^9\)
Tectonic setting of the Nakhlak area

The Triassic Nakhlak Group is an exotic succession in central Iran. Lithologically as well as palaeontologically the Triassic strata of Nakhlak differ completely from the shallow water carbonate platform successions of the Lower and Middle Triassic of Iran. The only correlative Triassic succession to the Nakhlak Group is the Triassic succession of the Aghdarband area in northeastern Iran. According to Alavi et al. (9) lithologic, palaeoenvironmental and palaeobiogeographic evidence suggests that both Triassic successions formed in a single tectono-sedimentary framework, at the southern active margin of the Turan Plate. The separation of the Triassic Nakhlak rocks from the rest of the Turan Plate and its transportation to the present position has been explained by the counterclockwise rotation of 135° of the East-Central Iranian Microcontinent since the Late Triassic. (10-14) However, this interpretation has recently been questioned, and a new model, postulating the existence of a small, short-lived oceanic basin in the area during the Triassic, has been put forth. (15)

Material and method

The Alam Formation

The up to 1298 m thick, mainly turbiditic, siliciclastic Alam Formation consists of conspicuous carbonate intercalations at the lower part, and predominantly of a sequence of marine turbidities with frequent volcanic components at the middle and upper parts, deposited on a forearc side of an active margin in a continental shelf to slope setting. (3, 13) The Alam Formation overlies the ophiolitic rocks (pre-Triassic?) of Nakhlak area on a thrust fault and is overlain by the Baqoroq Formation (Late Anisian?-Middle Ladinian) disconformably. The ophiolitic rocks of the Nakhlak area have been metamorphosed and consist predominantly of serpentine (Antigorite). The lithologically of Alam Formation can be subdivided into two parts (Fig. 2):

Lower part (Rock units 1-3): Carbonate and clastic facies at the base of formation with a thickness of 232 m. belong to continental shelf environment. These facies are consisted of the alternating yellow to buff, massive dolomite, brown to purple, thin to thick-bedded sandstone, green to purple, thin-bedded shale, dolomitic limestone and gray oolitic limestone with some bands of chert, purple microconglomerate and conglomerate (Fig. 3A). These alternations fine upwards and exhibit some sedimentary structures such as graded bedding, parallel laminations, cross-laminations, trace fossils and bioturbation fabric, and also bivalves.

Upper part (Rock units 4-33): Clastic facies which are mostly turbidity with a thickness of 1066 m. belonging mainly to continental slope and partly to basinal environment (3, 12). These facies make up the main part of alternating the Alam Formation (Fig. 3B). These alternations can be subdivided into the three following cases:

a) Alternation of purple, thin to thick-bedded microconglomerates, sandstones, tuffaceous sandstones, shales, wavy limestones, gray limestones and green shales. These alternations fine upwards and exhibit some sedimentary structures such as graded bedding, parallel laminations, convolute laminations, cross-laminations (A to D parts of Bouma cycle), Ichnofossil (Paleophycus, Zoophycos), bioturbation fabric, current ripple mark, flute and dish structures. In these sequence numerous slump folds and Olistolite fragments can be observed that show turbidity currents in sedimentary environment (rock units 4-10).
Fig. 2- Stratigraphic section of the Alam Formation in Nakhlah area, Central Iran.

<table>
<thead>
<tr>
<th>STRATIGRAPHIC COLUMN</th>
<th>LITHOLOGY</th>
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<tbody>
<tr>
<td>60D</td>
<td>Alternation of brown to purple, medium-bedded, tuffaceous sandstone, green shale, and two distinct black coquinit with frequent shell fragments.</td>
</tr>
<tr>
<td>60A</td>
<td>Grey conglomerate composed of limestone cobbles.</td>
</tr>
<tr>
<td>64B</td>
<td>Alternation of thick to medium-bedded, brown tuffaceous calcareous sandstone, grey limestone, green calcareous shale, micaceous sandstone, and conglomeratic sandstone (composed of limestone pebbles).</td>
</tr>
<tr>
<td>64A</td>
<td>Alternation of medium-bedded, brown sandstone, green calcareous shale, and grey limestone.</td>
</tr>
<tr>
<td>63C</td>
<td>Alternation of medium-bedded, grey limestone, green calcareous shale, and purple microconglomerate.</td>
</tr>
<tr>
<td>59B</td>
<td>Alternation of medium bedded, fusiliferous (Gastropods, Bivalves, Brachiopods, Algae &amp; echinoderm spines) boudinaged limestone, green calcareous shale &amp; purple sandstone with rare ammonoids.</td>
</tr>
<tr>
<td>53C</td>
<td>Alternation of purple to red, medium-bedded, sandstone with green shale.</td>
</tr>
<tr>
<td>52A-B</td>
<td>Alternation of purple, red, thin-bedded, micaceous tuffaceous sandstone, siltstone, and green shale, calcareous sandstone &amp; fusiliferous grey limestone.</td>
</tr>
<tr>
<td>51A</td>
<td>Brown &amp; dark conglomerate.</td>
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Violet shale with intercalations of purple, medium-beded microconglomerate, tuffaceous calcareous sandstone & limestone with ammonoid & erinoid (the first ammonoid-bearing beds).

Alternation of purple, well & thin-beded microconglomerate, tuffaceous sandstone & green shale with intercalations of limestone.

Alternation of purple, medium-beded, sandstone, dolomite limestone with intercalations of green shale, bivalve bearing.

Alternation of purple, thin to medium-beded, microconglomerate, sandstone & violet shale.

Alternation of brown, medium-beded, cherry dolomite limestone, Oolitic limestone & green shale with intercalations of microconglomerate sandstone & dolomite.

Alternation of purple, medium to thin-beded microconglomerate, sandstone & green shale.

Yellow to buff, massive dolomite (at the base) & alternation of purple, thick to thin-beded sandstone light green shale, yellow dolomite, light grey dolomitic limestone & Oolitic limestone with intercalations of microconglomerate bivalves bearing.

Slightly metamorphosed ophiolite, including serpentinite, serpentinized peridotite, gabbro, diabase & amphibolite.
Fig. 3- Carbonate and clastic facies (mainly dolomite and dolomitic limestone, rock units 1-3) at the base of the Alam Formation (A). Turbidity clastic facies (mainly tuffaceous sandstone and shale) of the Alam Formation (B). The first sedimentary ammonoid-bearing (violet shales with intercalations of microconglomerates, tuffaceous-calcareous sandstones and limestone, Lithozone 12) of the Alam Formation (C,D). The second sedimentary ammonoid-bearing (green shales with intercalations of microconglomerates, tuffaceous-calcareous sandstones and limestone, lithozone 28) of the Alam Formation (E, F).
b) Violet and green, thin-bedded shales with intercalations of purple, medium-bedded microconglomerates, tuffaceous-calcareous sandstones and limestone (lithozone 12, Fig. 2). These alternations contain crinoids and abundant ammonoids (Figs. 3C-F). Violet shales in the lower part of formation have been named as the first sedimentary ammonoid-bearing (Figs. 3C, D) and green shales in the upper part of formation (lithozone 28, Fig. 2) have been named as the second sedimentary ammonoid-bearing (Figs. 3E, F) of the Alam Formation by Vaziri. (3)

Alternations of upper part of the Alam Formation (the second sedimentary ammonoid-bearing) including green, thin-bedded calcareous shales with intercalations of purple, medium-bedded sandstone and grey limestone with abundant ammonoids (lithozone 28) can be correlated with the Nazarkardeh Formation in Aghdarband area of northeastern Iran, consists of alternating cherty fossiliferous limestone, shale, sandy shale and sandstone. (7)

Result and discussion
Ammonoids of the Alam Formation

In the present study, abundant ammonoids were collected from different levels of the Alam Formation which totally belong to 35 genera and 31 species and indicate a Late Scythian to Middle Anisian age for the formation as follow:

1. Late Scythian ammonoids include the Eophylrites davoudzadehi Tozer, Pseudosageceras sp., Prophyhitoides decipiens Spath, Procarnites sp., Paragoceras mediterraneum Arthaber, Columbits ventroangusts Shevyrev, Subcolumbites perrinismithi (Arthaber), Prenkites cf. malsorensis Arthaber, Stacheites undatus (Astachova), Dagnoceras nopscanum Arthaber, Albanites triadicus (Arthaber), Tirolites cassianus (Quenstedt), Metadognoceras amiidi Tozer, Iscuitoides seyedemamii Tozer and Leiphylites sp. that mainly belong to rock units 5 and 7 (Pls. 1, 2).

2. Early to Middle Anisian ammonoids include the Epacrochordiceras sp., Procladisctis sp., Storla sp., Acrochordiceras aff. hyatti Meek, Prophyhitoides decipiens Spath, Kazakhstanes dolnapensis Shevyrev, Eophylrites davoudzadehi Tozer, Leiphylites stoecklini Tozer, L. aff. Pitamaha (Diener), Hollandites tozeri Zacharov, Norites gondola (Mojsisovics), Nicomedes cf. toulai (Arthaber), Hungarites cf. Proponitic Toulou, Stenopagoceras transiens Tozer, Ussurites arthaberi (Welter), Semibeyrichites ruttnertii Krystyn and Tatzeriter, Aghdarbandites ismidicus (Arthaber), Paraceratites aff. binodosus (Hauer), Parapinoceras cf. damesi (Mojsisovics), Ptychites aff. Pauli Mojsisovics, Gymnites religiosus Diener, G. palmai (Mojsisovics), G. assereto Tozer and Monophyllites kieperitii Toulou that mainly belong to rock units 8-11 (Pls. 3-5).

Ammonoids of the first sedimentary ammonoid-bearing (lithozone 12, Fig. 2) include the Eophylrites davoudzadehi Tozer, Pseudococeras sp., Prophyhitoides decipiens Spath, Procarnites sp., Paragoceras mediterraneum Arthaber, Columbits ventroangusts Shevyrev, Subcolumbites perrinismithi (Arthaber), Prenkites cf. malsorensis Arthaber, Stacheites undatus (Astachova), Dagnoceras sp., Albanites triadicus (Arthaber), Tirolites cassianus (Quenstedt) and Metadognoceras amiidi Tozer with Late Scythian age (Pls. 1, 2).

Ammonoids of the second sedimentary ammonoid-bearing (lithozone 28, Fig. 2) include the Epacrochordiceras sp., Procladisctis sp., Storla sp., Acrochordiceras aff. hyatti Meek, Eophylrites sp., Leiphylites stoecklini Tozer, L. aff. Pitamaha (Diener), Hollandites tozeri Zacharov, Ussurites arthaberi (Welter), Semibeyrichites ruttnertii Krystyn and Tatzeriter, Aghdarbandites ismidicus (Arthaber), Paraceratites aff. binodosus (Hauer), Parapinoceras cf. damesi (Mojsisovics), Ptychites aff. Pauli Mojsisovics, Gymnites religiosus Diener, G. palmai (Mojsisovics), G. assereto Tozer and Monophyllites kieperitii Toulou with Early to Middle Anisian age (Pls. 3-5)
The above-mentioned ammonoid assemblages belong to a single bio-province at southern margin of Turan continent and have commonality faunas \((Leiophyllites \text{ sp.}, \text{ Procladiscites sp.}, \text{ Gymnites sp.}, \text{ Semibeyrichites rutneri, Aghdarbandites ismidicus and Gymnites asseretoi})\) with the Nazarkardeh Formation in Aghdarband area \(^7\) of northeastern Iran (Fig. 1). The position of \textit{Aghdarbandites ismidicus} ammonoida zone with Middle Anisian (Bithynian) age introduced by Krystyn and Tatzeriter \(^7\) in the Nazarkardeh Formation (fossil horizon number 1) is in the upper part of the Alam Formation.

Ammonoids of the Alam Formation can be correlated with the Triassic ammonoida zones as fellow:
1. Ammonoids of the Alam Formation with Late Scythian age can be correlated with the \textit{Olenikites pilaticus} and \textit{Keyserlingites subrobutus} zones\(^{16}\) and also \textit{Keyserlingites subrobutus} and \textit{Subolenikites pilaticus} zones.\(^{17}\)
2. Ammonoids of the Alam Formation with Early to Middle Anisian age can be correlated with the \textit{Anagymnotoceras varrum} and \textit{Lenotropites caurus} zones\(^{16}\) and also \textit{Bataonlites, Kocaella} and \textit{Paracrochordiceras} zones.\(^{17}\)
3. Ammonoids of the Alam Formation with Middle Anisian age can be correlated with the \textit{Anagymnotoceras varrum} Zone.\(^{17}\)

Plate 1 - (Late Scythian (Spathian) Ammonoids)

Figs. 1a, 1b: \textit{Kazahstanites dolnapensis} Shevyrev, x1, side (1a) and Venter (1b).
Figs. 2a, 2b: \textit{Pseudosagceras} \text{ sp.}, x1, side (2a) and Venter (2b).
Fig. 3: \textit{Propthyhitoides decipiens} Spath, side, 1/2x.
Figs. 4a, 4b: \textit{Procarnites} \text{ sp.}, x1, side (4a) and Venter (4b).
Figs. 5a, 5b: \textit{Isculitoides seyedemamii} Tozer, side, x1 (5a) and Venter x2 (5b).
Figs. 6a, 6b: \textit{Paragoceras mediterraneum} Arthaber, x1, side (6a) and Venter (6b).
Fig. 7: \textit{Columbits ventroangusts} Shevyrev, x1, side.
Fig. 8: \textit{Subcolumbites perrinsmithi} (Arthaber), x1, side.
Figs. 9, 10: \textit{Prenkites} \text{ cf. malsorensis} Arthaber, x1, side.
Figs. 11a, 11b: \textit{Stacheites undatus} (Astachova), x1, side (11a) and Venter (11b).
Plate 2 - (Late Scythian (Spathian) Ammonoids)
Fig. 1: *Dagnoceras nopscanum* Arthaber, x1, side.
Figs 2-3b: *Alanites triadicus* (Arthaber), x1, side (2, 3a) and *Venter* (3b).
Fig. 4: *Tirolites cassianus* (Quenstedt), x1, side.
Fig. 5: *Metadognoceras amidi* Tozer, x1, side.
Fig. 6: *Eophylites* sp., x1, side.
Fig. 7: *Eophylites davoudzadehi* Tozer, x1, side.

Plate 3 - (Early and Middle Anisian Ammonoids)

Fig.1: *Leiophyllites stoecklini* Tozer, x1/2, side, Early to Middle Anisian.
Fig. 2: *Leiophyllites* aff. *pitamaha* (Diener), x1/2, side, Middle Anisian.
Fig. 3: *Semibeyrichites ruttneri* Krystyn and Tatzreiter, x1/2, side, Early to Middle Anisian.
Fig. 4: *Acrochordiceras* aff. *hyatti* Meek, x1/2, side, Middle Anisian.
Plate 4- (Early and Middle Anisian Ammonoids)

Figs. 1a-c: Epacrochordiceras sp., x1, side (1a), front (1b) and Venter (1c), Middle Anisian.
Fig. 2: Hollandites tozeri Zacharov, x1, side, Early to Middle Anisian.
Figs. 3, 4: Paraceratites aff. binodosus (Hauer), x1, side, Middle Anisian.
Figs. 5a, 5b: Stenopapnoceras transiens Tozer, x1, side (5a), Early to Middle Anisian.
Fig. 6: Aghdarbandites ismidicus (Arthaber), x1/2, side, Early to Middle Anisian.

Plate 5- (Early and Middle Anisian Ammonoids)

Figs. 1a, 1b: Aghdarbandites ismidicus (Arthaber), x1, side (1a) and Venter (1b).
Figs. 2a, 2b: Ussurites arthaberi (Welter), x1, side (2a) and Venter (2b).
Fig. 3: Norites gondola (Mojsisovics), x1, side.
Fig. 4: Hungarites cf. proponticus Toula, x1, side.
Conclusions

The Alam Formation in the Nakhlak area of central Iran exhibits a moderately diverse ammonoid assemblage. It contains several taxa which belong to 35 genera and 31 species and indicate a Late Scythian to Middle Anisian age for the formation. The geographic distribution and paleobiogeographical relations of the Alam Formation's ammonoids in other parts of the world show the existence of a certain province in the southern margin of Tethyan Ocean, from its eastern most to western most and have common ammonoids with the Nazarkardeghe Formation in Aghdarband area of northeastern Iran. These ammonoids can be correlated with the Triassic ammonoida zones.

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References: