P-ISSN: 2798-1134 | E-ISSN: 2797-3549 | DOI: 10.52562/injoes.2025.1341

Indonesian Journal of Earth Sciences

https://journal.moripublishing.com/index.php/injoes

| Research Article |

Check for updates

# Introduction of Ammonites from the Dalichai Formation in Polour Section Central Alborz, Iran

**Masoomeh Sohrabi Mollayousefi[1]*, Kiana Kiarostami[2]**

[1]*Department of Petroleum, Mining and Materials Engineering, Islamic Azad University, central Tehran branch, Tehran, Iran*

[2]*Department of Geology, Science and Research Branch, Islamic Azad University, Tehran, Iran*

**Correspondence: Sohrabi705@gmail.com, ma.sohrabi1349@iau.ac.ir*

Received: 29 September 2024 / Accepted: 26 February 2025 / Published: 21 March 2025

**Abstract:** The studies done on Dalichai Formation in Central Alborz, South Polour Formation of an 80 m thick that are systematically sampled at intervals of 2 meters and selected the 40 rock samples for the preparation of thin sections considered and in addition to lithology; characteristics of the stone, and index examples of Ammonites were also studied. Dalichai formation lithology in the study area is rich in terms of alternating gray sandstone and marl with Ammonites Fauna. Based on the study of fossil fauna, the oldest identified ammonite in the studied section is Procerites (Early Bathonian), and the youngest is Reineckeia sp. (Late Callovian). The distribution of ammonites indicates that the eastern Alborz region had marine connections with northwestern Europe and the Mediterranean marginal areas during the Middle Jurassic period, and the study area was located north of the Tethys Ocean. Based on its stratigraphic position of the middle Jurassic Age Formation, Dalichai Ammonites with peer review study sections and microfossils Bathonian-Callovian age Dalichai is accurate. Lar Formation covers this formation with a gradual contact and has been parallel to the Shemshak Formation on an erosional unconformity. Through the examination of stratigraphy and the correlation of formations in the studied sequence, it was determined that the lower part of the Dalichai Formation is equivalent to other formations in Iran, including the Parvdeh Formation in the Shotori Mountains, the Kashfrood Formation in the Kopeh Dagh, and the lower part of the Baghamshah Formation in the Tabas Basin. The variations in thickness of the Dalichai Formation in the eastern Alborz region indicate relative subsidence of the sedimentary basin, a delay in sea-level rise, and the exit of sediments from seawater. These changes are indicative of the Middle Cimmerian tectonic event, which is observed as an erosional unconformity at the lower boundary of the Dalichai Formation.

**Keywords:** Ammonites, Dalichai Formation, Central Alborz, South Polour

## INTRODUCTION

The Dalichai Formation is the first rock unit of Alborz Jurassic marine sediments, which is clearly different from the Shemshak group's lake-lagoon conditions and the Lar Formation's carbonate layers. Dalichai Marly Formation is a greenish erosive guiding layer that separates the lower dark coal-colored rows from the upper rocks (Aghanabati, 2015). In most sections, especially in the underwater area, Firouzkoh and Semnan, the mentioned formation begins with the horizon of a white quartz conglomerate. The initial layers of this formation have abundant limonite fragments and clay cracks. The presence of these signs is a parallel unconformity in the area of Jam (Alavi-Naini, 1972), angular unconformity in the north of Qazvin (Annells, 1975), ten meters of iron-rich oolite in the Neshel area (Steiger, 1966), the presence of 30 meters of iron-rich red clay in the north of Jarat, confirm that the lower bounder of the discontinuous. The upper bounder of the Dalichai Formation with the Lar Formation is gradual (Stocklin & Setudehnia, 1991). The mentioned formation was studied in the northwest of Semnan by Rafiei (2013), in the north and northeast of Damghan by Dietze et al. (2014), and in the Binalud Mountains by Raoufian et al. (2019) and by Hashemi Yazdi (2015) in the center and east of Alborz. Seyed-Emami et al. (2013, 2015, 2017) have studied the stratigraphic units in the north and center of Iran to describe the ammonites' depositional environments and paleobiogeographic relationships. In 1976, Dehbozorgi et al. (1976) studied the palynostratigraphy and sedimentary environment of the Dalichai Formation in the Pol Dokhtar section.

Several other studies that have been conducted in connection with master's theses on the Dalichai Formation can be mentioned as follows: Mohammadi Monfared (1957) as well as Makvandi (1960) in

Mount of Sharaf Semnan (Eastern Alborz), Totonchi (1961) in the south of Polour (Central Alborz), Shafizad (1961) in section of west of Shahroud (Eastern Alborz), Niknahad (1948) in section Goydakh (Bakhtari Alborz). The Dalichai Formation was investigated in northern Semnan by Farahani et al. (2015, 2019), who constrained its age to the late Bajocian to late Oxfordian interval. In the eastern Alborz, Zadesmaeil et al. (2021) studied the formation and found that the ammonites were dated to the late Bajocian to early Kimmeridgian period. In the Binalud Mountains, Ezoji et al. (2023) analyzed the formation and identified three distinct biozones. There is a limited outcrop of the Dalichai Formation on the northeast road of Tehran towards the Damavand Road, which has not been noticed due to geographical limitations and the closeness of the type section of the Dalichai Formation. With the beginning of the studies, valuable results have been obtained, which will be very useful in completing the information related to the type section. The Dalichai Formation represents the initial marine sedimentary unit of the Jurassic period within the Alborz sedimentary basin.

This study offers a detailed analysis, surpassing previous efforts by emphasizing lithostratigraphy, biostratigraphy, and paleobiogeographic relationships, along with environmental conditions. The investigation centers on ammonite fauna, specifically the Reineckeiidae and Phylloceratidae families, which are crucial for age determination and provide insights into the paleobiogeography and depositional environments of the Dalichai Formation. Through the correlation of the Dalichai Formation across various regions, including Eastern and Central Alborz, a more refined understanding of stratigraphic correlations has been attained.

## METHOD

### Geographic Coordinates of the Studied Area

The Dalichai Formation in the Polour region, part of the Central Alborz, was selected for several reasons, including easy access, diverse rock sequences, and paleontological significance, as well as the importance of studying the Polour region as part of the Caspian area. After determining the sampling location and conducting geological surveying to establish the true thickness of the rock sequence, sampling was performed at 2-meter intervals using geological hammers and specialized tools. Approximately 40 samples were collected to represent all rock layers and fossil diversity, with the number adjusted based on research needs. The samples were stored in specialized boxes and bags, labeled to record sampling location and conditions. Finally, fossils in the rock samples were identified using available atlases including (Moore, 1957), dated, and photographed. A stratigraphic column was drawn using Corel software, and correlations with other sections were made.

The type section of the Dalichai Formation is located east of Zarinkooh and on the road from Damavand to Firozkooh. On the asphalted road of Tehran-Haraz, after passing through Bomehan city and Abali, we will reach the Polour area. Dalichai Formation is located in the central Alborz, south of Polour. The base of the formation is at the geographical coordinates of 35 48'41"N and 52 1'48"E, and the top of the formation is at the geographical coordinates of 35 48'40" N and 52 1'49"E (Figure 1).


Figure 1. Geographical location and access ways to the Polour section in Central Alborz.

## RESULTS & DISCUSSION

### Stratigraphy of Dalichai Formation in the Studied Area

The Dalichai formation is characterized by gray Oolitic limestones and limonitic concretions in the type section. This formation has characteristic ammonites and fragments of brachiopods, echinoderms, and pelecypods in the type section. Attention to the lithological conditions and fossil content in the relevant formation has been very important. Starting with the Dalichai formation, a row of marly limestones and conformable, rich in ammonite fossils in some places, is placed on the Shemshak Formation, which is mostly Clastic. Shemshak Formation, which consists of alternating coal shales and sandstones with a discontinuity due to the Middle Cimmerian event (Fürsich et al., 2005; Wilmsen et al., 2009). The Dalichai Formation has inappropriate features for a long distance.

In terms of morphology, these formations can only be seen at the foot of the Lar limestone walls due to the failure of the ground slope. It has been measured: 45 meters of limestone with a gray and somewhat green layer. The thickness of each layer is 0.2 meters, and the floors are uneven. Between the limestone layers are marl layers with a thickness of 5 to 10 cm (Figure 2). The limes have layers of gray silica. Animal remains (Zoophycus), and ammonite pieces are found on the surfaces of the floors. 35 meters of gray-green marl limestone, located after a thin deposit of mica and brown-colored sandstones of the Shemshak Formation. The typical color of the Dalichai Formation is light green (Figure 2). It is often difficult to identify the boundaries of the Dalichai formation. The area in which the Clastic rock is gradually reduced and the amount of limestone material is increased connects the Dalichai and Shemshak formations placed below it. The upper bounder (Dalichai to Lar Limestone) shows itself with gradual changes and reduction of marl layers.

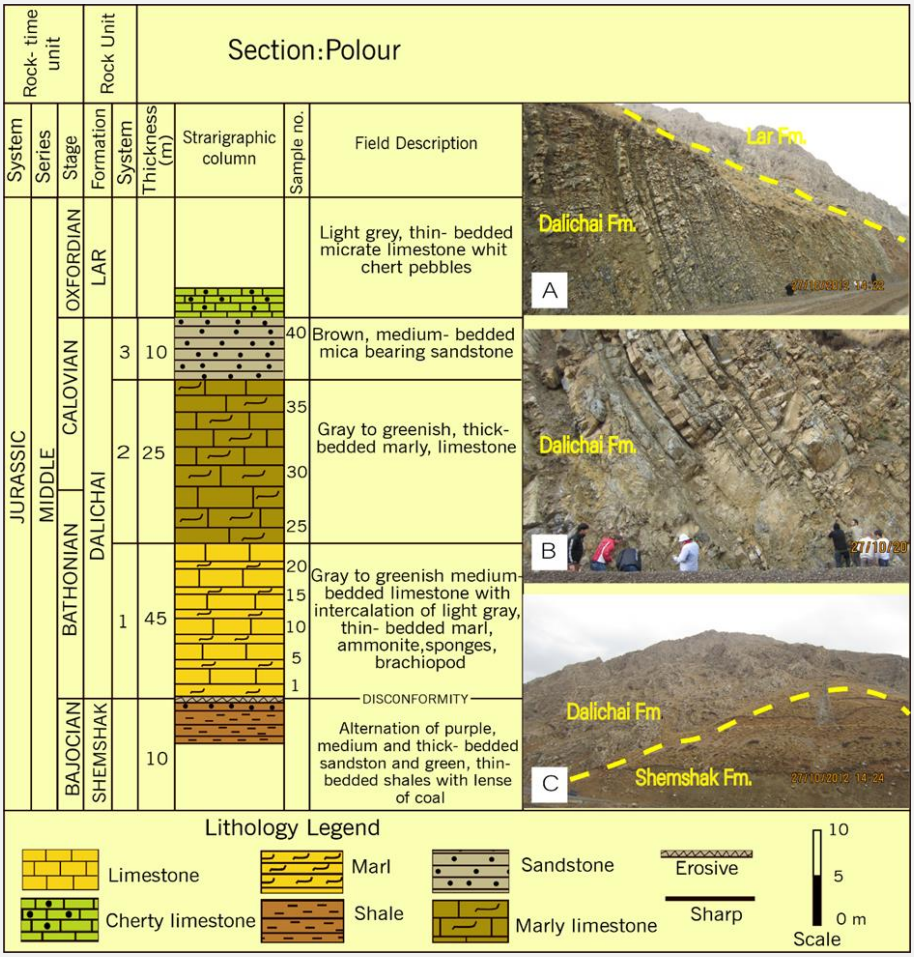


Figure 2. Stratigraphic column and Field aspects of Dalichai Formation, Polour section in central Alborz;(A) transitional contact between the Dalichai and Lar formation, (B) Limestone sequence with interbedded of marl and shale in Dalichai Formation (C) Disconformity contact between the Shemshak and Dalichai Formation.

**Stratigraphic Comparison of Dalichai Formation in Iran and Arab countries**

The stratigraphy of the Dalichai Formation related to this study has been compared with the study of Sarmeran section, In the Binalud Mountains, northwest Iran (Ezoji et al., 2023), and the Mahdishahr section in northern Semnan (Farahani et al., 2019) which can be summarized as follows:

In the analysis of stratigraphic columns, it is observed that the upper boundary of the Dalichai Formation with the Lar Formation is gradual across all three sections. The Dalichai Formation rests unconformably on the Shemshak Formation. Lithologically, the Dalichai Formation is characterized by a significant thickness of marly limestone. In the Sarmeran and Mahdishahr sections, following an erosional unconformity, the Dalichai Formation begins with sequences of marl. In the Mahdishahr and Polour sections, cherty limestones are noted at the top of this formation; however, this sequence is absent in the Sarmeran section. Another distinctive feature of the Dalichai Formation is the presence of red limestones in the Sarmeran section, with a thickness of 95 meters. In contrast, red limestones have not been reported in the Mahdishahr section or in other studied areas within Central Alborz. These observations indicate significant lithological variations and stratigraphic relationships within the Dalichai Formation across different sections, highlighting its unique geological characteristics (Figure 3).

The DaliChai Formation in the Central Alborz is lithologically equivalent to the Sargelu Formation found in Kuwait and southeastern Iraq. It primarily consists of black shales and thin to medium-bedded limestones. The Dhruma Formation in Bahrain and Saudi Arabia, which predominantly consists of limestone and dolomite in Saudi Arabia, while in Bahrain, this formation also features dolomitic limestones. The Araej and Izhara Formations in the United Arab Emirates and Qatar consist of limestone and shale. Similarly, the Mafraq Formation in Oman consists of limestone and shale (James & Wynd, 1965).

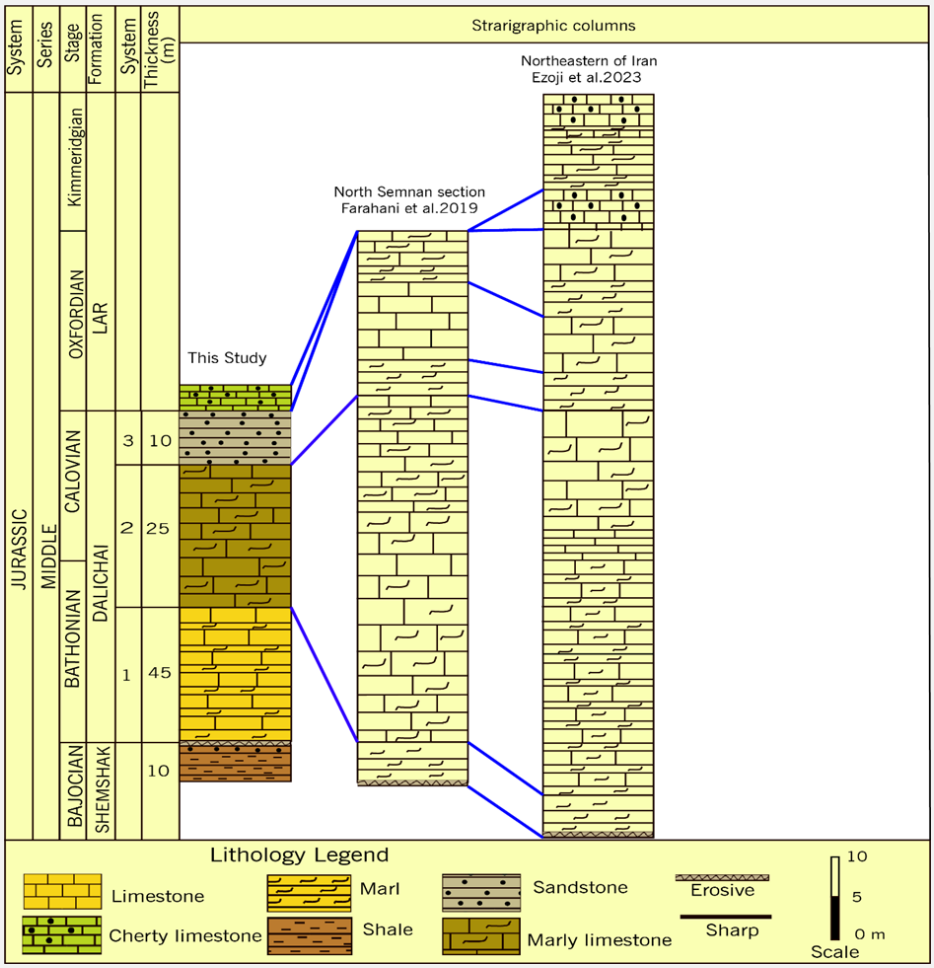


Figure 3. Correlation of the stratigraphic column of the Dalichai Formation in the study area with the Sarmeran section, In the Binalud Mountains, northwest Iran (Ezoji et al., 2023), and the Mahdishahr section in northern Semnan (Farahani et al., 2019).

**Biostratigraphic and Paleoenvironmental Analysis of Ammonites from the Dalichai Formation: Similarities and Unique Characteristics in the Tethys Realm**

The identified ammonites in the Dalichai Formation in this study (Figure 4) exhibit similarities and unique characteristics with other Jurassic formations in the Tethys realm. For instance, the ammonites Loboplanulites sp. and Homoeoplanulites sp. are also observed in Jurassic formations in Europe and the Mediterranean margin, confirming the age range from Bajocian to Callovian. These ammonites are indicative of parts of the Bajocian biozones. The ammonites Reineckia sp. and Choffatia sp. are found in similar formations in the Mediterranean margin and Europe, serving as temporal indices for the Late Callovian. A notable feature of Reineckia sp. is that they are recognized as the last ammonites of the Dalichai Formation. The ammonites Rehmannia sp. and Macrocephalites sp. exist in Jurassic formations across the Tethys realm and Europe, acting as temporal indices from Bajocian to Callovian. Macrocephalites sp. is particularly noted for being part of the Bajocian biozones. The ammonites Hecticoceras sp. and Procerites sp. are present in similar formations in the Mediterranean margin and Europe, indicating an early Bajocian age. Procerites sp. is distinguished as one of the oldest ammonites in the Dalichai Formation. Sowerbyceras sp. serves as a temporal index for the Bajocian and is found in Jurassic formations in Europe and other parts of the Tethys realm. In summary, the ammonites of the Dalichai Formation share similarities with those of other Jurassic formations in the Tethys realm but also possess unique characteristics that reflect the paleoenvironmental and ecological conditions of that region.

The role of the identified ammonites in the studied section as time indicators (Determining the age of the Dalichai Formation in the studied section, from Bathonian to Callovian), Examination of paleoenvironments (The presence of ammonites Macrocephalites sp. and Hecticoceras sp. indicates an open marine environment, as part of the carbonate platform), Analysis of sedimentary conditions (The presence of ammonites Reineckia sp. and Choffatia sp. indicates a Late Callovian age, reflecting stable environmental conditions and a well-organized lithostratigraphic succession), Biostratigraphy and paleogeography significantly contribute to( Similarity of ammonites from the Dalichai Formation with other regions of the world, such as Northwestern Europe and the Mediterranean margin) the further identification and more accurate interpretation of the mentioned formation (Figure 4).

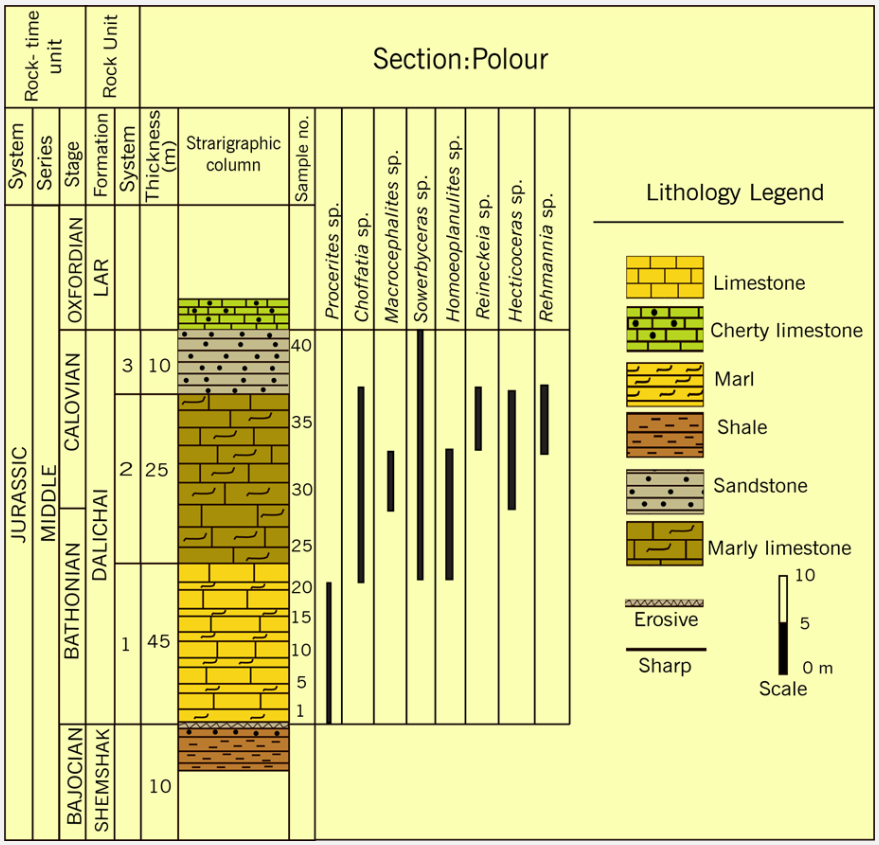


Figure 4. Stratigraphic column and Vertical distribution diagram of ammonite obtained from Dalichai formation in the Polour section, central Alborz.

## CONCLUSION

The main parts of Middle Jurassic rocks in this area are marl and limestone. With several meters of medium limestone sandstone layer with para disconformity, this complex is located on the Shemshak Formation and gradually with the same slope as limestone. The rock-forming rocks of the Lar Formation become.

The middle Cimmerian event is visible in the form of a para disconformity in central Alborz and its outcrop at the base of the rock units of the Dalichai Formation.

The thickness of the Dalichai Formation in the west of Shahroud (East Alborz) is 235 meters, but it decreases towards the west of Alborz. This difference in thickness can be attributed to the topography's unevenness, the sedimentation basin's relative subsidence and the arrival of materials, and the delay in the Sea level rise and exit of sediments from seawater.

The oldest known ammonite in the studied section named Procerites sp. is of early Bathonian age, and the youngest ammonite known in the study section, Reineckia sp. is of Late Callovian age, according to which the age of Dalichai Formation is Bathonian to Callovian.

Due to the similarity of the known ammonites in the section studied in the Dalichai Formation with the ammonites of North-Western Europe and the Mediterranean marginal areas, it can be concluded that in the late Bajocian-Early Oxfordian, the existing sea in Eastern Alborz from the north with the existing sea It is in contact in North Western Europe and Mediterranean marginal areas, and the paleogeographic location of the studied area was in the north of the Tethys Ocean.

The Middle Jurassic rocks of the studied section are equivalent to their contemporaneous rocks in other parts of Iran, so that the lower parts of the Dalichai Formation with the Parvdeh Formation in the Shotori mountains and north of Tabas (Central Iran), Kashfrood in Kope Dagh, the lower part of Baghamshah in Tabas Basin and the upper parts of Dalichai Formation with Shall Formation in Talesh Mountains (northwest of Alborz), Chamanbeid in Kepe Dagh, Baghamshah in Tabas-nayband, Qala Dokhtar in West of Shotori Mountains (Central Iran) And Surmeh in Zagros, considered worthy of comparison.

Given the importance of examining stratigraphic relationships and the science of biostratigraphy within the Dalichai Formation sequences, it is recommended to conduct high-resolution stratigraphic studies that focus more on lithological changes and a more precise identification of existing fossils at the species level. This approach will facilitate the correlation between sequences in different regions and lead to a better understanding of environmental changes and tectonic influences.

Additionally, conducting geochemical studies on existing samples from the Dalichai Formation and its related formations can be effective in determining age boundaries and understanding sedimentary processes. Furthermore, developing tectonic models to investigate the impacts of tectonic events, such as the Middle Cimmerian event, on sequences and sea level changes will enhance our understanding of the region's dynamics.

Ultimately, findings derived from geochemical and stratigraphic data will aid in identifying depositional environments, analyzing marine connections, and assessing the effects of tectonic events. This comprehensive approach will contribute to a more accurate interpretation of the sedimentary sequences of the Middle Jurassic period and facilitate the reconstruction of paleo-geography.

## REFERENCES

Aghanabati, A. (2015). *Geology of Iran*. Geological survey and mineral exploration of Iran.

Alavi-Naini, M. (1972). *Etude geologique de la region de Djam* (Report No. 2). Geological survey of Iran.

Annells, R. N. (1975). *Explanatory text of the Qazvin and Rasht quadrangles map*. Geological survey of Iran, Tehran.

Dehbozorgi, A., Hashemi Yazdi, F., & Sajjadi Hazaveh, F. (1976). Palynostratigraphy and paleo- sedimentary environment of Dalichai Formation in Poldokhtar stratigraphic section. *Journal of Applied Sedimentology, 6*(11), 35-48.

Dietze, V., Seyed-Emami, K., & Raoufian, A. (2014). Morphoceras Douvillé, 1880 and Ebrayiceras Buckman, 1920 from the Dalichai Formation (Lower Bathonian) North and Northeast of Damghan (Northeast Alborz, Iran). *Zitteliana, 54*, 15-22.

Ezoji, H., Majidifard, M.R., Maleki, Z., & Vaziri, S. H. (2023). Biostratigraphy of Dalichai Formation in Bar and Sarmeran sections (Binalud Mountains) Northeastern of Iran based on ammonite fauna with special emphasis on Phylloceratidae Family. *Geopersia, 13*(1), 209-227. https://doi.org/10.22059/geope.2023.351966.648691

Farahani, T. S., Majidifard, M. R., & Kebreaee-Zadeh, M. R. (2019). Middle and Upper Jurassic Ammonites from the Dalichai Formation (North Semnan, Iran). *Iranian Journal of Geoscience Museum, 1*(1), 25-48.

Farahani, T. S., Majidifard, M. R., Kebreaee-Zadeh, M. R., & Mohamadi, M. (2015). Study of the lithostatigraphy and biostratigraphy of ammonite fauna of the Dalichai Formation at the Mahdishar section, N Semnan. *Quarterly Journal of Geosciences, 24*(94), 27-39. https://doi.org/10.22071/gsj.2015.42563

Fürsich, F. T., Wilmsen, M., Seyed-Emami, K., Cecca F., & Majidifard, M. R. (2005). The upper Shemshak Formation (Toarcian - Aalenian) of the Eastern Alborz (Iran): Biota and palaeoenvironments during a transgressiv-regressive cycle. *Facies, 51*, 379-398. https://doi.org/10.1007/s10347-005-0051-z

Hashemi Yazdi, F. (2015). *Palynology and palaeoecology of the Dalichai Formation in central-eastern Alborz Basin and the Hojedk Formation at the east-central Iran* (Doctoral dissertation, Faculty of Geology, College of Science, University of Tehran, 388 p. In Persian).

James, G. A., & Wynd, J. G. (1965). Stratigraphic nomenclature of Iranian oil consortium, agreement area. American Association of Petroleum. *AAPG Bulletin, 49*(12), 2182–2245. https://doi.org/10.1306/A663388A-16C0-11D7-8645000102C1865D

Makvandi, R. (1960). *The study of stratigraphy and paleontology of Dalichai and Lar formations in Mount Sharaf Semnan, Eastern Alborz* (Masters dissertation, Azad University, North Tehran branch).

Mohammadi Monfared, M. (1957). *Stratigraphy and Ammonite Fauna of Dalichai and Lar formations in Mount Sharaf Semnan, Eastern Alborz* (Masters dissertation, University of Isfahan).

Moore, R. C. (1957). *Treatise on Invertebrate Paleontology- Part L.* Geological Society of America and University of Kansas Press, Kansas.

Niknahad, M. (1948). *The study of stratigraphy and paleontology of Dalichai formations in the southeast of Maraqa (Western Alborz) according to Ammonite Fauna* (M.Sc. dissertation, Geological Survey and mineral exploration of Iran).

Rafiei, A. (2013). *Miospores of Jurassic sediments, northwest of Semnan, Central Alborz* (M.Sc. dissertation, University of Tehran).

Raoufian, A., Zand Moghaddam, H., & Seyed–Emami, K. (2019). Depositional history of Middle-Upper Jurassic succession at the Binalud Mountains, NE Iran: implications of ammonite, trace fossil and stable isotopes in palaeoenvironmental analysis. *Historical Biology, 32*(2), 1-18. https://doi.org/10.1080/08912963.2018.1563078

Seyed-Emami, K., & Raoufian, A. (2017). Ammonites from Bathonian and Callovian (Middle Jurassic) North of Damghan, Eastern Alborz, North Iran. *Zitteliana, 89*, 253-270.

Seyed-Emami, K., Schairer, G., Raoufian, A., & Shafeizad, M. (2013). Middle and Late Jurassic ammonites from the Dalichai Formation west of Shahrud (East Alborz, North Iran). *Neues Jahrbuch für Geologie und Paläontologie, 267*(1), 43-66. https://doi.org/10.1127/0077-7749/2012/0296

Seyed-Emami, K., Raoufian, A., & Mönnig, E. (2015). Macrocephalitinae (Ammonoidea, Middle Jurassic) from North and Central Iran. *Neues Jahrbuch für Geologie und Palontologie, 278*(3), 257-279. https://doi.org/10.1127/njgpa/2015/0527

Shafizad, M. (1961). *The study of stratigraphy and paleontology of Dalichai Formation in Eastern Alborz, west of Shahroud* (M.Sc. Thesis, Islamic Azad University, North Tehran branch).

Steiger, R. (1966). *Die Geologie der West-Firuzkuh-Area, Zentralelburz/Iran* (Doctoral dissertation, University of Zurich).

Stocklin, J., & Setudehnia, A. (1991). *Stratigraphic Lexicon of Iran, Central, North and East Iran* (Report No. 18). Geological Survey of Iran.

Totonchi, B. (1961). *Stratigraphic and paleontological study of Dalichai Formation in the south of Polour area, southeast of Poldokhtar* (Masters dissertation, Islamic Azad University, North Tehran branch).

Wilmsen, M., Fürsich, F.T. & Taheri, J. (2009). The Shemshak group (Lower-Middle Jurassic) of the Binalud mountains, NE Iran: stratigraphy, depositional environments and geodynamic implications. In *Geological Society London, Special Publications* (Vol. 312), 175-188. https://doi.org/10.1144/SP312.8

Zadesmaeil, M., Majidifard, M. R., Vaziri, S. H. & Jahani, D. (2021). Lithostratigraphy and Biostratigraphy of the Dalichai Formation in Absharaf Section, Northwest of Damghan on the base of Ammonites (East Alborz), Scientific Quaterly Journal. *Geosciences, 31*(2), 91-100. https://doi.org/10.22071/GSJ.2017.97439.1250