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

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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 Paleoethys 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 Paleoethys 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

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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
omenclature 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

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 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]).
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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 shaly 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-beded 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-beded limestone (1 m.).
  - Light gray, nodular thin-beded limestone (3 m.).
  - Light brown, massive to thick-beded limestone (13.50 m.).
- 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).
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<table>
<thead>
<tr>
<th>Age</th>
<th>Formation</th>
<th>Lithology</th>
</tr>
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<tbody>
<tr>
<td>M. Apt.</td>
<td>Sarchesh</td>
<td>Light brown, thin-bedded limestone (21 m.)</td>
</tr>
<tr>
<td>Early Apt.</td>
<td></td>
<td>Light gray, thin-bedded limestone contains bivalves and ammonites (Turkmeniceras sp., Deshayesites sp.1 and Deshayesites cf. oglanlensis) (13 m.).</td>
</tr>
<tr>
<td>Late Barremian</td>
<td>Tirgan Formation</td>
<td>Light gray, thick-bedded limestone contains a huge amount of ammonites (Deshayesites cf. tuaryricus, Deshayesites cf. planus, Deshayesites sp.2, ?Deshayesites sp., Hemihoplites sp. and Deshayesites sp.3) (30 m.).</td>
</tr>
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- 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.).
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Figure 4. The ammonite ranges plotted on the stratigraphic column of the Tirgan Formation in the Shahr Abad stratigraphic section.
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].


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 biozonzation 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, Raisosadat (2011) [23] is recorded Barremites cf. difficilis, Argyvethites 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 (Kakabzade, 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. sarasinii 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]. Raisosadat (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
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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

**Results and Discussion**


![Plate 1-1](image)

**Plate 1-1**

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

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