Journal of Sciences, Islamic Republic of Iran 30(1): 51 - 59 (2019) http://jsciences.ut.ac.ir
University of Tehran, ISSN 1016-1104

Late Barremian-Early Aptian Ammonites from the Tirgan Formation, Kopet-Dagh Sedimentary Basin, NE Iran

M. Molaei[1], S. H. Vaziri[*1], S. N. Raisossadat[2], M. Taherpour-Khalil-Abad[3], J. Taheri[4]

[1] *Department of Geology, North Tehran Branch, Islamic Azad University, Tehran, Islamic Republic of Iran*
[2] *Department of Geology, Faculty of Sciences,University of Birjand, Birjand, Islamic Republic of Iran*
[3] *Young Researchers and Elite Club, Mashhad Branch, Islamic Azad University, Mashhad, Islamic Republic of Iran*
[4] *Geological Survey of Iran, NE Territory, Mashhad, Islamic Republic of Iran*

Received: 12 September 2017 / Revised: 12 November 2017 / Accepted: 21 July 2018

Abstract

During the recent field research on the Tirgan Formation in the west of Kopet-Dagh sedimentary basin, ammonite assemblages were obtained from the carbonate strata of this formation. This new finding is important for stratigraphical purpose. In this research, 3 genera belong to *Heteroceras, Deshayesites* and *Cheloniceras*? as well as one uncertain genus belongs to *Turkmeniceras* are determined. The ammonite fauna dates the Tirgan Formation from the late Barremian to early Aptian in the studied stratigraphic section.

Keywords: Ammonite; Lower Cretaceous; Late Barremian; Early Aptian; Tirgan Formation.

Introduction

The Palaeotethyan suture, which resulted from the Late Triassic collision of the Iran Plate with the southern margin of Eurasia (Turan Plate), runs south of the Caspian Sea from the northwest to the northeast of Iran. In this area, it separates the Kopet-Dagh (or Koppeh Dagh) from the Binalud Mountains, the southeastern extension of the Alborz Mountains of northern Iran. The Kopet-Dagh mountain range represents a NE-trending, about 650 km long and 200 km wide, active fold belt at the border between Iran (54°00′ to 61°14′E and 36°00′ to 38°16′N) and Turkmenistan, east of the Caspian Sea, stretching northwest-southeast from near the Caspian Sea in the northwest to the Harirud River in the southeast. In northeastern Iran, the Paleotethys suture zone corresponds to the boundary between the Kopet-Dagh fold-and-thrust belt to the NE, and the eastern prolongation of the Alborz range to the SW (Figure 1). Remnants of the Paleotethys Ocean are located in the northern margin Binalud Mountains where the Cimmerian event is characterized by a collisional type event during the Late Triassic/Early Jurassic. Following this collision, the Kopet-Dagh Basin was deposited on the southern margin of the Turan Plate from the Jurassic to the Tertiary with about 10 km of mostly conformably Mesozoic-Tertiary sediments (mostly carbonates) [1] (for more data see Afshar-Harb 1994; Golonka 2004; Robert et al., 2014; Niebuhr et al., 2016 [2-5]). It should

[*] Corresponding author: Tel: +9809121782079; Fax: +9802177009848; E-mail: h_vaziri@iau-tnb.ac.ir

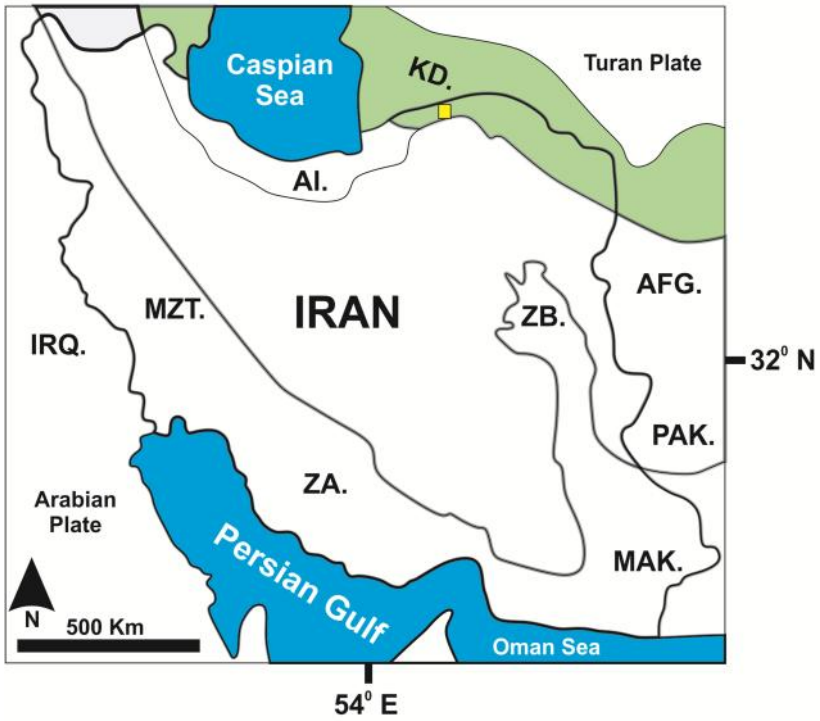

Figure 1. The subdivisions of structural zones of Iran (Abbreviations: KD.: Kopet-Dagh, Al.: Alborz, MZT.: Main Zagros Thrust, ZA.: Zagros, MAK.: Makran, ZB.: Zabol-Baluch). Studied area is marked by yellow rectangle (After Poursoltani and Pe-Piper., 2015 with minor revision [29]).

be reminded after the collisional event in late Triassic-Early Jurassic an extensional phase and fragmentation of Iran Plate has occurred in Middle Jurassic [6]. Such event resulted in a new cycle of sedimentation and marine transgression in different parts of Iran especially in NE of Iran the rejoin which entitled as Kopet-Dagh today. This new basin started to evolve from Late Bajocian to Holocene.

Lower Cretaceous successions in Iran

The complete Cretaceous sections in North Iran are found in the Kopet-Dagh Range on the border of Iran and Turkmenistan. The rocks consist of marine shales, marls, limestones and subordinate sandstones. The sequence reaches a thickness of more than 3000 m and seems to represent all major stages of the Cretaceous system, specially its lower part. The stratigraphic nomenclature for this region has been carried out by geologists of National Iranian Oil Company (NIOC) and is referred here to the Tirgan through Kalat formations [4] (with minor revision).

In the Alborz (=Elborz) mountains and farther south, Cretaceous rocks, mainly limestones and marls, are widely distributed, but the sections are less complete. In particular, the Lower Cretaceous seems to be missing nearly everywhere; possible exceptions to this are few limestone exposures close to the "Main Zagros Thrust", and those few and limited areas of the western and eastern Alborz and south of Kerman, where Tithonian-?Berriasian *Calpionella* limestones have been observed. Elsewhere, unfossiliferous red clastic basal beds in the north of Ravar-Darband area initiate the Cretaceous sequence and are followed by limestones and marls of different ages. The oldest marine beds are *Orbitolina*-bearing limestones (here referred to the Tiz-Kuh Formation), which are conventionally regarded as Aptian-Albian but may include stages as old as Barremian and as young as Cenomanian.

An unusual shale facies reaching great thickness and containing very rare cephalopods represents the Barremian-Albian in the Biabanak area of Central Iran (here referred to Biabanak Shales). Detrital limestones, reef limestones, marls and shales prevail. However, the sequences are frequently interrupted by conglomerates, red beds, sedimentary gaps and unconformities, and the sections vary in detail over short distances, reflecting the unstable sedimentary environment during the initial phases of the Alpine Orogeny [7]. Among the thick package of different marine and occasionally non-marine strata (for instances, Lower Cretaceous Shourijeh Formation) the Tirgan Formation represents more or less monotonous medium to thick-bedded

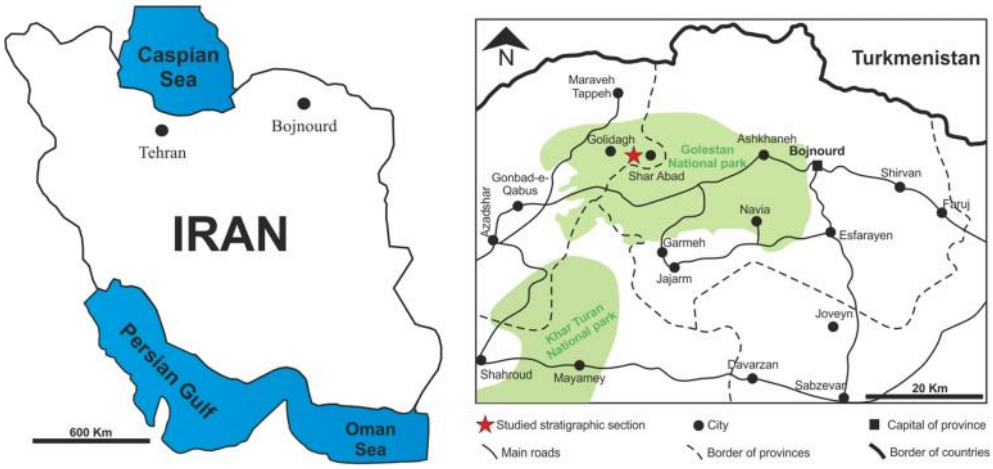

Figure 2. The location map of the studied stratigraphic section.

carbonate rocks in most parts of the Kopet-Dagh sedimentary basin, but in the study area showing new subdivisions, members and data. In this area [8] has introduced the following members of this formation:

- Member 1. Light brown to reddish sandy limestone, micritic limestone with cherty nodules and oolitic limestone in the upper part of this member.

- Member 2. Intercalation of shally limestone and thin beds of grayish marls, with fossil remnants of ammonites, brachiopods, bivalve and gastropods.

- Member 3. Medium bedded, creme to light brown limestone with ooids and ploiids. This member is transitionally replaced by dark gray to black marls and shale of Sarcheshme Formation (Lower Cretaceous, for more information see Amend's report sheet, GSI). In this paper, we will present our results on Ammonite determination, which extracted from a fieldwork and bed by bed measuring in the study area which is described in detail in the "lithostratigraphy" part of the present study.

Geological setting

The Shahr Abad stratigraphic section is located about 20 km west from Shahr Abad city (37 34' 13.20''N and 56 7' 53.64''E). The Shurijeh and Sarcheshmeh formations are well-exposed next to the Tirgan Formation in the studied area (Figure 2). In this study, the Tirgan Formation is investigated in one stratigraphic section with regard to ammonites contains. The Tirgan Formation is mainly composed of thin to thick-bedded limestones and argillaceous limestones in the studied stratigraphic section.

Tirgan Formation

This formation is named from its exposure in the Tirgan Valley of Kopet-Dagh. It was introduced by geologists of the National Iranian Oil Company for a feature-forming unit of massively-bedded, oolitic and organo detrital limestone occurring throughout the Kopet-Dagh ranges. The 700 m Tirgan type-section consists mainly of mid-sized to thick-beds of gray fossiliferous limestone [2]. For the eastern part of Kopet-Dagh, Afshar-Harb (1969) [2] indicates the thickness of the Tirgan Formation to be only 50 m. It overlies the Shurijeh Formation and underlies the Sarcheshmeh Formation; both contacts are conformable but a transitional interfingering between the Tirgan and the Shurijeh formations exists in southeastern Kopet-Dagh. Immel *et al*. (1997) [9] reported the ammonite *Paraspiticeras percevali* from Tirgan Formation, which is of Barremian age.

Lithostratigraphy of the Tirgan Formation in the study area

- *Shahr Abad stratigraphic section*

Both boundaries of the Tirgan Formation in the Shahr Abad stratigraphic section are conformable and continue in the studied area. From the lithological point of view, the Tirgan Formation in the studied area is mainly composed of rock units as follow (Figures. 3-4):

- Light brown, massive to thick-bedded limestone (9 m.).
- Eroded creamy, thin-bedded limestone contain of bivalves (6 m.).
- Eroded light gray, thin to medium-bedded limestone (6.50 m.).
- Light brown, thick-bedded limestone (1 m.).
- Light gray, nodular thin-bedded limestone (3 m.).
- Light brown, massive to thick-bedded limestone (13.50 m.).

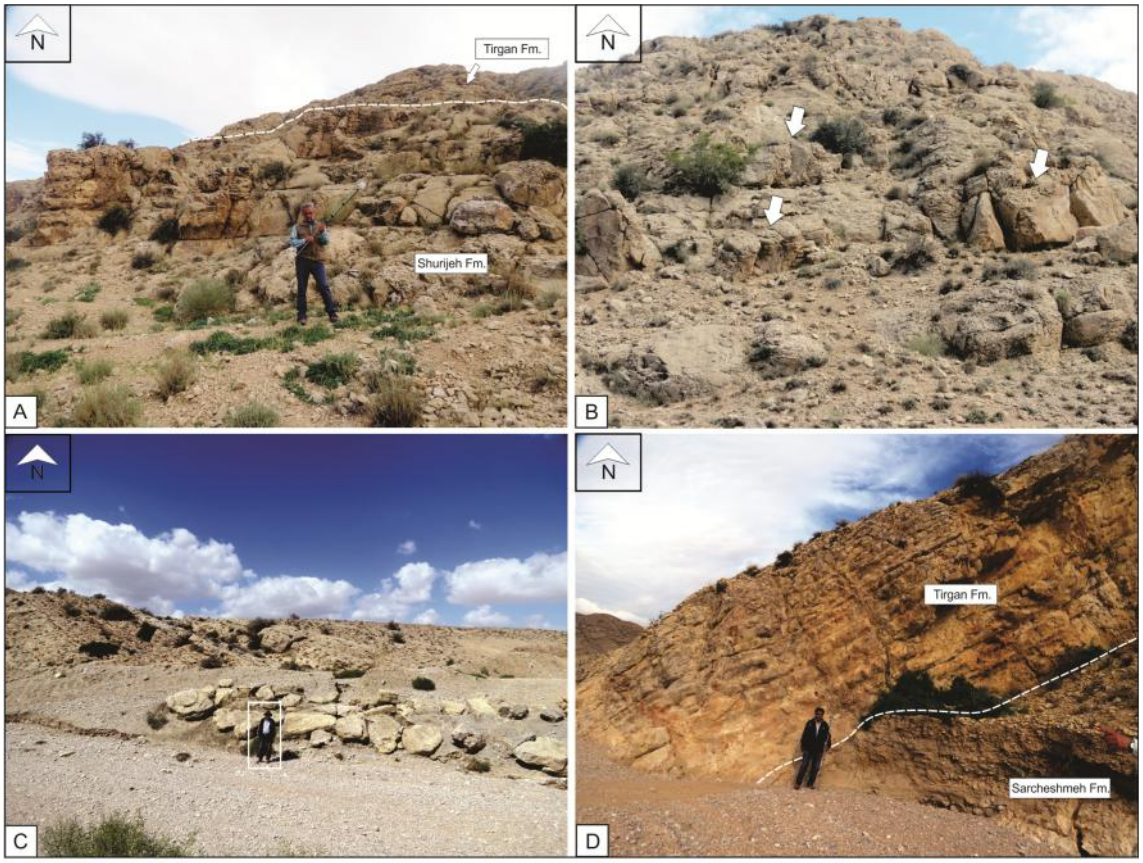

Figure 3. Filed photos of the Shahr Abad stratigraphic section. **A.** lithostratigraphical boundary between the Shurijeh and Tirgan formations. **B.** Carbonate units in the Tirgan Fm. (Ammonite bearing limestones are shown by arrows). **C.** Marl and shale beds in the Sarcheshmeh Fm. **D.** lithostratigraphical boundary between the Tirgan and Sarcheshmeh formations (Field photos from Molaei et al., 2017) [34].

- Light gray, massive to thick-bedded limestone (10 m.).
- Light brown, thick-bedded limestone contains *Planolites* ichnofossils (1.50 m.).
- Light brown, massive to thick-bedded fossiliferous limestone (7 m.).
- Gray, massive to thick-bedded limestone contains Orbitolinids (11 m.).
- Gray, massive to thick-bedded limestone (3 m.).
- Light brown, thin-bedded cherty limestone contain of *Ophiomorpha* ichnofossils (4 m.).
- Light gray, thin to medium-bedded cherty limestone contains *Planolites* ichnofossils (9 m.).
- Dark gray, thick-bedded cherty limestone (3 m.).
- Light to dark gray, thin to medium-bedded limestones contains *Planolites* ichnofossils, Belemnites and ammonites (*Heteroceras* sp.) (4.50 m.).
- Light gray, medium-bedded marly limestone (7.50 m.).
- Light gray, thin-bedded marly limestone (6 m.).
- Light gray, massive to thick-bedded limestone with cherty nodules, ammonites (*Heteroceras* sp.) and *Thalasinoides* ichnofossils (18 m.).
- Light gray, massive to medium-bedded limestone contains ammonites (*Heteroceras* sp.) (12 m.).
- Limonitic, medium to thin-bedded limestone with cherty nodules and *Thalasinoides* ichnofossils (10.50 m.).
- Intercalation of medium-bedded limestone and limonitic marls (35.50 m.).
- Creamy to gray, thin to medium-bedded marly limestone contains *Planolites* ichnofossils (34 m.).
- Light creamy, thin to medium-bedded limestone with cherty nodules and ammonites (?*Turkeminiceras* sp. and *Deshayesites* sp.1) and *Thalasinoides* ichnofossils (11.50 m.).
- Light gray, thin to medium-bedded limestone contain of ammonites (?*Turkeminiceras* sp. and *Deshayesites* sp.1) (39.50 m.).
- Light brown, thin to medium-bedded limestone contains ammonites and *Thalasinoides* ichnofossils (31 m.).

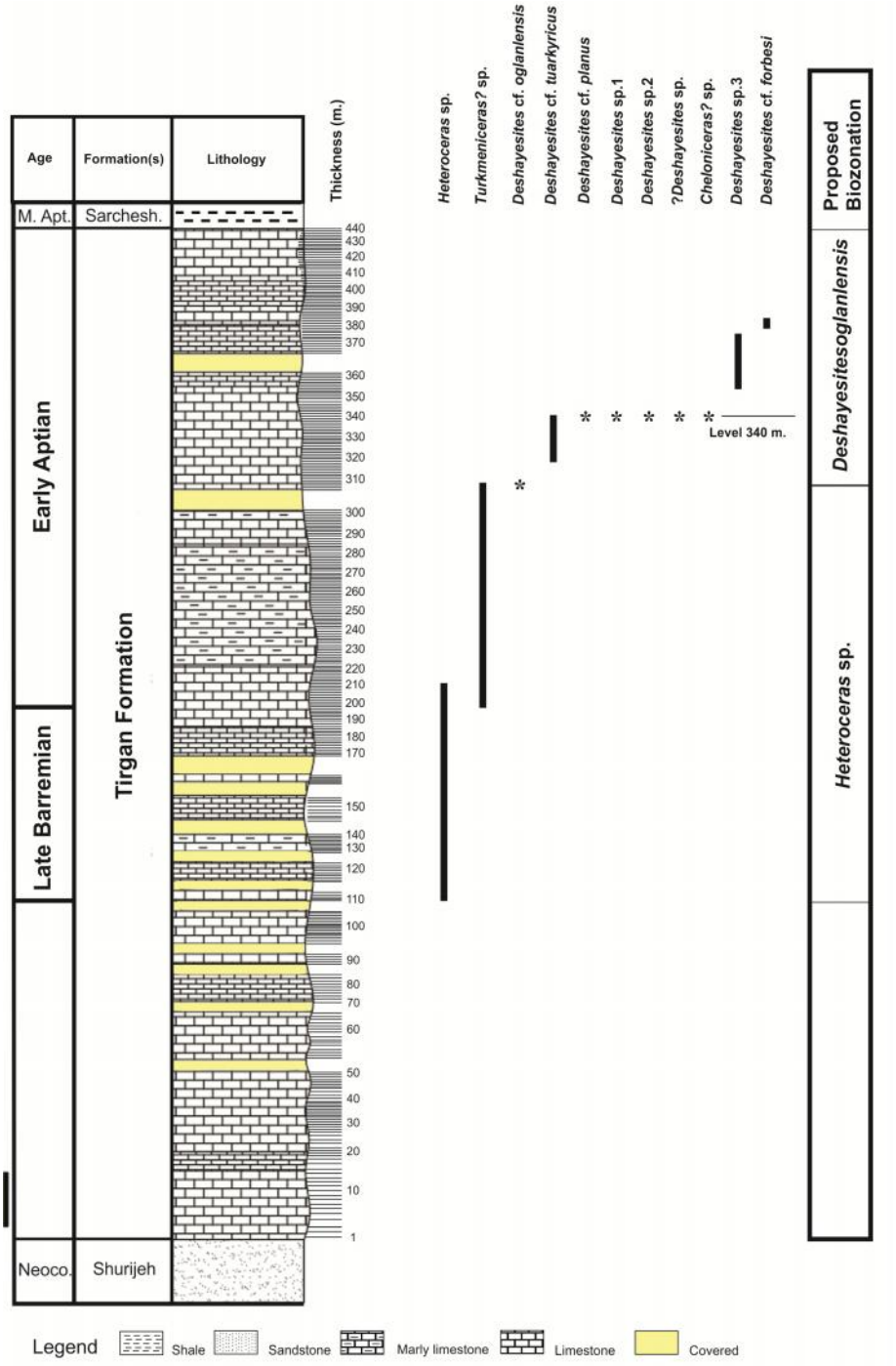

Figure 4. The ammonite ranges plotted on the stratigraphic column of the Tirgan Formation in the Shahr Abad stratigraphic section.

- Light brown, thin-bedded limestone (21 m.).
- Light gray, thin-bedded, limestone contains bivalves and ammonites (?*Turkmeniceras* sp., *Deshayesites* sp.1 and *Deshayesites* cf. *oglanlensis*) (13 m.).
- Light gray, thick-bedded limestone contains a huge amount of ammonites (*Deshayesites* cf. *tuarkyricus*, *Deshayesites* cf. *planus*, *Deshayesites* sp.2, ?*Deshayesites* sp., *Hemihoplites* sp. and *Deshayesites* sp.3) (30 m.).

- Dark gray, thin-bedded limestone contains ammonites (*Deshayesites* sp.3 and *Deshayesites* cf. *forbesi*) (10 m.).
- Dark gray, thick-bedded limestone contains ammonites (*Deshayesites* cf. *forbesi*) (3.50 m.).
- Dark brown, thin-bedded limestone contains bivalves (20 m.).
- Dark gray, thick-bedded limestone (30 m.).

Materials and Methods

The material comprises almost 25 specimens of ammonites cleaned and covered by ammonium chloride for taking photographs in order to achieve the best contrast and finally have been determined paleontologically. All of the studied specimens which were collected by the authors as well as the thin sections are housed in the repository system of Geological Survey of Iran and Geosciences Research Center, NE territory (M. Taherpour Khalil Abad collection).

Ammonite Biostratigraphy

The Barremian stage was first defined by Coquand (1862) [10], based on successions in the southeast of France. One of his cited localities, Angles (Basses-Alpes), was designated by Busnardo (1965) [11] as 'stratotype'. The typical Barremian ammonite faunas belong to the Tethyan Realm (Mediterranean Province). They have been studied extensively in recent years, especially in France (Delanoy, 1997 [12]), Alp [13], Georgia and adjacent areas [13 & 14], Czech Republic [15] Bulgaria [16], North Africa [17] and Japan [18].

The Aptian Stage boundaries and index faunas, eapicially ammonites in Tethys region have been discussed by Casey (1961) [19] from England, Ropolo et al. (2006) [20] from France, Bogdanova and Prozorovsky (1999) [1] and Tovbina (1980) [21] from Turkmenistan and Mangyschlak, Seyed-Emami et al. (1971) [22] from Central Iran, Immel et al., (1997) [9] from Kopet-Dagh, Raisosadat (2011) [23], Moreno-Bedmar et al. (2010) [24] from Spain.

Ammonites provide one of the most precise biostratigraphical tools for correlating marine Lower Cretaceous sediments. For much of Early Cretaceous time, there was a separation into Tethyan and Boreal Realms, with distinct endemic ammonite faunas, which sometimes makes long-distance correlation difficult. During the last decade the Lower Cretaceous Cephalopod Team, now a working group of the Subcommission on Cretaceous Stratigraphy (SCS) of IUGS has held five International Workshops, concerned primarily with improving the standard biozonation for the Mediterranean area of the Tethyan Realm [25, 26, 27 & 28].

Biostratigraphy of the Tirgan Formation: comparison to literature data

Heteroceras sp. Zone: This zone is an assemblage zone. The base of the zone is defined by the first appearance of *Heteroceras*. Other characteristic taxa include *Turkmeniceras* sp. They also recorded the following genera and species from Sarcheshmeh Formation in Takal Kuh stratigraphic section: *Colchidites securiformis, C. ratshensis, C. tenuicostatus, C. tinae, C.* sp. ex. gr. *colchicus*, *Imerites favrei* and *Hemihoplites* sp. Moreover, Raisossadat (2011) [23] is recorded *Barremites* cf. *difficilis, Argvethites* sp., *Imerites favrei, Imerites sparcicostatus, Toxoceratoides* sp., *Heteroceras* cf. *colchicus, Turkmeniceras multicostatum*, and *T.* cf. *tumidum* from Sarcheshmeh Formation. These assemblages indicate the Late Barremian age.

The collected specimens by authors from Tirgan Formation could be compared with the *Imerites favrei-Heteroceras astieri* Zone, which represents the whole of the Late Barremian, in the Caucasus (Kakabadze, 1989) [29], and the *Hemihoplites feraudianus* and *Imerites giraudi* Zones of the West Mediterranean Province [26] or probably *Heteroceras emerici* subzone (Reboulet et al., 2014) [27]. It also correlates with the *securiformis* Zone of Georgia [14 & 30] and the *M. sarasini* and *Pseudocrioceras waagenoides* zones of the West Mediterranean Province [31].

Deshayesites oglanlensis Zone: The identified assemblage in this study shows more similarity to previous genera and species that reported from Iranian and Turkmenian part of Kopet-Dagh and Caucasian faunas than to those from north-west Europe. The *Deshayesites tuarkyricus* Zone was suggested by Bogdanova (1983) [32] for sequences in Turkmenistan. Then it was chosen for the whole of the Mediterranean region [25]. Raisossadat (2011) [23] considered the geographical occurrence of *D. tuarkyricus* to be restricted to Mangyschlak (Turkmenistan) and Transcaspia. Therefore he suggested *D. oglanlensis* as the name of the zone. The latter species more geographically widespread and could be a more suitable index fossil for this Zone and this has been accepted.

This zone is an interval zone. The base of the zone is marked by the appearance of *Deshayesites oglanlensis* in the studied stratigraphic section. In Tirgan Formation of Shahr Abad stratigraphic section typical fauna of the *oglanlensis* Zone has been collected in-situ. The lowest occurrence of *Deshayesites* in the Tirgan Formation in the Shahr Abad stratigraphic section is 340 m. above the

base of the formation and consists of *Deshayesites* cf. *oglanlensis*, *Deshayesites* cf. *tuarkyricus*, *Deshayesites* cf. *planus*, *Deshayesites* cf. *forbesi*, *Cheloniceras*? sp., *Deshayesites* sp.1, *Deshayesites* sp.2 and *Deshayesites* sp.3. Immel *et al*. (1997) [9] reported the ammonite *Prodeshayesites* (=*Deshayesites*) *tenuicostatus* from the lowermost part of Sarcheshmmeh Formation. Moreover Raisossadat (2004) [23] recorded *Deshayesites dechyi, D.* cf. *euglyphus*, *D. luppovi*, *D. oglanlensis*, *D.* cf. *planus*, *D.* cf. *weissiformis*, *D.* cf. *tuarkyricus*, *D.* sp.1, *D.* sp.2, *Ancyloceras* cf. *mantelli*, *Pedioceras* sp. from *Deshayesites oglanlensis* Zone in Takal Kuh and Amand stratigraphic sections.

Results and Discussion

The Lower Cretaceous, the Tirgan Formation in the Kopet-Dagh sedimentary basin was investigated from paleontology and lithostratigraphically point of views but there were not valuable reports on the ammonites from this formation till yet. It led to this fact that in the Barremian and Early Aptian of the Kopet-Dagh sedimentary basin (especially the Tirgan Formation) ammonites as well as the zone species of this macrofauna are missing in principles. The present study based on new ammonite specimens deals with the assignment of strata rather rich in ammonites to the level of ammonite zones of the Tethyan realm. During the paleontological investigations four genera and eight species as well as two biozones, *Heteroceras* sp. zone (Late Barremian) and *Deshayesites oglanlensis* Zone (lowermost Aptian) are distinguished. The determined ammonites proposed the Late Barremian to Early

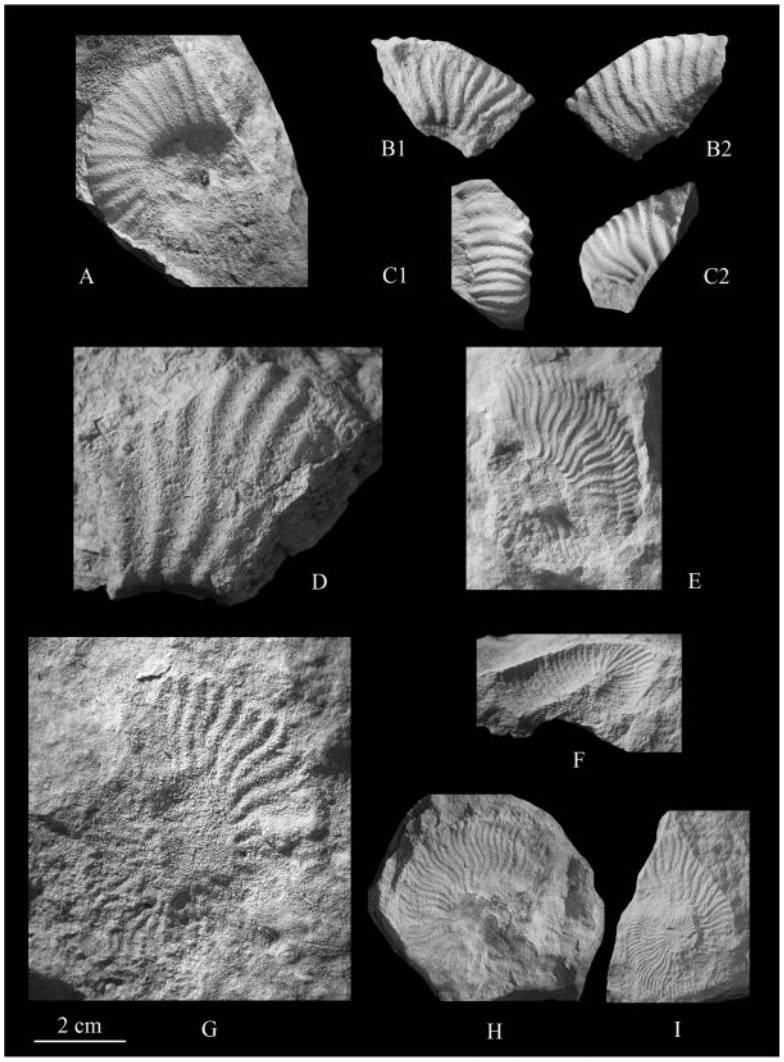

Plate 1-1

A: *Cheloniceras*? sp.**, B1, B2:** *Deshayesites* sp. 1, **C1, C2:** *Deshayesites* sp.2, **D:** *Deshayesites* sp. 3, **E:** *Deshayesites* cf. *oglanlensis*, **F:** *Heteroceras* sp., **G:** *Deshayesites* sp. 3, **H:** *Deshayesites* cf. *tuarkyricus*, **I:** *Deshayesites* cf. *tuarkyricus.*

Plate 2-2
A1-A3: *Deshayesites* sp., **B:** *Heteroceras* sp.

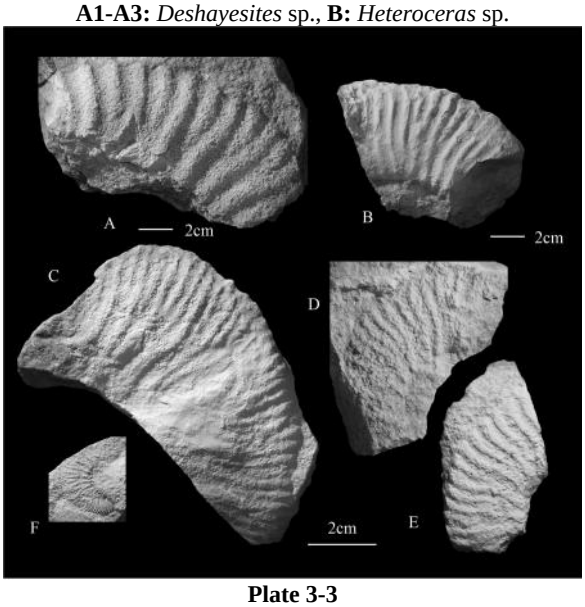

Plate 3-3
A, C: ?*Turkmeniceras* sp., **B:** *Deshayesites* cf. *planus*, **D:** *Deshayesites* cf. *forbesi*, **E:** *Deshayesites* cf. *forbesi*, **F:** *Turkmeniceras* sp.

Aptian stages for the middle to upper part of the Tirgan Formation in the Shar Abad stratigraphic section.

Acknowledgment

The authors' acknowledgment goes to the Geological Survey of Iran, NE territory for special supporting on the field excursions, helping in samplings and taking photographs of the ammonite specimens. We thank the anonymous reviewers for their careful reading of our manuscript and their many insightful comments and suggestions..

References

1. Bogdanova T.N., and Prozorovsky V. Substantiation of the Barremian/ Aptian boundary. *Scripta geologica*, **3:** 45-81 (1999).
2. Afshar-Harb A. Geology of Kopet-Dagh. *Treatise on the Geology of Iran*, Geological Survey of Iran Publication, **11:** 1-275 (1969).
3. Golonka J. Late Triassic and Early Jurassic palaeogeography of the world. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **244(1):** 297-307 (2007).
4. Niebuhr B., Taherpour Khalil Abad M., Wilmsen M., Razmi J.N., Aryaei A.A., and Ashouri A. First record of late Campanian ammonites from the Abderaz Formation of the Koppeh Dagh, northeastern Iran. *Cretaceous Research*, **58:** 202-222 (2016).
5. Robert M.M., Letouzey J., Kavoosi M.A., Sherkati Sh., Müller C., Vergés J. and Aghababaei A. Structural evolution of the Kopeh Dagh fold-and-thrust belt (NE Iran) and interactions with the South Caspian Sea Basin and Amu Darya Basin. *Marine and Petroleum Geology*, **57:** 68-87 (2014).
6. Seyed-Emami K. and Alavi-Naini M. Bajocian stage in Iran. *Memorie del Descrizione della Carta Geologica d'ltalia*, **40:** 215-222 (1990).
7. Stocklin J. and Setudehnia A. Stratigraphic Lexicon of Iran. *Geological Survey Iran, Tehran, Iran*, **Report No. 18** (1991).
8. Ghaemi F. Amend Geological Sheet (Scale of 1:100000), Under publication, Geological Survey of Iran (2017).
9. Immel H., Seyed-Emami K. and Afshar-Harb A. Kreide-Ammoniten aus dem iranischen teil des Koppeh-Dagh (NE-Iran). *Zitteliana*, **21:** 159-190 (1997).
10. Coquand H. Sur la convenance d'établir dans le groupe inférieur de la formation crétacée un nouvel étage entre le Néocomien proprement dit (couches à Toxaster complanatus et à Ostrea couloni) et le Néocomien Supérieur (étage Urgonien d'Orbigny). *Mémoires de la Societé d'Emulation Provence*, **2:** 1-127 (1862).
11. Busnardo R. Le stratotype du Barrémien, Lithologie et macrofaune in Colloque sur le Crétacé inférieur (Lyon, September 1963). *Mémoires Bureau de Recherches Géologiques et Minières*, **34:** 101-116 (1965).
12. Delanoy G. Biostratigraphie des faunes d'Ammonites à la limite Barrémien-Aptien dans la region d'Angles-Barrême-Castellane. *Annales du Muséum d'Histoire Naturelle de Nice*, **12:** 1-270 (1997).
13. Lukeneder A. New biostratigraphic data on an Upper HauterivianeUpper Barremian ammonite assemblage

from the Dolomites (Southern Alps, Italy). *Cretaceous Research*, **35:** 1-21 (2012).
14. Kotetishvili E., Kakabadze M. and Kakabadze I. Steps in Evolution of the Early Cretaceous ammonites of Georgia. *Trudy Akademya Nauk Gruzinskoi SSR, A. Djanelidze Geologiskii Institut, Novya Serie,* **115:** 76-85 (2000).
15. Vasicek Z. Michalik J. and Borza K. To the "Neocomian" biostratigraphy in the Krizna-Nappe of the Strazovske Vrchy Mountains (northwestern Central Carpathians). *Zitteliana*, **10:** 467-483 (1983).
16. Ivanov M. and Idakieva V. Upper Barremian ammonite biostratigraphy in Central-North and Northeastern Bulgaria. *Proceedings of National Conference Geosciences 2009, Bulgarian Geological Society*, 55-56 (in Bulgarian) (2009).
17. Company M., Sandoval, J., Tavera J.M. Aoutem M. and Ettachfini M. Barremian ammonite faunas from the western High Atlas, Morocco-biostratigraphy and palaeobiogeography. *Cretaceous Research*, **29:** 9-26 (2008).
18. Matsukawa M., Obata I. and Sato K. Barremian ammonite fauna of the lower Ishido Formation, eastern part of the Sanchu Cretaceous, Japan. *Bulletin of Tokyo Gakugei University, Natural Sciences*, **59:** 77-87 (2007).
19. Casey R. The stratigraphical palaeontology of the Lower Greensand. *Palaeontology*, **3:** 487-621 (1961).
20. Ropolo P., Moullade M., Gonnet R., Conte G. and Tronchetti G. The Deshayesitidae Stoyanov, 1949 (Ammonoidea) of the Aptian historical stratotype region at Cassis-La Bédoule (SE France). *Carnets de Géologie/Notebooks on Geology*, **CG2006 (M01):** 1-46 (2006).
21. Tovbina S.Z. On the Zone Acanthohoplites prodromus of the Upper Aptian of Turkmenia. *Izvestiya Akademya Nauk SSSR, Seriya Geologiskaya*, **7,** 142-144. (1980).
22. Seyed-Emami K., Brants A. and Bozorgnia F. Stratigraphy of the Cretaceous rocks southeast of Esfahan. *Geological Survey of Iran*, **20:** 5-40 (1971).
23. Raisossadat S.N. The Early Aptian (Early Cretaceous) ammonites from the Aralar Mountains, Basque-Cantabrian Basin, Northern Spain. *Carnets de Géologie/Notebooks on Geology*, **CG2011(M02)** (2011).
24. Moreno-Bedmar J.A., Company M., Bover-Arnal T., Salas R., Delanoy G., Maurrasse F.J.M.R., Grauges A. and Martínez R. Lower Aptian ammonite biostratigraphy in the Maestrat Basin (Eastern Iberian Chain, Eastern Spain). A Tethyan transgressive record enhanced by synrift subsidence. *Geologica Acta*, **8(3):** 281-299 (2010).
25. Hoedemaeker Ph.J. and Bulot L. Preliminary ammonite zonation for the Lower Cretaceous of the Mediterranean region. *Géologie Alpine*, **66:** 123-127 (1990).
26. Hoedemaeker Ph.J. and Rawson P. Report on the 5th International Workshop of the Lower Cretaceous Cephalopod Team (Vienna, 5 September 2000). *Cretaceous Research*, **21:** 857-860 (2000).
27. Reboulet S., and Szives O., Aguirre-Urreta M.B., Barragán, R. Company M., Idakieva V., Ivanov M., Kakabadze M.V., Çaglar M.K., González-Arreola C., Fozy, I., Baraboshkin, E.Y., Kenjo S., Lukeneder, A., Raisossadat, N., Rawson P.F. and Tavera, J.M. Report on the 5th International Meeting of the IUGS Lower Cretaceous Ammonite Working Group, the Kilian Group (Ankara, Turkey, 31st August 2013). *Cretaceous Research*, **50:** 126-37 (2014).
28. Reboulet S., Rawson P.F., Moreno-Bedmar J.A., Aguirre-Urreta M.B., Barragán R., Bogomolov Y., Company M., González-Arreola C., Idakieva K. Report on the 4th international meeting of the IUGS Lower Cretaceous ammonite working group, the "Kilian Group"(Dijon, France, 30th August 2010). *Cretaceous Research*, **32(6):** 786-793 (2011).
29. Kakabadze M.V. The Barremian biostratigraphical subdivisions of Georgia (USSR) and comparison with some Western Mediterranean regions. In Cretaceous of the Western Tethys (ed. Wiedmann, J.). *Proceedings 3rd International Cretaceous Symposium Tubingen*, 551-560 (1989).
30. Kakabadze M.V. Lower Cretaceous heteoceratides of Georgia and adjacent regions. Issues of Palaeontology and Stratigraphy of Mesozoic of Georgia. *Trudy Geologichskago Akademya Nauk Gruzinskoi SSR*, **47:** 63-131. (1975).
31. Hoedemaeker P.J., Reboulet S., Aguirre-Urreta M.B., Alsen P., Aoutem M., Atrops F., Barragan R., Company M., Gonzalez Arreola, C., Klein J., Lukeneder A., Ploch I., Raisossadat N., Rawson P.F., Ropolo P., Vasicek Z., Vermeulen J. and Wippich M., Report on the 1st International Workshop of the IUGS Lower Cretaceous Ammonite Working Group, the ''Kilian Group'' (Lyon, 11 July 2002). *Cretaceous Research*, **24:** 89-94 (2003).
32. Bogdanova T.N. *Deshayesites tuarkyricus* Zone; the lowermost zone of the Aptian in Turkmenistan. *Ezhegodnik Vsesoyuznogo Paleontologicheskogo Obshchestva*, **26:** 128-147 (1983).
33. Poursoltani M.R. and Pe-Piper G. Source and diagenesis of Middle Jurassic marine mudstones, Kopet-Dagh Basin, NE Iran. *Geopersia*, **5(2):** 93-109 (2015).
34. Molaei M., Vaziri S.H., Taherpour-Khalil-Abad M. and Taheri J. Early Cretaceous *Neotrocholina* Reichel, 1956 from the Tirgan Formation, Kopet-Dagh sedimentary basin, NE Iran: systematic and biometric interpretation. *Arabian Journal of Geosciences*, **10(14):** 1-15 (2017).