



Biostratigraphy of Dalichai Formation in Bar and Sarmeran sections (Binalud Mountains) Northeastern of Iran based on ammonite fauna with special emphasis on Phylloceratidae Family

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Abstract

In this research, the biostratigraphy of the Dalichai Formation in the Bar and Sarmeran sections at the Binalud Mountains has been studied with special emphasis on the most abundant ammonite family (Phylloceratidae family). The Dalichai Formation is mostly composed of marl, shale, siltstone, nodular marly limestone and limestone. In this study, by studying 219 specimens taken from the Bar and Sarmeran sections, ammonites belonging to 11 species, 4 Genus and 1 subgenus of the Phylloceratidae family have been identified. Based on the research completed, it is possible to consider an age equivalent to the Middle to Late Jurassic for the examined sequence of the Dalichai Formation in the Bar and Sarmeran sections. Paleobiogeographically, the existing ammonite fauna are closely related to the sub-Mediterranean Province of the northwestern Tethys. The Zigzag Zone of the Early Bathonian and the Bimammatum and Planula Zones of the Late Oxfordian have been recognized.

Keywords: Binalud, Jurassic, Ammonite, Phylloceratidae Family, Dalichai, Palaeobiogeography.

Introduction

Binalud Mountain Range is a sinusoidal mountain range with an east-west trend and convexity to the north in northeastern Iran (Darvishzadeh, 1992). The southern boundary of Binalud is the Miami or Shahroud fault and its northwestern boundary is known as the Semnan fault. The Paleotethys suture line is located in the north of these Mountains (Alavi, 1979; Bratesh, 1975, Stocklin, 1974, 1977).

Despite the fact that the real extension of the Binalud structural zone is between the northern regions of Sabzevar, Neishabur to Mashhad, considering that in the discussed zone, there is an igneous geological structure that can be traced across the border, it is Therefore believed that in the east, this zone continues to the Pardpamisos Mountains belonging to the Hindu Kush of Afghanistan (Darvishzadeh, 2002). Nabavi (1977) The Binalud geological unit is considered a gradual zone of Central Iran and Alborz due to some facies similarities and the effect of folds. Because the Paleozoic sediments and facies of this zone are similar to those of Alborz, but, according to Eftekharnjad (1981), the Eastern Alborz (including the Binalud and Aladagh Mountains) is not an independent zone but is part of central Iran, where Paleozoic epicontinental sediments are exposed almost everywhere.

Middle to late Jurassic rocks that represent the first rock unit of Alborz marine sediments in

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the western part of Binalud have a lot of expansion and thickness and a greenish-gray color between the silica-clastic Shemshak Formation below and the Lar Formation (limestone) located at the top (Figure 2. A).

In this formation, the types of rocks and fossils indicate deposition in the marine environment, which is clearly different from the lake-marsh conditions of its lower sediments (the Shemshak Formation) and thick carbonates of the Lar Formation (Aghanbati, 2005).

East of Damavand City is where the type section of the Dalichai Formation may be found. It has a thickness of 107 meters (Steiger, 1936). Most of the time, the top boundary of the Dalichai Formation with the Lar Formation is gradual, whereas the bottom boundary is typically a discontinuity (Aghanbati, 2005). Ammonites, which make up the majority of the fossils in this formation, are crucial for understanding the conditions of the prehistoric environment (Figure 2. D).

The ammonites of the Dalichai Formation by many paleontologists have been studied such as Seyed- Emami et al. (1985, 1989, 1991, 1994, 1998, 2001, 2010, 2011b, 2013), Schairer et al. (1991, 1999), Majidifard (2003, 2015), Taheri et al. (2006, 2009), Wilmsen et al. (2009), Shams and Seyed- Emami (2010), Dietze et al. (2014), Vaziri et al. (2009, 2011), Behfar et al. (2012), Sarbandi Farahani et al. (2015), Raoufian et al. (2011, 2014).

Lithostratigraphy

Bar section (northwest of Neishabour)

The Dalichai Formation in the Bar section is located 32 km northwest of Neishabour (Figure 1) at E58°-45'-57", N36°-31'-33". Its thickness is 672.5 meters and includes shale, marl, marly limestone, alternation of marl and marly limestone, limestone and cherty limestone, so that in the lower parts it consists of dark gray marls and in the upper part of marly limestone with marly intercalation and it ends with pea-colored limestone and thick layer of the Lar Formation. (Figure 2.A)

Shemshak Formation, which consists of alternating coal shales and sandstones containing plant remains with a discontinuity due to the Middle Cimmerian event (Seyed-Emami & Alavi-Naini, 1990); Fürsich et al, 2005; Wilmsen, 2009a); is located below the Dalichai Formation. Due to environmental erosion and the presence of marly sediments, the paleosol, which indicates the Middle Cimmerian event and is one of the characteristics of the border between the Shemshak and Dalichai formations in Eastern Alborz and Binalud, was not observed in the contact. A limited number of browns to red nodules can be seen at the base of the section. The upper part of the Dalichai formation is the Lar formation, which is characterized by the gradual removal of marly layers and the beginning of cherty limestones. The lithology of the Lar Formation includes thick to massive limestones with cherty nodules, and the transition from the Dalichai Formation to the Lar limestones is continuous and gradual. (Figure 2.B)

Sarmeran section (northwest of Esfarayen)

The Sarmeran section is located in the Saluk National Park, 23 km northwest of Esfarayen and 6.8 km north of Sarmeran village (Figure 1) at E = 57, 16, "46, N = 37, 11, "59. The measured thickness of the Dalichai Formation in the Sarmeran section is 734.5 meters, and it is mainly composed of marl, marly limestone, limestone, and nodular limestone, which are dominated by marl in the lower parts and calcareous sediments in the upper parts. In this section, the Dalichai Formation is placed on the clastic rocks of the Shemshak Formation with a discontinuity. Unlike many of the studied sections of the Dalichai Formation in the Binalud structural zone, in the first layers of this section, the abundance of brown nodules is very low and they are rarely seen.

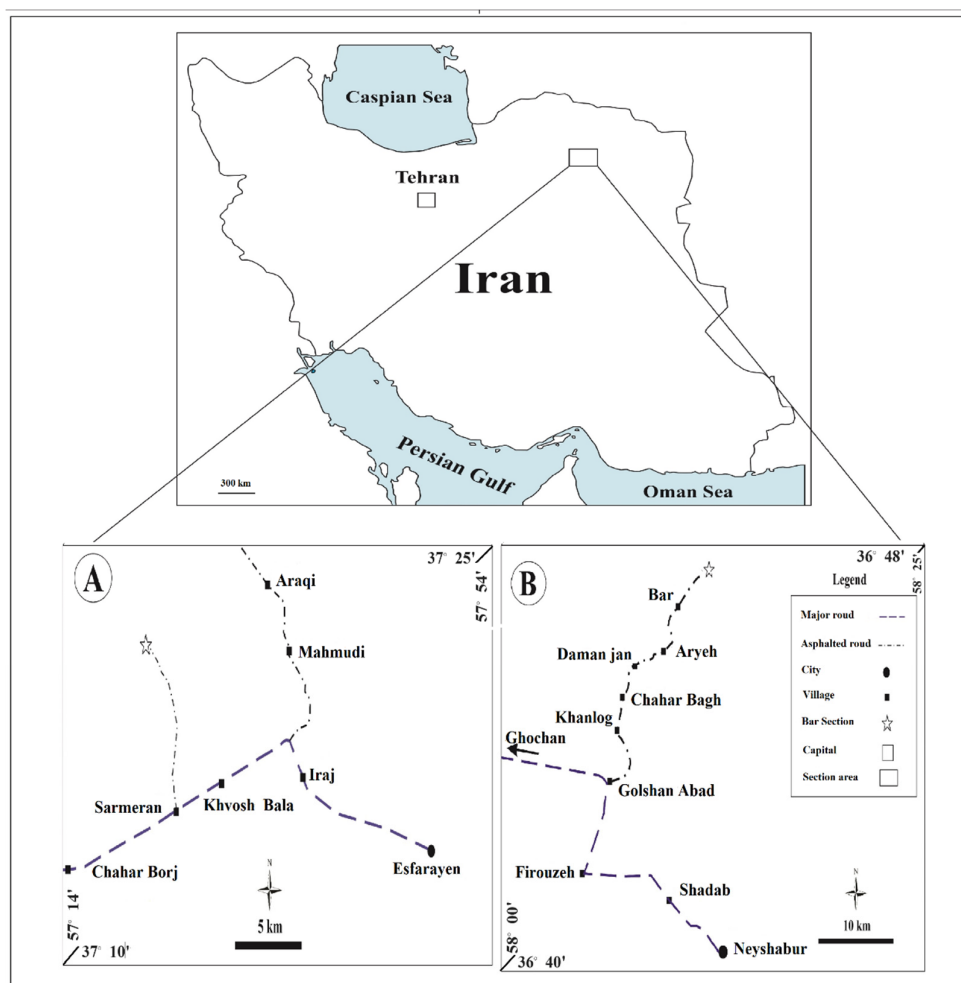


Figure 1. Geographical location and access ways to A: Bar & B: Sarmeran sections

Coaly lenses are found in the last layers of the Shemshak Formation in this location, indicating shallow and deltaic conditions. At the intersection of these two units, paleosoil may be seen, which indicate Middle Cimmerian event. (Figure 2. C). The upper boundary of the Dalichai Formation with the Lar formation in this section is gradual. The Dalichai Formation is divided into seven unofficial rock units in both the Bar and Sarmeran sections based on lithological traits, layer stratification, structural traits, and textural traits.

One of the prominent and general features of the Dalichai Formation, which can also be seen in the Bar and Sarmeran sections, is the presence of dark red to brown layers. These strata include thin-layered and nodular limestones with red marls and they are also referred to as “condensed beds” (Figure 2-D). This unit is a prominent lithological feature of the the Dalichai Formation in eastern Alborz and Binaloud. These condensed beds are very rich in terms of macro and microfossil content (Kandemir & Yilmaz, 2009; Martire, 1989; Rais et al., 2007). These types of sediments were mainly formed during the opening of the continental margin and are related to the opening of the Tethys Ocean (Cecca et al., 1992).

Systematic Paleontology

In this study, 550 ammonite specimens were collected from the Dalichai Formation in Bar and Sarmeran sections that 219 specimens are from the Phylloceratidae family (figure 3). In this part 121 specimens are selected and described based on their characteristics. (Moore, 1968).

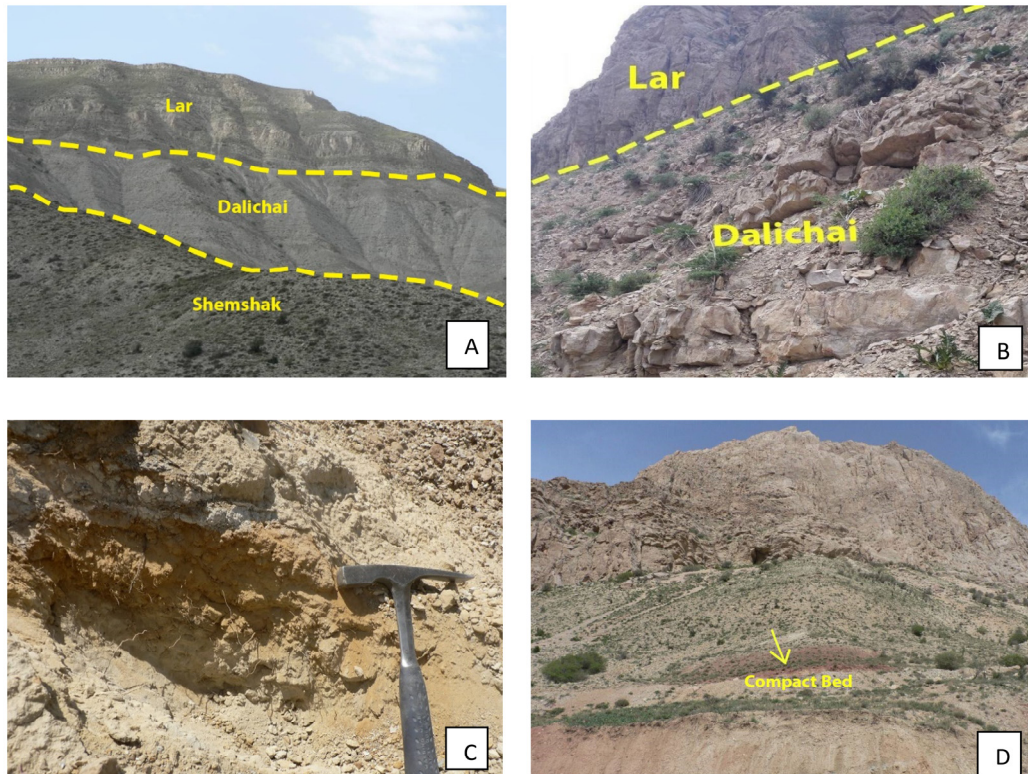


Figure 2. Field aspects of the Dalichai Formation in the Binalud Range: (A) Dalichai Formation between the Shemshak and Lar formations at Bar section. (B) transitional contact between the Dalichai and Lar formation at Bar section. (C) Paleosol observed at the border of Shemshak and Dalichai Formations at the sarmeran section. (D) Condensed beds available in the Bar section.

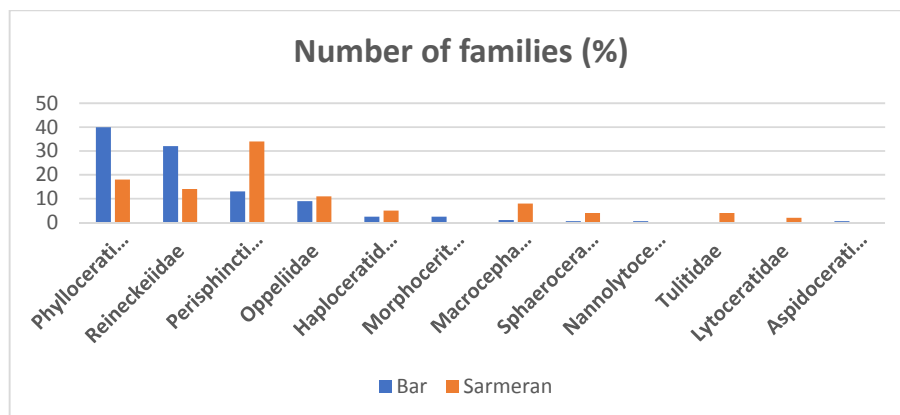


Figure 3. Relative frequency of ammonite families in the Bar and Sarmeran sections

As far as permitted by the preservation of the specimens, measurements of the following parameters are given:

- D diameter in mm
- U% umbilical width as % of diameter
- H% whorl height as % of diameter
- W% whorl width as % of diameter
- PR/2 primary ribs on a half whorl
- SR/2 secondary ribs on a half whorl
- Q = H/W

Class Cephalopoda Dumeril, 1806
 Order Ammonoidea Zittel, 1884
 Suborder Phylloceratina Arkell, 1950
 Superfamily Phyllocerataceae Zittel, 1884
 Family Phylloceratidae Zittel, 1884
 Subfamily Phylloceratinae Zittel, 1884
 Genus *Phylloceras* Suess, 1865
Phylloceras sp.

Plate 1, figure 5a -c.

Material: 9 complete specimens (B19, B20, B21, B22, B23, B25, B30, B31, B39) and 26 specimens without parametric characteristics from Bar section (B26, B27, B28, B29, B32, B33, B34, B35, B36, B37, B38, B40, B64, B65, B66, B67, B68, B69, B70, B71, B72, B73, B74, B75, B76, B77) and four complete specimens (S50, S52, S55, S56) and 2 specimens without parametric characteristics from Sarmeran section (S53, S54) (Figure 4-5).

Dimension:

SN	D(mm)	Wh (mm)	Wt (mm)	u(mm)	H (%)	W (%)	U	Q
B19	54	25	19	17	47	36	0.31	1.3
*B20	31	14	10	6.2	45	31	0.20	1.4
B21	37	16	9	6.6	43	24	0.18	1.7
B22	30	11	7	6.3	36	23	0.21	1.5
B23	75	22	16.5	10.5	29	22	0.14	1.3
B25	39	17	13	9	43	33	0.23	1.3
B30	62	30	20	15	48	32	0.24	1.5
S55	73	23	20	9.5	31	28	0.13	1.1
S56	75	32	11	14	43	24	0.19	1.7
B31	38	14	12	7	37	32	0.18	1.1
S52	30	11	7	5	36	23	0.16	1.5
B39	37	12	11.5	9	33	31	0.24	1.06
S50	25	10	7	7	40	28	0.28	1.4

Description: Involute, small to medium, the dorsal is round and convex. Steep umbilicus, rounded venter and shell very thin. The umbilical area is closed, and the Whorl height is slowly increased. The surface of the shell is somewhat flat and the phyllocerate suture line is hardly visible on it. The cross-section of the circle is elongated in the shape of an oval.

Distribution: Late Bajocian- Early Bathonian.

Phylloceras duodecimsulcatum Collignon, 1959

Plate 1, figure. 7a-b.

1959 *Phylloceras duodecimsulcatum* Collignon, pl. 34, figs. 162, 163.

1977 *Phylloceras duodecimsulcatum* Collignon - Joly, p. 148, pl. 2, figs. 2, 5, pl. 39, fig.2.

2014 *Phylloceras* aff. *duodecimsulcatum* Collignon, 1959 - Raoufian, et al., pl. 1, figs 1a-c.

Material: 2 complete specimens (S12, S13) and 1 specimen without parametric characteristics from Sarmeran section (S14).

Dimensions:

SN	D(mm)	Wh (mm)	Wt (mm)	u (mm)	H (%)	W (%)	U	Q
*S12	46	20	15	4.1	43	32	0.08	1.3
S13	78	20	-	10.9	25	-	0.14	-

Description: Shell Involute, small to medium sized, compact with relatively flat margins. The outer edge is somewhat round and convex and has a smooth inner mold. The umbilical is narrow, the cross-section is often elongated ovoid and the dorsal surface (abdominal region) is convex to arc-shaped. 6 to 8 shallow furrows can be seen on the sides, which become shallower and more blurred towards the back margin.

Discussion: The studied sample is different of the studied sample in Madagascar, *Phylloceras*

(*Hypophylloceras*) *serum*, so that in the studied sample the suture lines are more complex.

Geographical distribution: Madagascar and Iran (Middle Bathonian- Late Callovian).

Distribution: Middle Bathonian- Late Callovian.

Phylloceras isotypum (Benecke, 1866)

Plate 2, figure 8a-b.

1979 *Phylloceras isotypum* Benecke - Sapunov, p. 26, pl.1, figs.2a, b, 3a, b.

1995 *Phylloceras cf. isotypum* Benecke, Branger *et al.* p. 21, pl. 4, fig. 9.

2000 *Phylloceras isotypum* Benecke, 1866 - Joly, p. 44, pl. 6, figs. 4a, b, pl. 7, figs. 1a, b, fig. 79-81.

2014 *Phylloceras isotypum* Benecke, 1866 - Raoufian, *et al.*, pl. 1, figs 2a-c, 3.

Material: 8 complete samples (S25, S21, S23, S28, S19, S24, S20, S18) and 5 samples without parametric characteristics from Sarmeran section (S15, S16, S17, S22, S29). Number of 1 sample of Bar section (B78).

Dimensions:

SN	D (mm)	Wh(mm)	Wt(mm)	u (mm)	H(%)	W (%)	U	Q
B78	50	21	-	8	42	-	0.16	-
S25	44	19	15	7	43	34	0.15	1.2
*S21	80	30	-	9	37	-	0.11	-
S23	50	24	17	9	48	34	0.18	1.4
S28	45	17	18	7	37	40	0.15	0.9
S19	82	41	20	18	50	24	0.21	2.08
S24	52	20	-	6	38	-	0.11	-
S20	84	23	23	9	27	27	0.10	1
S18	67	20	20	9.3	31	-	0.13	-

Description: The shell is somewhat compact and thin, the size is small to medium. The whorl sides are slightly convex to smooth. The outer margin is rounded and the cross-section is semi-square, which becomes oval in the samples with larger dimensions. The umbilical area is closed. The phylloceratite suture line is clearly visible and is similar to the sample studied by Joly (2000, fig. 8, p, 45).

Discussion: The present specimens is completely similar to the European sample, *P. isotypum*.

Geographical distribution: France (Oxfordian and Kimmeridgian), Italy (Kimmeridgian), Romania, (Kimmeridgian), Kenya (Kimmeridgian), Madagascar (Kimmeridgian), Iran, Binalud (Early Callovian- Late Oxfordian, Bimammatum Zone).

Distribution: Late Oxfordian (Bimammatum Zone).

Phylloceras kunthi (Neumayr, 1871)

Plate 1, figure 2a-b-c, 6a-b-c.

1964 *Phylloceras kunthi* Neumayr - Sturani, p. 10, fig. 4.

1977 *Phylloceras kunthi* Neumayr- Joly, p. 162, pl. 3, fig. 2, pl. 39, fig. 9.

2000 *Phylloceras kunthi* Neumayr, 1871- Joly, p. 47.

2014 *Phylloceras kunthi* Neumayr, 1871- Raoufian, *et al.*, pl. 1, figs, 4a-c.

Material: 19 complete samples (S35, S44, S47, S46, S34, S39, S33, S37, S38, S43, S1, S2, S4, S5, S6, S7, S8, S9, S10) and 7 samples without parametric characteristics from Sarmeran section (S31, S30, S45, S36, S32, S3, S11).

Dimensions:

SN	D (mm)	Wh(mm)	Wt(mm)	u (mm)	H (%)	W (%)	U	Q
S43	31	14	10	7.7	45	32	0.24	1.4
S34	35	15	14	4.6	42	41	0.13	1.02
S46	23	11	-	4.8	47	-	0.20	-
S47	24	8	10	3.8	33	43	0.16	0.7
S44	26	13	11	2.8	50	42	0.11	1.1
S35	54	21.5	17	4.8	40	31	0.08	1.2

S37	50	20	-	8	40	-	0.16	-
S33	35	13	13	13.1	37	37	0.37	1
S39	41	16	14	7	39	34	0.17	1.14
S38	45	18	14	5	40	31	0.11	1.2
S7	65	34	-	6.5	53	-	0.10	-
S8	53	24	19	6.8	45	37	0.13	1.2
S9	41	16	17	5.8	39	41	0.14	0.9
S10	48	20	-	4.8	42	-	0.10	-
S1	73	23	-	9.5	32	-	0.13	-
S2	52	22	-	3.6	43	-	0.07	-
*S4	50	17	19	4	34	38	0.08	0.8
S5	65	23	-	7.8	35	-	0.12	-
S6	110	46	-	19.8	42	-	0.18	-

Description: The shell size is small to medium, compressed with relatively flat sides and the siphonal margin is rounded. The whorl cross-section is semi-rectangular to oval, and the umbilicus area is closed. The surface of the shell is smooth and has a suture line that is typically phylloceratid.

Discussion: The studied specimen is similar to the specimen of Joly, 1977 and has a smaller size and a slightly more depressed umbilical.

Geographical distribution: France (Early Callovian), Austria (Early Callovian), Italy (Bathonian), Switzerland (Late Oxfordian), India (Callovian), East of Africa (Callovian), Alaska (Middle Bajocian), Madagascar (Late Bathonian), Iran (Late Bathonian).

Distribution: Late Bathonian.

Subfamily Calliphylloceratinae Spath, 1927

Genus *Holcophylloceras* Spath, 1927

Holcophylloceras indicum Lemoine, 1910

Plate 2, figure 3.

1976 *Holcophylloceras indicum* sp. nov. Joly: 239, pl. 22, figs. 2-4, pl. 23, fig. 1, pl. 25, figs. 3-5, pl. 26, figs. 2, 5, pl. 27, figs. 1-2, 4-9.

Material: 1 specimen without parametric characteristics from the Sarmeran section (S163).

Description: Involute shell, medium size, slightly open umbilical area, and the last whorl has 5 sigmoidal constriction that start from the umbilical shoulder and terminate on the venter, Fine ribbing and dense secondary ribs starts on about the outer 3/4 of the rounded venter.

Discussion: Based on the shape of the constrictions and the fine ribbing on the outer part of the whorl, this specimen closely matches *Holcophylloceras indicum*.

Distribution: Middle Callovian.

Holcophylloceras aff. *zignodianum* d'Orbigny, 1848.

Plate 1, figure 4a-b.

1893 *Phylloceras friderici augusti* Pompeckj, p. 35, pl. 1, figs. 12, 13, 14, 14a, b, fig. 7.

1895 *Phylloceras delongcampsi* Brasil, p. 29, pl. 1, fig. 6, 8.

1895 *Phylloceras zignodianum* (d'Orbigny).- Stremoukhoff, p. 389, pl. 1, figs. 4a-c, 5.

1924 *Phylloceras mediterraneum* Neumayr.- Roman, p. 45, 73, 87, pl. 7, figs. 1, 9.

1924 *Phylloceras zignoi* (d'Orbigny).- Roman, p. 45, pl. 1, figs. 10, 10a.

1951 *Holcophylloceras zignodianum* (d'Orbigny).- Jeannet, p. 28, pl. 5, fig. 7.

1966 *Holcophylloceras mediterraneum* (Neumayr).- Sturani, p. 22, pl. 3, fig. 5, 6, pl. 5, fig. 5.

1979 *Holcophylloceras mediterraneum* (Neumayr).- Sapunov, p. 29, pl. 2, fig. 2.

1995 *Holcophylloceras mediterraneum* (Neumayr).- Branger et al., p. 21, pl. 14, fig. 6.

2000 *Holcophylloceras mediterraneum* (Neumayr, 1871). Joly, p. 100, pl. 24, fig. 9; pl. 25, fig. 1-3, fig. 203-207 2000 *Holcophylloceras zignodianum* (d'Orbigny, 1848) - Joly, p. 107, pl. 26, figs. 8a, b-12, pl. 27, figs. 1-4a,b, fig. 229-226.

2007 *Holcophylloceras zignodianum* (d'Orbigny, 1848) - Joly & Fonters, pl. 1, figs., 4-10; pl. 2, fig. 2, 4, 5, p. 222, tabl. 1, p. 228, tabl. 2.

2013 *Holcophylloceras zignodianum* (d'Orbigny, 1848) - Seyed-Emami *et al.* fig. 4a-b.

2014 *Holcophylloceras zignodianum* (d'Orbigny, 1848) - Raoufian, *et al.*, pl.3,2a-c.

Material: 1 specimen without parametric characteristics of the Bar section (D16).

Description: Due to the fracture of this sample, many parametric features and descriptions are not possible.

Discussion: *Holcophylloceras zignodianum* species is distinguished from other species of this genus by having a plate shape and falcate constriction in the number of 6 to 8 in one round. According to Joly (2000), the age of this species is? Bajocian - Oxfordian ?.

Geographical distribution: France (Bajocian-Oxfordian), Italy (Bajocian), Spain (Oxfordian), Greece (Bajocian), Iran (Early Bathonian-Early Kimmeridgian).

Distribution: Early Bathonian (Zigzag Zone)

Holcophylloceras sp.

Plate 2, figure 4.

Material: 4 complete samples (S102, S103, S107, S110) and 3 samples without parametric characteristics from the Sarmeran section (S106, S108, S109), and 3 samples without parametric characteristics from the Bar section (D18, D61, D62, D63).

Dimensions:

SN	D (mm)	Wh (mm)	Wt (mm)	u (mm)	H (%)	W (%)	U	Q
S107	40	10	13	6.8	25	32	0.17	0.7
S102	30	12	10	4.8	40	33	0.16	1.2
S103	54	18	19	5.4	33	35	0.10	0.9
*S110	50	20	20	18	40	40	0.36	1

Description: Involute and medium size, the dorsal surface is convex and rounded, and the cross-section is oval. The umbilical is closed, and the slope of the umbilical wall is low. The appearance shape is discocone, and the height and thickness of the whorl have gradually increased.

Abdominal constrictions start at the umbilical and extended with a significant curvature to the opposite side of the opening to the dorsal surface and created distinct depressions can be seen in the last whorl of the surface.

Distribution: Late Bajocian- Middle Callovian.

Genus: *Sowerbyceras* Parona & Bonarelli, 1895

Sowerbyceras tortisulcatum d'Orbigny, 1841

Plate 2, figure 1a-b.

1960 *Sowerbyceras tortisulcatum* (d'Orbigny) - Christ, p. 61, pl. 2, fig. 7.

1979 *Sowerbyceras tortisulcatum* (d'Orbigny).- Sapunov, p. 35, pl. 4, figs. 2a, b.

1995 *Sowerbyceras tortisulcatum* (d'Orbigny).- Branger *et al.*, p. 21, pl. 19, fig. 7.

2000 *Sowerbyceras tortisulcatum* (d'Orbigny, 1841).- Joly, p. 113, pl. 28, figs. 4a, b, 5a, c, 6, figs. 236-242 .

2010 *Sowerbyceras tortisulcatum* (d'Orbigny, 1841).- Seyed-Emami & Schairer, p. 271, figs. 6a, b (with synonymy).

2011 *Sowerbyceras tortisulcatum* (d'Orbigny, 1841).- Seyed-Emami & Schairer, p. 12, figs. 4 A, B.

2013 *Sowerbyceras tortisulcatum* (d'Orbigny, 1841).- Seyed-Emami *et al.*, figs 4c-d.

2014 *Sowerbyceras tortisulcatum* (d'Orbigny, 1841)- Raoufian, *et al.*, pl. 4, figs. 3a-c, 4a-c.

Material: 5 complete specimens (S92, S95, S90, S94, and S91) and two specimens without parametric characteristics of Sarmeran section (S96, S93).

Dimensions:

SN	D (mm)	Wh(mm)	Wt(mm)	u (mm)	H (%)	W (%)	U	Q
*S94	54	25	18	18	46	33	0.33	1.3
S90	49	16.5	-	14	34	-	0.28	-
S95	37	13.5	13.5	12.9	37	37	0.35	1
S92	63	16	-	14.5	26	-	0.23	-
S91	26	8.9	7.8	6.7	34	30	0.26	1.13

Description: The size is medium and thin, involute to slightly evolute, the umbilical is open, the slope of the umbilical wall is high and the umbilical is deep. The whorl are mostly flat and the dorsal surface is slightly convex. The thickness and height of the whorl have increased slowly in the last whorl. The shell has the appearance planorbicone. 3 sigmoid and deep constrictions can be seen on the last whorl which start of the umbilical area and continue with a clear tendency towards the opening for about half of the whorl and then with a clear change in direction. They go backwards and again after that they are forward until the dorsal surface, on the dorsal surface, these lateral constrictions meet and the low ridges are curved and inclined towards the opening.

Discussion: The appearance, dimensions and type of constrictions, this sample is similar to the samples in July (2000).

Geographical distribution: France (Callovian-Oxfordian), Germany (Oxfordian), Iran (Middle Callovian- Late Oxfordian)

Distribution: Middle Callovian- Late Oxfordian (Planula Zone).

Sowerbyceras sp.

Plate 1, figure 1a-b., Plate 2, figure 2.

Material: 12 complete specimens (S101, S104, S105, S89, S99, S78, S83, S79, S80, S85, S84, and S87) and 4 specimens without parametric characteristics from Sarmeran section (S81, S82, S86, S88), 9 complete specimens (A86, A123, A52, A76, A77, A50, A89, A72, A159) and 12 specimens without parametric characteristics from Bar section (A55, A138, A90, A68, A63, A73, A36, A39, A87, A53, A88, A42).

Dimensions:

SN	D (mm)	Wh(mm)	Wt(mm)	u (mm)	H (%)	W (%)	U	Q
S105	46	15.5	11	9.66	34	23	0.21	1.4
S104	48	18	17	7.6	37	35	0.16	1.05
S101	46	18	11	12.2	39	23	0.28	1.6
*S89	57	20	17.5	14.8	35	31	0.26	1.1
S78	87	28	-	19	33	-	0.22	-
S83	47	14	-	6.75	31	14	0.17	-
S79	60	20	-	20	33	-	0.23	-
S80	52	-	-	9.8	-	-	0.19	-
S85	55	20	-	5.4	36	-	0.27	-
S84	63	22	-	19.5	34	-	0.31	-
S87	49	-	-	9.8	-	-	0.2	-
A52	53	18.5	-	14	35	-	0.26	-
A123	34	16	11	-	47	32	-	1.4
A86	32	14	8	13	43	25	0.4	1.7
A76	60	-	12	6.6	-	20	0.11	-
A77	61	25.5	11.6	-	42	19	-	2.2
A50	52	25	14.5	8.3	48	28	0.16	1.7
A89	35	11	9	4	31	25	0.11	1.24
A72	57	20.5	13.5	-	36	24	-	1.5
A159	19	-	4	2	-	21	0.10	-

Description: Involute to ovulate, shell medium to small in size, the umbilical is half-open with a steep wall and distinct umbilical shoulder. The constriction is deep, wide, and sigmoidal (s-shaped), the whorl height slightly increased in last whorl.

Distribution: Bathonian - Callovian.



Plate 1. Ammonite fauna from the Dalichai Formation in Bar and Sarmeran sections. Figures 1a-b. *Sowerbyceras* sp. † S89, Sarmeran sections. Figures 2a-b-c. *Phylloceras kunthi*. Neumayr, 1871 † S4, Sarmeran sections. Figures 3a-b. *Ptychophylloceras* sp. † A77, Bar section. Figures 4a-b. *Holcophylloceras zignodianum* d'Orbigny, 1848 † D16, Bar section. Figures 5a-b-c. *Phylloceras* sp. † B20, Bar section. Figures 6a-b-c. *Phylloceras kunthi* † S44, Sarmeran section. Figures 7a-b. *Phylloceras duodecimsulcatum* Collignon, 1959 † S12, Sarmeran section

Genus *Ptychophylloceras* Spath, 1927

Subgenus *Tatrophylloceras* Beznosov, 1958

Ptychophylloceras(*Tatrophylloceras*) *hommairei* d'Orbigny, 1844

Plate 2, figs 6a-c.

1977 *Ptychophylloceras hommairei* (d'Orbigny).- Joly, p. 281, pl. 36, fig. 5a, b.

2000 *Ptychophylloceras* (*Tatrophylloceras*) *hommairei* (d'Orbigny, 1844).- Joly.

2014 *Ptychophylloceras* (*Tatrophylloceras*) *hommairei* (d'Orbigny, 1844)- Raoufian et al., pl. 4, 6a-c.

123, pl. 30, figs. 3a, b, fig. 255.

Material: 16 complete specimens (S100, S74, S76, S77, S69, S60, S58, S67, S71, S70, S57, S72, S73, S61, S59, S66) and 7 specimens without parametric characteristics from Sarmeran section (S75, S56, S62, S63, S64, S65, S68), 10 complete specimens (A44, A49, A43, A38,

A47, A57, A80, A85, A66, A78) and 7 specimens without parametric characteristics from Bar section (A45, A62, A35, A67, A37, A65, A46).

Dimensions:

SN	D(mm)	Wh(mm)	Wt(mm)	u (mm)	H (%)	W (%)	U	Q
A44	56	28	17	10	50	30	0.18	1.6
A49	51	17	12	-	33	24	-	1.3
A43	54	-	-	9.7	-	-	0.18	-
A38	68	-	-	9.5	-	-	0.14	-
A47	50	20	13	7	40	26	0.14	1.5
A57	49	18	9	10.7	36.5	18	0.22	2
*A80	49	20.5	14	5.8	42	28	0.12	1.5
A85	46	14	-	7.8	30	-	0.17	-
A66	80	-	-	12	-	-	0.15	-
A78	42	14	6.7	8.8	33	16	0.21	2
S69	26	9	8.5	3	34	33	0.11	1.03
S60	46	15.5	15	6	34	32	0.13	1.06
S58	39	15	10.5	4.6	38	27	0.12	1.4
S67	30	15	13	6	50	43	0.20	1.16
S71	21	-	-	4.8	-	-	0.23	-
S70	29	13	8	5.8	44	27	0.20	1.6
S57	45	12.5	-	7	28	-	0.20	-
S72	20	7	9	5	35	45	0.25	0.7
S73	18	7	6	3	38	33	0.16	1.1
S61	63	22	21	12	35	33	0.19	1.06
S59	54	25	-	7.5	46	-	0.14	-
S66	44	17	-	6.6	38	-	0.15	-
S100	50	23	-	7	46	-	0.14	-
S74	71	28	-	10.5	40	-	0.15	-
S76	80	30	-	14.5	38	-	0.18	-
S77	83	26.5	-	9.9	32	-	0.12	-

Description: Involute, medium, the appearance is disk-shaped, it has thin sides on the siphon edge and is somewhat wide with a semi-rectangular to trapezoidal cross-section, the umbilical area is slightly open and the umbilical area has a moderate slope. The height and thickness in the last whorl has increased rapidly. The number of 6-8 lateral constriction can be seen on the last whorl which start from the shoulder umbilical with a sharp bend and a concave turn towards the back and after the siphonal edge, they incline towards the front. After reaching the back region, the lateral constriction form short ridges that have a slight tendency towards the opening. In the specimen (A80), ventral furrows are hardly visible, the number of ventral protrusions (bourrelets) is equal to the lateral furrows, and when the lateral furrows disappear on the sides, in that area (mostly on the phragmocone) traces A petal shape is visible.

Discussion: The presence of features such as semi-rectangular cross-section, wide sides and siphon edge are used to distinguish *Ptychophylloceras* (*Tatrophylloceras*) *hommairei* from other similar species.

Geographical distribution: France (Early Callovian- Late Callovian?), Crimea (Middle- Late Callovian), and Iran (Early Bathonian- Late Kimmeridgian).

Distribution: Early- Middle Bothonian.

Ptychophylloceras sp.

Plate 1, figure 3a-b., pl. 2, figure 7a-b.

Material: 9 complete specimens from Sarmeran section (S97, S98, S111, S112, S113, S114, S115, S116, S117), 15 complete specimens (D58, D59, A77, A81, A82, A41, A74, A61, A83, A86, A52, A48, A123, A160, A158) and 15 specimens without parametric characteristics from

Bar section (A55, D80, D27, A70, A54, A64, A141, A84, A71, A58, A56, A51, A60, A55, A40).

Dimensions:

SN	D (mm)	Wh (mm)	Wt (mm)	u (mm)	H (%)	W (%)	U	Q
*S97	41	17	10	10	41	24	0.24	1.7
S98	61	24.5	-	6.7	40	-	0.11	-
S111	30	14	9	7.8	46	30	0.26	1.5
S112	28	11	11	5.8	46	39	0.21	1.17
S113	33	11	12	6	33	36	0.18	0.91
S117	23	10	9	11	43	39	0.46	1.1
S114	21	9	7	4	42	33	0.19	1.2
S115	26	10	9	5	38	34	0.19	1.1
S116	20	9	8	4	45	40	0.20	1.1
D59	31	11	12	5	36	39	0.17	0.92
D58	45	18	16	7	40	35	0.16	1.1
A81	51	18	18	6.6	35	35	0.13	1
A82	39	-	-	5.8	-	-	0.15	-
A41	62	-	-	15	-	-	0.24	-
A74	80	34.5	-	16	43	-	0.80	-
A61	66	30	-	18.5	45	-	0.28	-
A83	47	-	7.5	5.6	-	16	0.12	-
A86	32	14	8	13	43	25	0.40	1.7
A52	53	19	-	14	35	-	0.26	-
A48	49	16	19.5	-	32	40	-	0.8
A123	34	16	11	-	47	32	-	1.4
A160	24	10	4	4.8	41	16	0.20	2.5
A158	22	9	4	3.9	40	18	0.18	2.2

Description: Involute and small which has the shallow constrictions on the last whorl which start out as concave near the umbilical shoulder and turn convex in a ventral direction. The umbilical is somewhat closed. The cross-section around the Whorl is oval, and the whorl height has increased slowly in the last whorl. The umbilical slope gentle and low with typical Phylloceratid suture line.

Distribution: Early Bathonian- Callovian.

Biostratigraphy

Considering the affinity of the identified species with the species of Central, Eastern and Southern Europe and parts of North Africa, the Ammonites Zones of these regions under the title "Sub- mediterranean Province" has been used. (Cariou & Hantzpergue, 1997). After studying and identifying the ammonite samples and in accordance with the standard Submediterranean zonation, the age of different parts of the section have been determined.

The identified Zones are: the Zigzag Zone from the Early Bathonian, the Bimammatum Zone from Late Oxfordian, and the Planula Zone of Late Oxfordian (Figures 6-7).

In the Bar and Sarmeran sections, the presence of *Ptychophylloceras* sp., *Ptychophylloceras* (*Tatrophylloceras*) *hommairei* and *Holcophylloceras* *zignodianum*, with *Ebrayiceras* *sulcatum* and *Morphoceras* (*Morphoceras*) *multiforme*, can represent the Zigzag Zone.

The presence of the *Phylloceras* *isotypum* together with *Ochetoceras* *semifalcatum* in the Bar section and with the species *Orthosphinctes* (*Orthosphinctes*) *polygyratus*, *Perisphinctes* cf. *panthieri*, *Lytoceras* *album* and *Passendorferia* sp., in the Sarmeran section can represent the Bimammatum Zone of Late Oxfordian.

The presence of *Sowerbyceras* *tortisulcatum* among the species of *Glochiceras* (*Iingulaticeras*) *sculptatum* and *Ochetoceras* *mexicanum*, is an indicator of the Planula zone of Late Oxfordian.



Plate 2. Ammonite fauna from the Dalichai Formation in Bar and Sarmeran sections. Figures 1a- b. *Sowerbyceras tortisulcatum* d’Orbigny, 1841: S94, Sarmeran section. Figures 2. *Sowerbyceras* sp. : A52, Bar section. Figure 3. *Holcophylloceras indicum* Lemoine, 1910: S163, Sarmeran section. Figure 4. *Holcophylloceras* sp.: S168, Sarmeran section. Figures 5a-b. *Ptychophylloceras* (*Tatrophylloceras*) *hommairei* d’Orbigny, 1844: S76, Sarmeran section. Figure 6a-b-c. *Ptychophylloceras* (*Tatrophylloceras*) *hommairei* d’Orbigny, 1844: A80, Bar section. Figure 7a-b. *Ptychophylloceras* sp.: S97, Sarmeran section. Figures 8a- b. *Phylloceras isotypum* Benecke, 1866: S21, Sarmeran section

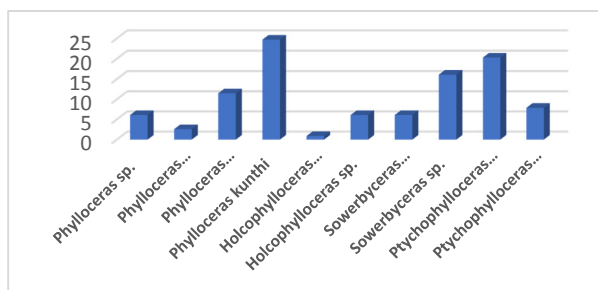


Figure 4. Frequency percentage of Phylloceratidae family in Sarmeran sections

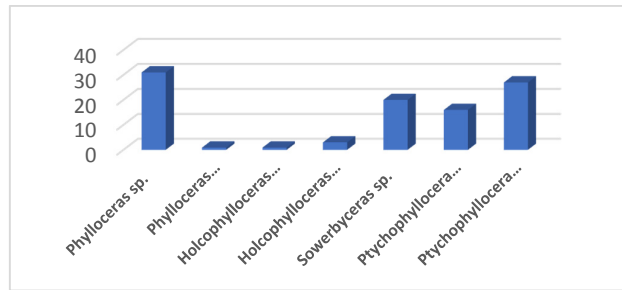


Figure 5. Frequency percentage of Phylloceratidae family in Bar sections

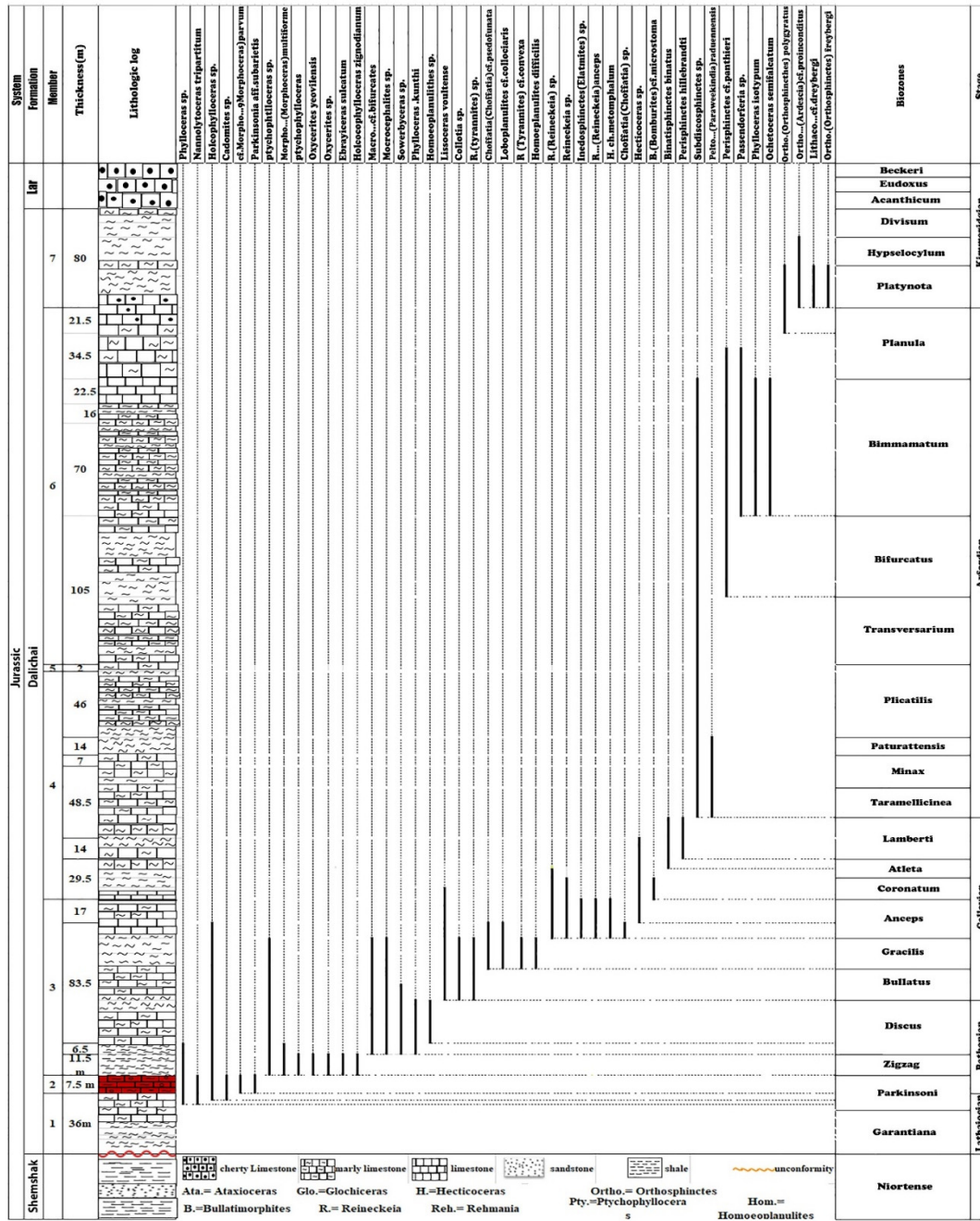


Figure 6. Stratigraphic column. Vertical distribution diagram of ammonite obtained from Dalichai formation in the Bar stratigraphic section and Biozones identified based on it

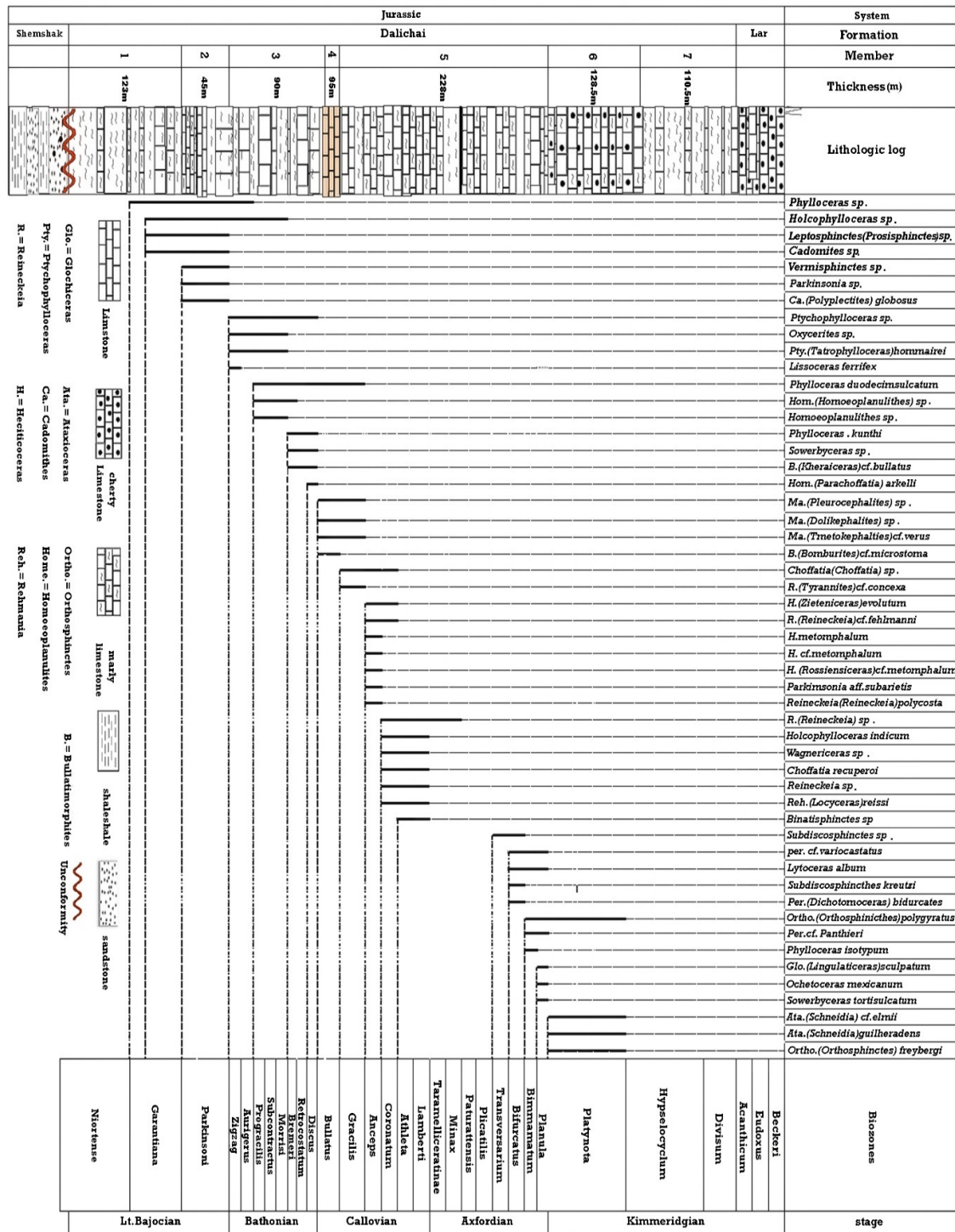


Figure 7. Stratigraphic column. Vertical distribution diagram of ammonite obtained from Dalichai formation in Sarmeran stratigraphic section and Biozones identified based on it

Conclusions

219 ammonites (*Phylloceratidae* family) were collected from the Dalichai Formation in the Bar and Sarmeran sections of which 121 specimens are selected and described in this study. The studied specimens of the *Phylloceratidae* family belong to 4 genus, 1 subgenus, and 11 species,

which are described. 10 species of the Phylloceratidae family have been identified in Sarmeran, section that are:

Ptychophylloceras sp. (8%), *Ptychophylloceras (Tatrophylloceras) hommairei* (19/5%), *Sowerbyceras* sp. (14/5%), *Sowerbyceras tortisulcatum* (6%), *Holcophylloceras indicum* (1%), *Holcophylloceras* sp. (6%), *Phylloceras kunthi* (24%), *Phylloceras isotypum* (12%), *Phylloceras duodecimsulcatum* (3%), *Phylloceras* sp (6 %). (Figure 4). Among the above species, *Phylloceras kunthi* is the most abundant with 24% and *Holcophylloceras indicum* is the least abundant with 1%.

The species identified from the Bar section are:

Ptychophylloceras (Tatrophylloceras) hommairei (15/7%), *Ptychophylloceras* sp. (27/5%), *Sowerbyceras* sp. (19/4%), *Holcophylloceras zignodianum* (1%), *Holcophylloceras* sp. (3%), *Phylloceras isotypum* (1%), *Phylloceras* sp (32/4%). (Figure 5). Among these, the highest frequency of *Ptychophylloceras* sp. (27/5%) and the lowest is related to *Holcophylloceras zignodianum* (1%) and *Phylloceras isotypum* (1%).

The identified ammonites Zones are: the Bimammatum, Zigzag, and Planula zones.

The comparison of the number of identified species from the Phylloseratidae family in the two sections shows that the more we move towards the west of the Binalud mountain range, the abundance and number of species increases, which can be due to the increase in the depth of the sedimentary basin during the increase in the relative level of sea water or the subsidence of the sedimentary basin floor due to the dominant extensional phase in the region (Raoufian, 2008).

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