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The Kazhdumi Formation (Lower Cretaceous, upper Aptian–upper Albian) in the Zagros Basin, Iran

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ABSTRACT

In the Zagros Basin (southwestern Iran), a 270 m thick section of shales, marls, marly limestones and limestones of the Kazhdumi Formation has yielded a diverse ammonite fauna which allowed for a detailed biostratigraphic zonation. Aptian ammonites of the families Deshayesitidae and Parahoplitidae occur indicating a latest early to late Aptian age. Albian Douvilleiceratidae, Lyelliceratidae and Brancoceratidae indicate early, middle and late Albian age. Their range and generic and specific determinations are tabulated and illustrated.

1. Introduction

The Zagros fold-thrust belt in southwestern Iran exhibits a Triassic to Cenozoic succession accumulated on a Paleozoic platform (James and Wynd, 1965; Kheradpir, 1975; Khalili, 1976, Setudehnia, 1978; Szabo and Kheradpir, 1978, Rahaghi, 1984; see Fig. 1). The succession contains a number of mega-sequences which define an elongate, asymmetrical, dynamically fluctuating pro-foreland basin during the Mesozoic (Alavi, 2004). The Lower Cretaceous deposits in the area studied are included in the Khami and Bangestan Groups (Fig. 1). The Bangestan group (Motiei, 1993) includes the Lower Cretaceous Kazhdumi Formation and the overlying Sarvak Formation (Fig. 2), the faunas of which indicate a late Aptian to late middle Albian (Early Cretaceous) for the Kazhdumi Formation and a late Albian to early Turonian age for the Sarvak Formation (Fig. 2).

Hydrocarbon sources are important in the Zagros belt. Both the 'Neocomian' Garau and the Aptian–Albian Kazhdumi formations are well known reservoir and source rocks (Bordenave and Hegre, 2005; Bordenave and Hegre, 2010) in black shale intervals deposited in deep marine environments (James and Wynd, 1965; Ghazban, 2007; Heydari, 2008). Black shale facies are widespread in the Tethys and Atlantic-Pacific oceanic areas at that time (Arthur et al., 1990; Leckie et al., 2002; Baudin, 2005). The Kazhdumi Formation is the major source for hydrocarbons of the Asmari and Sarvak reservoirs (Bordenave and Burwood, 1990, 1995).

The present work contributes greater precision to the biostratigraphy and ammonite zonation of the Aptian and lower Albian of the Zagros belt. Collignon (1981) studied ammonite fauna of Kazhdumi Formation in Fars and Khuzestan. Based on calcareous nannofossils, Nowrouzi (2005) attributed an Aptian–early Albian age to the Kazhdumi Formation. Kennedy et al. (2009) discussed species discrimination in the Early Cretaceous (Albian) ammonite genus *Knemiceras* (Buch, 1848/1850). Bulot (2010) carried out a systematic study of Aptian and Albian ammonites from

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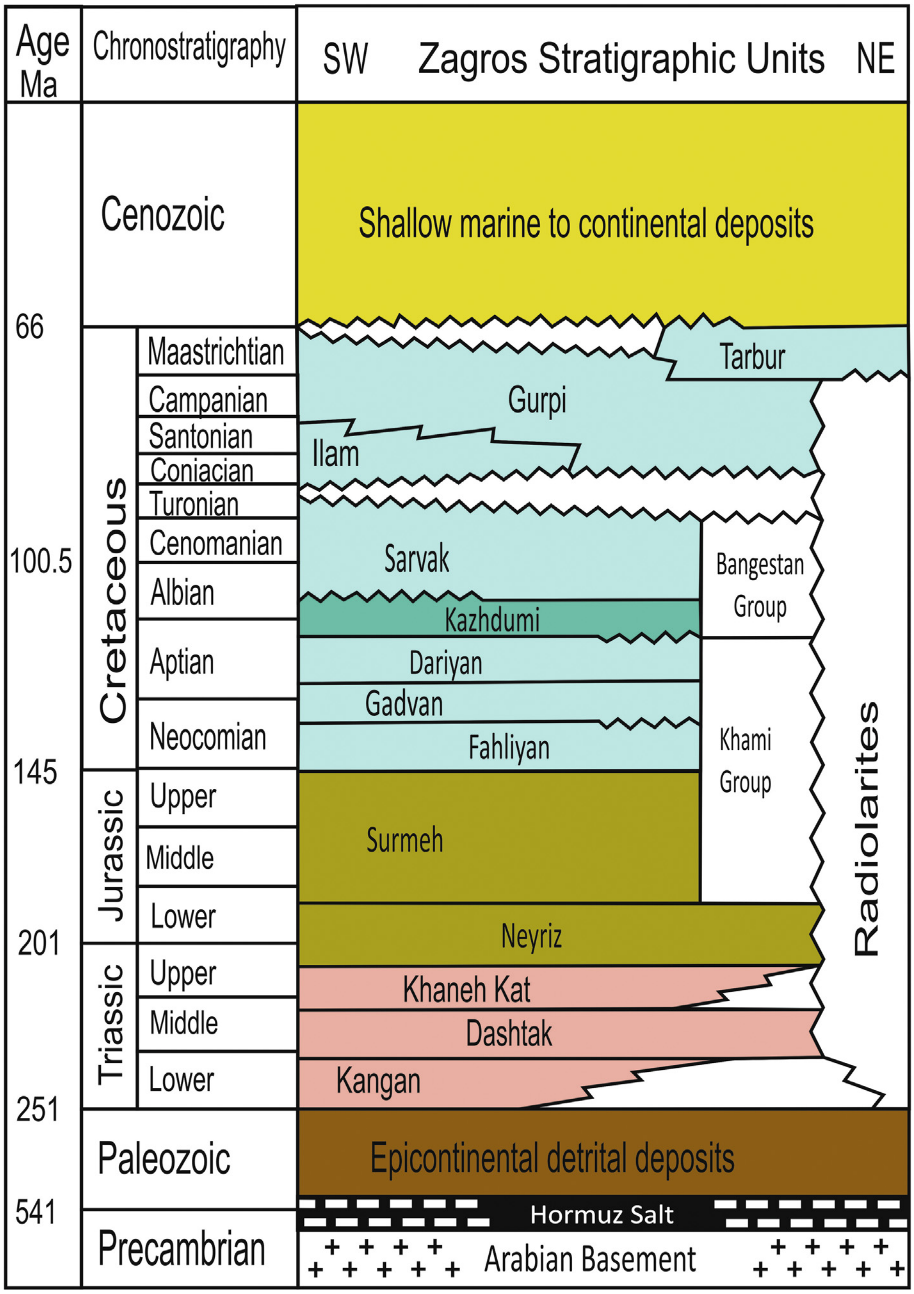

Fig. 1. Simplified table of rock units in southwestern Iran, based on numerous references.

southwestern Iran, including the Kazhdumi Formation. Nazeri Tahroodi et al. (2013) and Asadi et al. (2016) also reported Albian Kazhdumi ammonites in the Bushehr area (near to Persian Gulf). Abdollahi et al. (2014) worked on a foraminifera assemblage in the Behbahan area and suggested a late Aptian–middle Albian age for the Kazhdumi Formation there. Sharifi et al. (2019) had a preliminary discussion on the Aptian–Albian boundary in the Kazhdumi Formation.

In the present study, ammonites were collected bed-by-bed during field work in 2013 in the section of the Kazhdumi Formation at Tange Maghar, situated on the north east flank of the Bangestan anticline (Fig. 2). The section is illustrated photographically in Figs. 4–6. The ammonite occurrences are listed and illustrated (Figs. 8–12). The aim of this study is to discuss the lower Aptian–upper Albian biostratigraphy of the studied section. The ammonite biostratigraphy of the Zagros basin is reviewed, updated and compared with the standard Mediterranean ammonite zonation (Reboulet et al., 2014, 2018) and other biostratigraphic schemes in southern Tethys. The studied and illustrated specimens are kept at the Department of Geology, University of Birjand, Iran, under label KTM (Kazhdumi Tange Maghar).

2. The Kazhdumi Formation in the Tanga Maghar section

The name Kazhdumi is taken from the Kazhdumi Castel in the Dezful embayment. The type section is located in the southwestern flank of Kuh Mish, 7 km away from northeast Gachsaran (Dugonbadan) (Fig. 3).

The Kazhdumi Formation in the type section is a 210 m thick series of calcareous shale, shaly limestone, clay and sandy siltstone

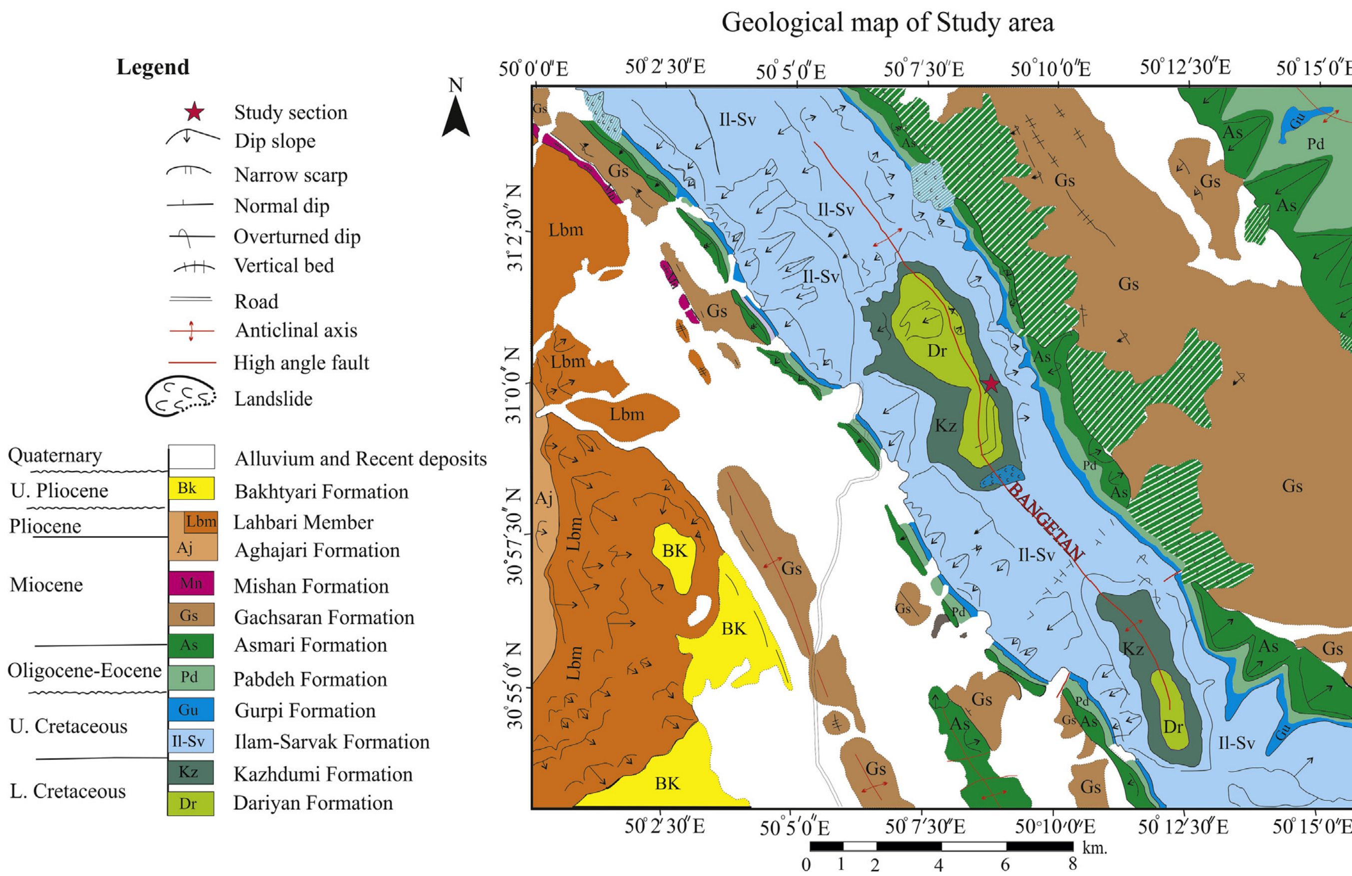

Fig. 2. Geological maps of part of the Bangestan Anticline (after Macleod, 1970 and Macleod and Akbari, 1970).

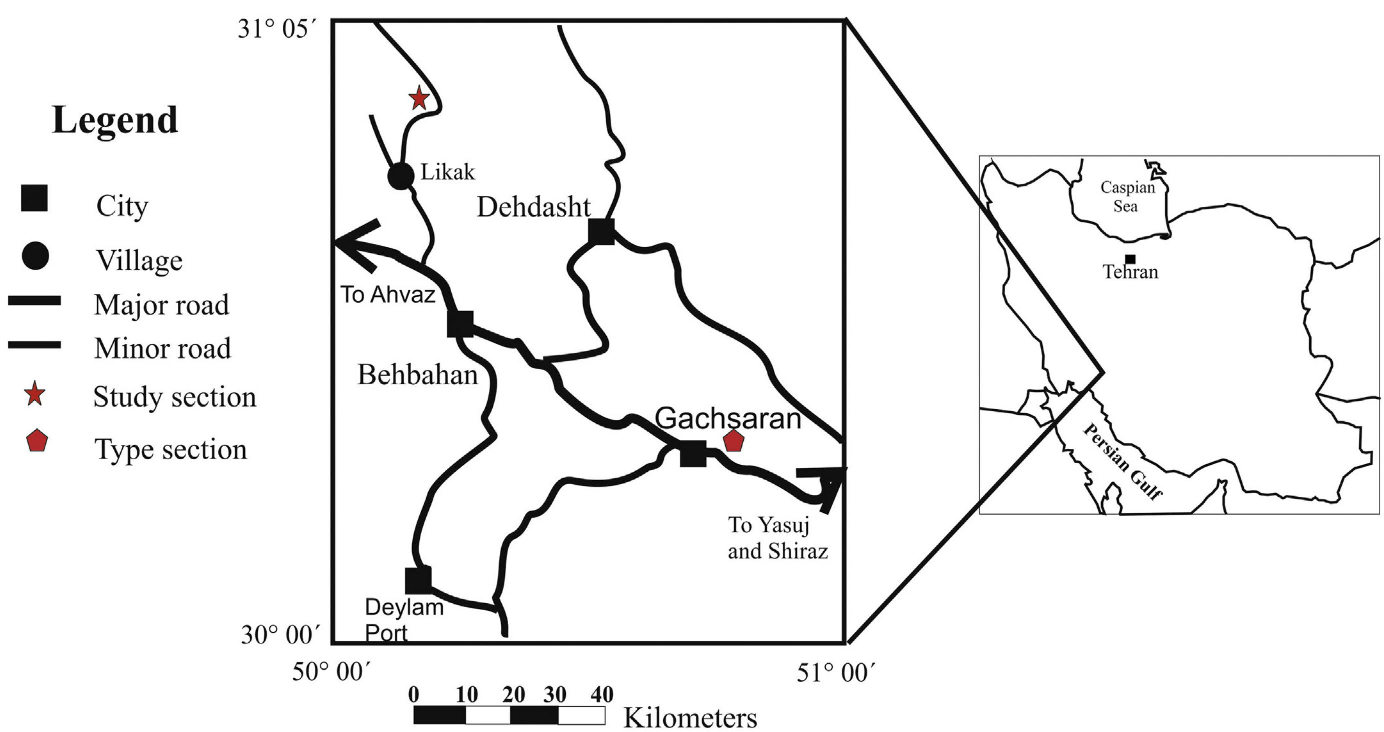

Fig. 3. Geographical position of the study and type sections of Kazhdumi Formation.

which can be divided into three units. Some limestone beds are dark brown to green in colour and contain bitumen and pyrite. A sandstone horizon occurs in the middle part of the formation. The lower contact with the Dariyan Formation, is a red bed and the upper boundary with the Sarvak Formation is a conformable and gradual change to marly limestone and limestone beds (James and Wynd, 1965). The formation includes bitumen-bearing black shales and dark clay limestone in the Dezful Embayment and northeastern Fars. It inter-fingers with the Burgan Formation and Omar Nahar in Kuwait and southwestern Iraq. In other areas of the Persian Gulf, the formation exhibits shallow-water sedimentary conditions with laterite and iron oxides zones and sandstone and silt layers. The Kazhdumi Formation laterally grades into the Garu Formation in central and southwestern Lorestan (Motiei, 1993).

The studied section is located in Tange Maghar, at 50°8′5″N and 31°01′28″E (Fig. 3). Exposed strata and their position are indicated on the geological map of the Zagros Basin (Fig. 2).

2.1. Unit 1

Toward the end of the Aptian, a major regression saw the termination of thick limestone bed deposition of the Dariyan Formation, followed by a low amplitude transgression marked by a sudden influx of clastics of the Kazhdumi Formation. The basal unit of the Kazhdumi Formation is composed of grey to light grey thin bedded shales with interbeds of limestone and marl (Figs. 4 and 5). Beds are brown grey to cream with iron oxide nodules containing brachiopods and nautiloids. The ammonite fauna indicates a range from the latest early Aptian with *Cheloniceras* sp. and *Dufrenoyia* aff. *furcata* (Sowerby, 1836); a late Aptian age with *Epicheloniceras* sp., *Parahoplites* sp. and *Hypacanthoplites* sp.; an early Albian age with *Douvilleiceras* aff. *mammillatum* (Quenstedt, 1849), *D. mammillatum* aff. *aequinodum* (Quenstedt, 1849); and latest early Albian age with *Lyelliceras* aff. *pseudolyelli* (d'Orbigny, 1841). The biostratigraphic distribution of the ammonites is shown in Fig. 7, and the specimens are illustrated in Figs. 8 and 9.

2.2. Unit 2

The unit is composed of dark grey thin bedded to laminated shales with few intercalations of nodular marly limestone. It has yielded the following ammonites; *Oxytropidoceras* (*Mirapelia*) aff. *buarquianum* (White, 1887), *O. (Mirapelia)* aff. *mirapelianum* (d'Orbigny, 1850) and *O. (Mirapelia)* cf. *mirapelianum* (d'Orbigny, 1850) (Figs. 7, 9 and 10), indicating an early-middle Albian age.

2.3. Unit 3

The unit consists of dark to grey thin bedded shales, with thin to thick bedded limestones (Fig. 5). It is overlain conformably by the Sarvak Formation and shows a lithology which changes gradually to marly limestone and limestone beds (Fig. 6). The following ammonites were found in this unit; *Hysteroceras* sp., *Oxytropidoceras* sp., *Oxytropidoceras* (*Venezoliceras*) aff. *bituberculatum* (Collignon, 1966), *O.* (*Venezoliceras*) cf. *karsteni* (Stieler, 1920) and *O.* (*Venezoliceras*) sp. (Figs. 7, 11 and 12) indicating a late middle to early late Albian age

3. Biozonation and biostratigraphy

There are two principle ammonite faunal provinces in the Early Cretaceous in respect of Europe and the Middle East. Most of Europe comes within a well-defined province characterized by hoplitid ammonites. Southern Europe and the Middle East come within a southern Tethyan faunal province characterized by a more diverse ammonite fauna. Separate ammonite zonal schemes have

Fig. 4. Lower boundary of the Kazhdumi Formation overlying the Dariyan Formation.

Fig. 5. Upper part of the Kazhdumi Formation (Unit 3).

been developed in these two provinces and migration of Tethyan elements northward at intervals permit some correlation between the two. The Lower Cretaceous of Iran falls within the Tethyan faunal province. We use here the ammonite zonal scheme for the Aptian and Albian of the Tethyan Ammonite Faunal Province given in Reboulet et al. (2018) (Table 1). Ammonite zones positively identified in the Kazhdumi Formation and the ranges of the collected ammonites are tabulated in Fig. 7.

The Cretaceous stages, their boundaries and index faunas in Europe have been discussed by Birkelund et al. (1984) and Hancock (1991). More recently the Barremian, Aptian and Albian stages were discussed by Rawson (1996), Erba (1996), Hart et al. (1996) and Moullade et al. (2011), respectively.

The Aptian and Albian ammonites have been studied in the past and recent years. Aptian ammonite faunas have been extensively studied in England (Casey, 1960, 1961, 1980), Germany (Brinkmann, 1937; Kemper, 1967, 1971, 1973, 1982, 1995), France (Breistroffer, 1947), Romania (Avram, 1999), Russia (Bogdanova, 1983, 1991), Central and North East of Iran (Seyed-Emami, 1977; Seyed-Emami and Immel, 1995 and 1996; Raisossadat, 2004 and 2006; Mosavinia et al., 2007 and 2014), Caucasus (Enson, 2009), Spain (Moreno-Bedmar et al., 2010 and 2017; Martín-Martín et al., 2013), Mexico (Moreno-Bedmar et al., 2013, 2015; Barragán et al., 2016), Argentina (Medina and Riccardi, 2005), Chile (Pérez et al., 1999), Peru and Colombia (Robert et al., 2002, 2009), Egypt (Aly and Abdel Gawad, 2001; Aly, 2006), Morocco (Luber et al., 2019; Giraud et al., 2021), and Tunisia (Latil, 2011; Ben Chaabane et al., 2019; Latil et al., 2021).

Casey (1961) introduced a biozonation for the Aptian stage that has been quoted in numerous papers in the last few decades. The study was based on the sequences in southeast England, but is applicable much more widely with some local modifications (e.g. Kemper, 1976). Faunal differentiation between the English and German faunas on the one hand, and those of the southeast of

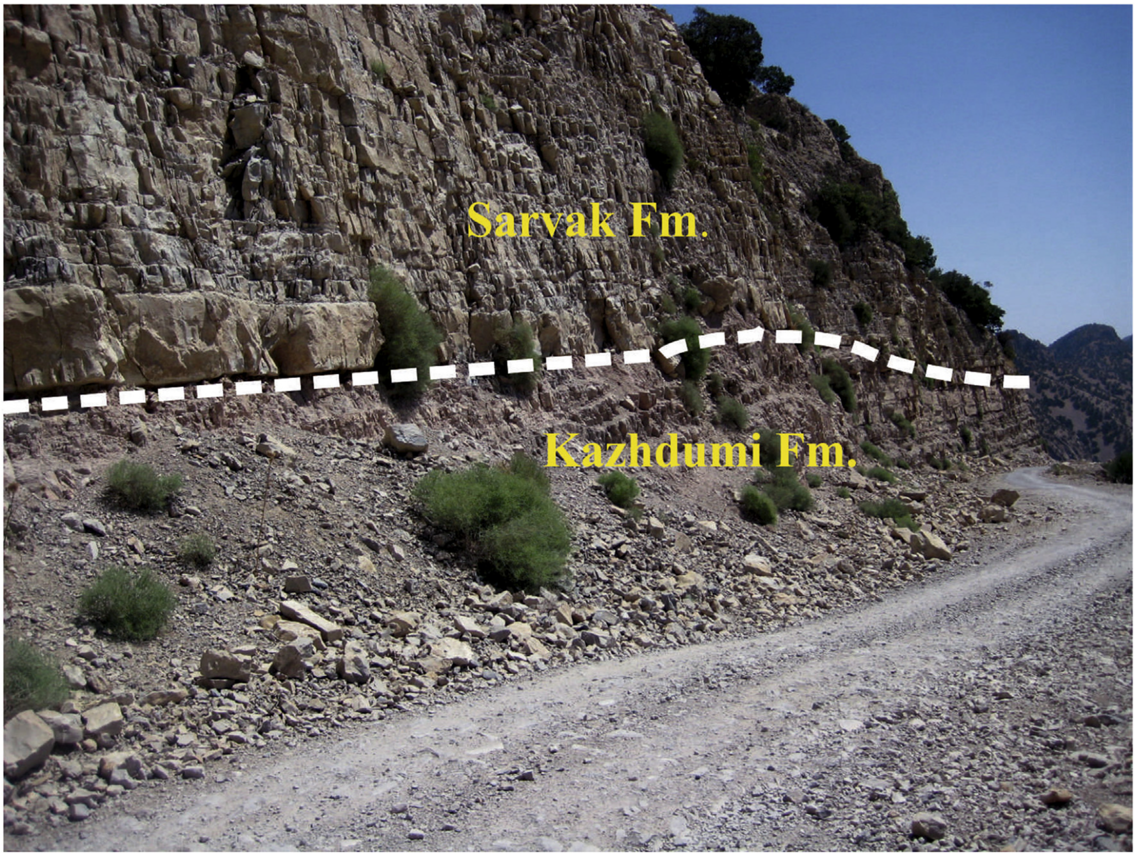

Fig. 6. Boundary between the Kazhdumi and overlying Sarvak Formation.

France on the other, is much less marked than earlier in the Cretaceous (Rawson, 1981; Hoedemaeker, 1990). Hence the current zonation for the Mediterranean region (Hoedemaeker and Rawson, 2000) uses many of the same genera, and even some of the same species.

Ammonite faunas of the Albian were studied in France (Breistroffer, 1947; Latil, 1994; Kennedy and Latil, 2007; Rey et al., 2013; and Matrion, 2010), Spain (Lopez-Horgue et al., 2009), Germany (Brinkmann, 1937; Kemper, 1982), and in England (Spath, 1923–1943; Casey, 1965). Owen (1971, 1973, 1988, 1996, 1999) focused on the Albian biostratigraphy and palaeobiogeography of the European area. Albian ammonite faunas and their biostratigraphy were described from the Carpathians (Vasicek, 1995), Crimea (Marcinowski and Naidin, 1976; Marcinowski and Wiedmann, 1985), Hungary (Szives, 2007) and former Soviet Union (Druschitz and Kudryutzeva, 1960; Saveliev, 1973, 1992; Mikhailova and Saveliev, 1989; Baraboshkin, 1996), Iran (Seyed-Emami, 1980 and 1995), Venezuela (Renz, 1982) and Madagascar (Collignon, 1962 and 1966).

More recent work could be cited, for example in Cuba (Barragán et al., 2011), South Africa (Kennedy and Klinger, 2008), Pakistan (Kennedy and Fatmi, 2014), Ecuador (Bulot et al., 2005), Tunisia (Latil, 2005; Chihaoui et al., 2010), Algeria (Latil, 2011), Japan (Obata and Futakami, 1992 and, 2009; Kawabe et al., 2003; Takashima et al., 2007).

In a discussion about the Aptian–Albian boundary, Casey (1999) suggested that the current use of the first occurrence of *Leymeriella* to mark the base of the Albian is unsatisfactory because of its limited geographical distribution. He proposed that the first occurrence of *Hypacanthoplites* should be used instead, because of the world-wide distribution of the *Acanthohoplites*-*Hypacanthoplites* lineage, which would put the base of the Albian at the base of the *Hypacanthoplites jacobi* Zone. However, he mentioned that early *Hypacanthoplites* can only be distinguished easily from *Acanthohoplites* in microconchs and juvenile macroconchs. This is complicated by the fact that *Acanthohoplites* and *Hypacanthoplites* species are very often recorded together within the same levels in the upper Aptian (e.g. Druschitz and Kudryutzeva, 1960; Collignon, 1962; Casey, 1965; Mandov and Nikolov, 1992). Hence Casey's proposal raises new difficulties in recognizing the boundary.

Kennedy et al. (2000) also discussed the Aptian–Albian boundary and suggested two sections in France as potential global boundary stratotype sections. In a first attempt, they put the *Hypacanthoplites jacobi*, *Proleymeriella schrammeni* and *Leymeriella germanica* zones in the upper Aptian and defined the base of the Albian stage at the first appearance of *Leymeriella tardefurcata*. After Kennedy et al. (2014, 2017), the GSSP for the base of the Albian is defined in the col de Pré-Guittard section (SE France), with the first occurrence of the planktonic foraminifera *Microhedbergella renilaevis*. This makes it very difficult to recognize the Aptian–Albian boundary on the basis of the ammonites.

Workshops of the Kilian Group (formerly the Lower Cretaceous Cephalopod Team, a working group of the Subcommission on Cretaceous Stratigraphy (SCS) of IUGS) focused on ammonite biozonation of the Lower Cretaceous in the Mediterranean Province (Hoedemaeker and Bulot, 1990; Hoedemaeker et al., 1993, 1995; Rawson et al., 1999; Hoedemaeker and Rawson, 2000; Hoedemaeker et al., 2003; Reboulet et al., 2006, 2009, 2011, 2014, 2018) (Table 1).

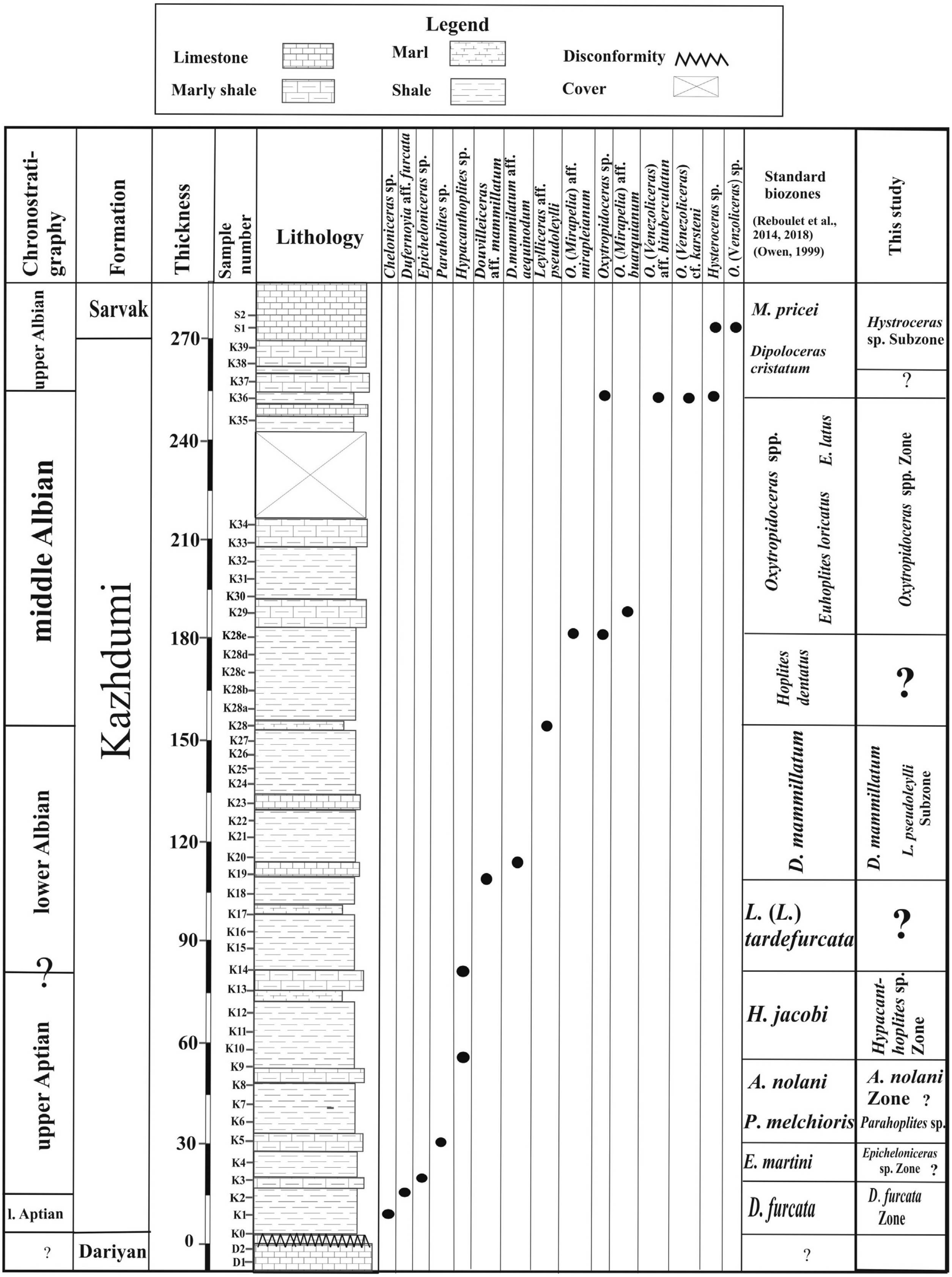

Fig. 7. Stratigraphical column, ammonite distribution and proposed biozones of the Kazhdumi Formation in Tange Maghar, Zagros basin.

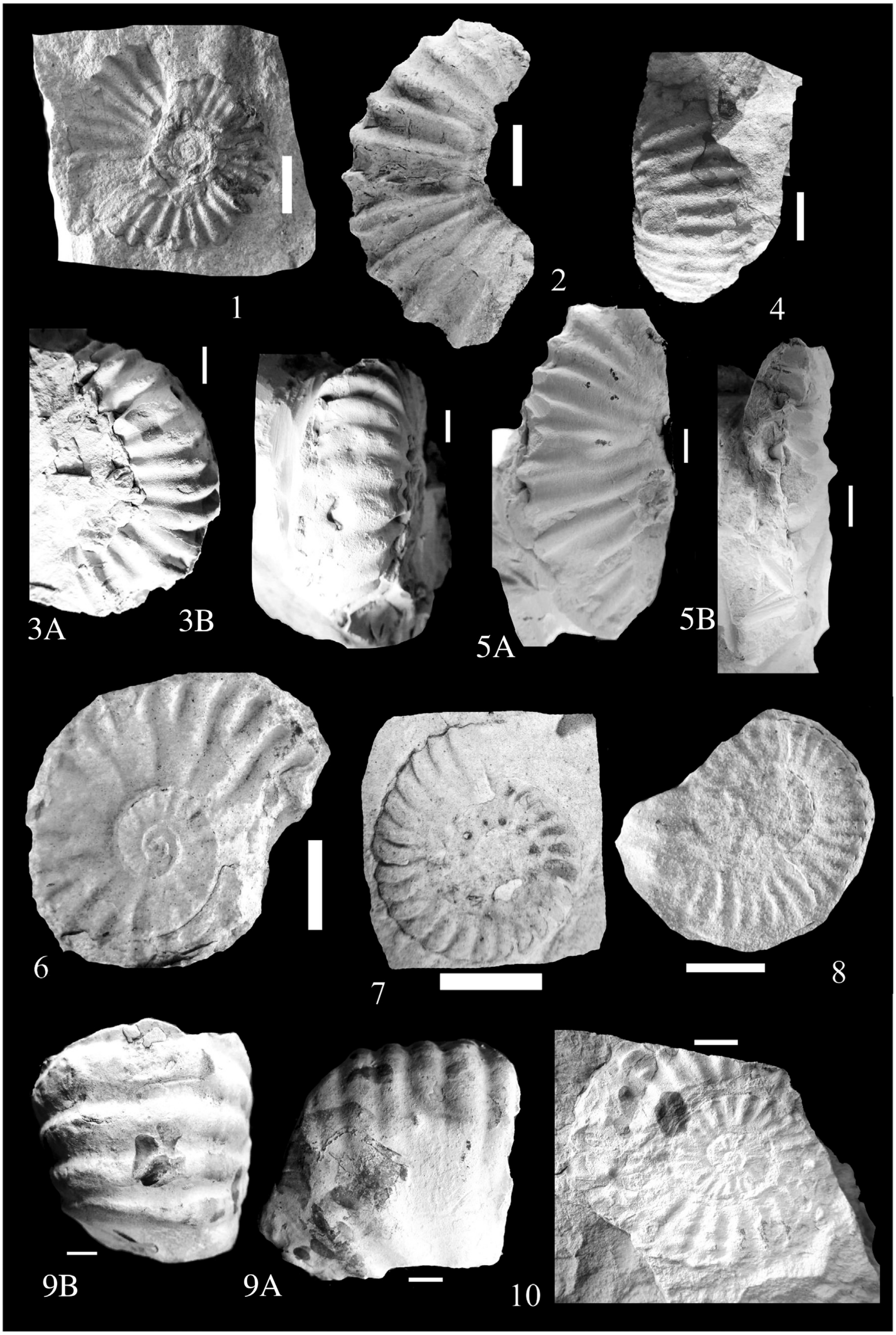

Fig. 8. 1, *Cheloniceras* sp.?, k1a; 2, *Cheloniceras* sp., k1b; 3A, B, *Cheloniceras* sp., k1c; 4, *Cheloniceras* sp., k1d; 5A, B, *Dufrenoyia* aff. *furcata* (Sowerby, 1836), k2a; 6, *D.* aff. *furcata* (Sowerby, 1836), k2b; 7, *Hysteroceras* sp., k37a; 8, *Hypacanthoplites* sp., k14a; 9A, B, *Hypacanthoplites* sp., k14b; 10, *Lyelliceras* aff. *pseudolyelli* (d'Orbigny, 1841), k28-2; all scale bars: 1 cm.

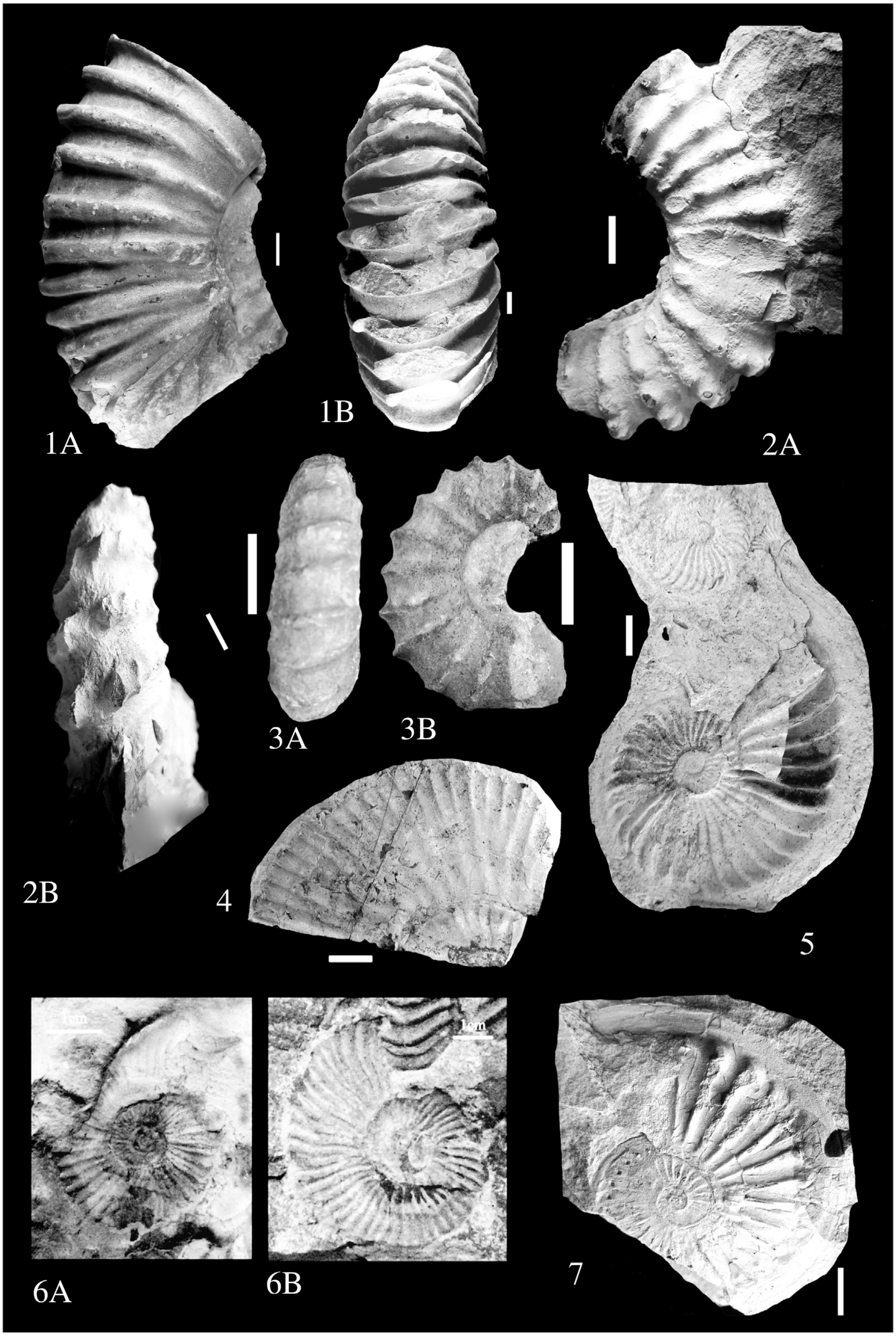

Fig. 9. 1A, B, *Hypacanthoplites* sp., k10a; 2A, B, *Douvilleiceras* aff. *mammillatum* (Schlotheim, 1813), k19a; 3A, B, *D. mammillatum* aff. *aequinodum* (Quenstedt, 1849), k20a; 4, *Parahoplites* sp., k5a; 5, *Oxytropidoceras* (*Mirapelia*) aff. *mirapelianum* (d'Orbigny, 1850), k28e-4; 6A, B, *Nolaniceras* aff. *nolani* (Seunes, 1887) (Kamyabi Shadan, 2014); 7, *Oxytropidoceras* (*Venezoliceras*) cf. *bituberculatum* (Collignon, 1966), k36c, all scale bars: 1 cm.

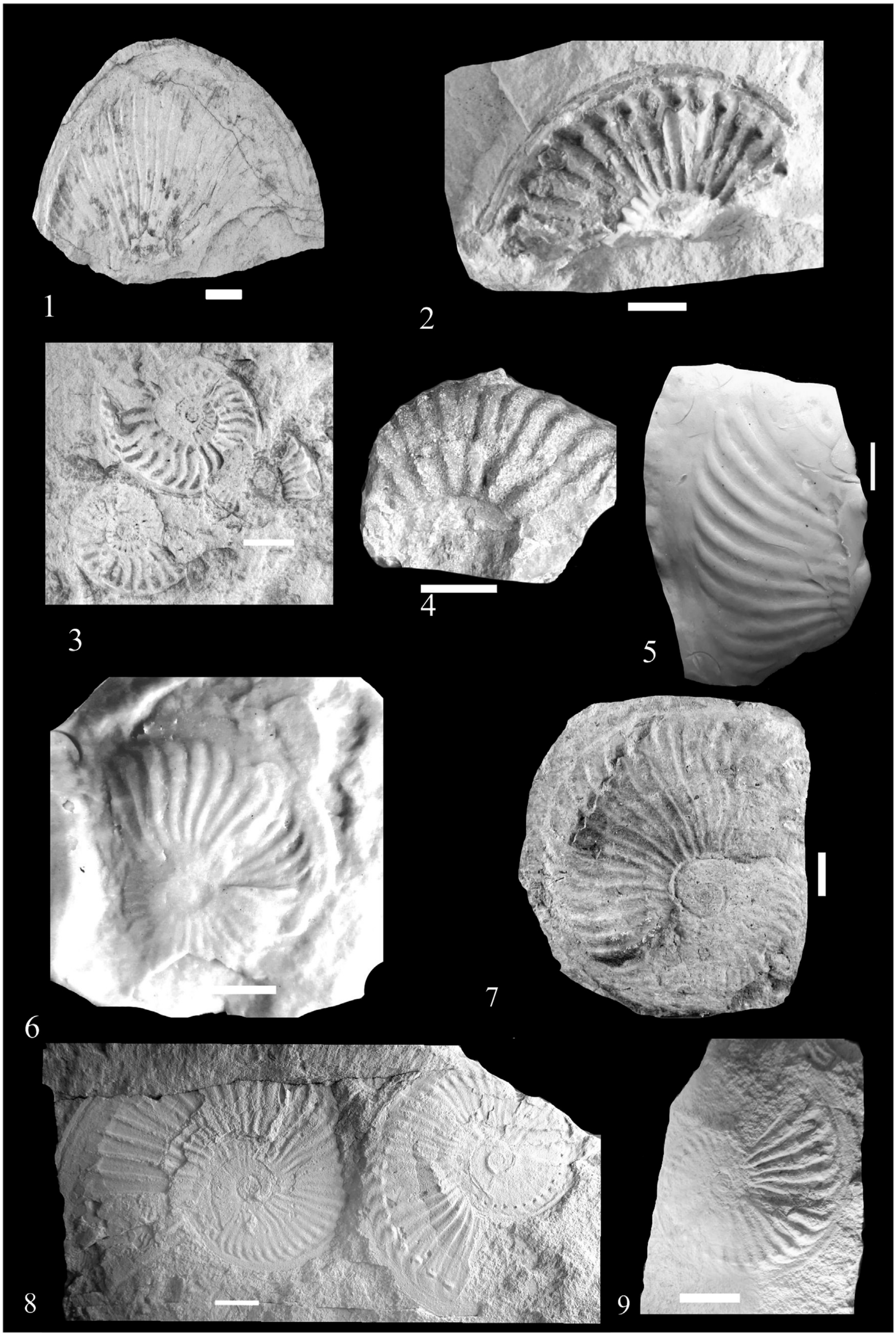

Fig. 10. 1, *Oxytropidoceras* (*Oxytropidoceras*) sp., k36a; 2, *O.* (*Venezoliceras*) sp., S1; 3, *Hysteroceras* sp. k36g; 4, *Hysteroceras* sp. S1; 5, *Oxytropidoceras* (*Mirapelia*) aff. *buarquianum* (White, 1887), k30a; 6, *O.* (*Mirapelia*) aff. *mirapelianum* (d'Orbigny, 1850), k28e-1; 7, *O.* (*Mirapelia*) aff. *mirapelianum* (d'Orbigny, 1850), k28e-2; 8, *O.* (*Venezoliceras*) cf. *bituberculatum* Collignon, 1966, k36h; 9, *O.* (*Venezoliceras*) cf. *bituberculatum* Collignon, 1966, k36d, all scale bars: 1 cm.

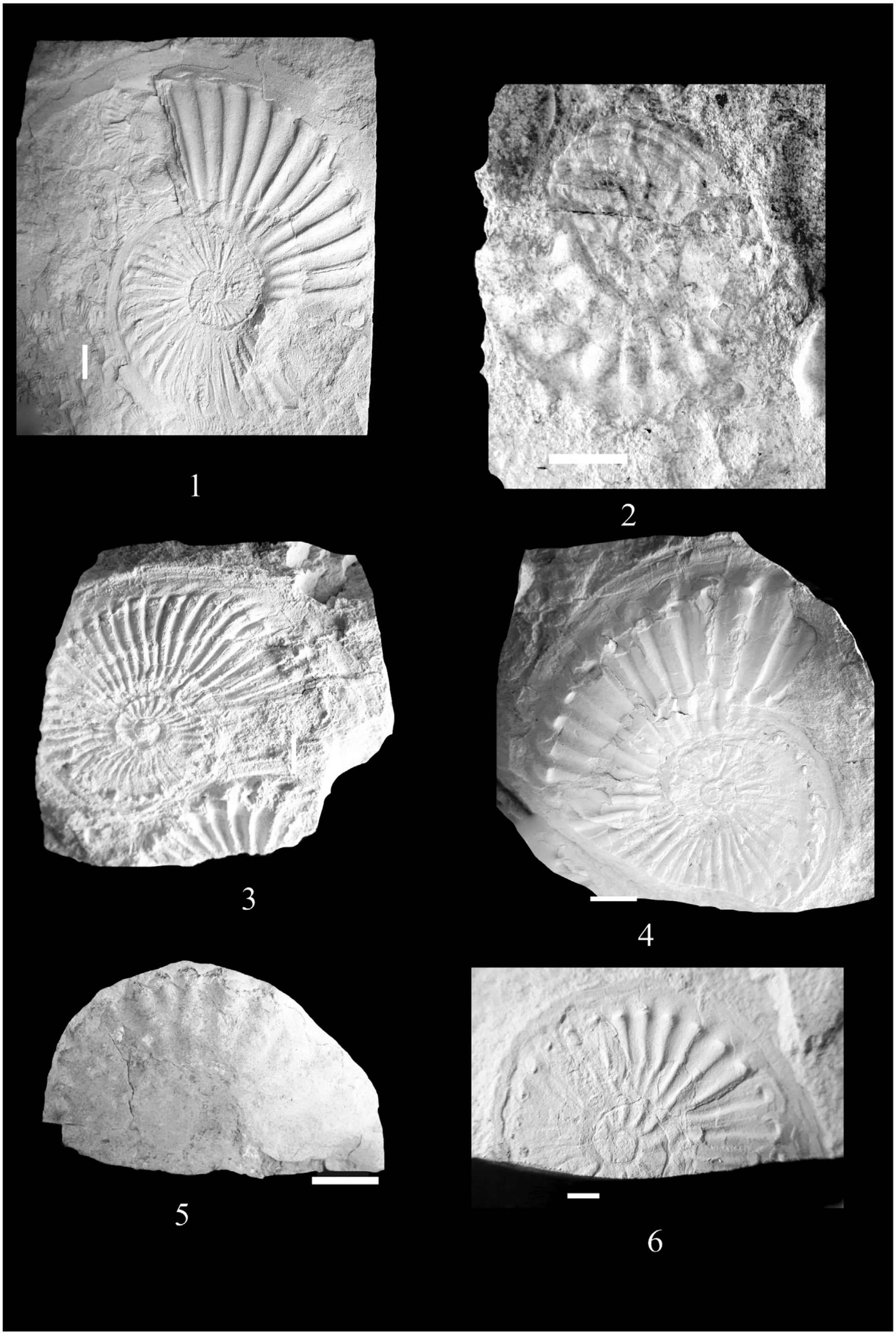

Fig. 11. 1, *Oxytropidoceras* (*Mirapelia*) aff. *buarquianum* (White, 1887), k30b; 2, *Lyelliceras* aff. *pseudolyelli* (d'Orbigny, 1841), k28-1; 3, *Oxytropidoceras* (*Venezoliceras*) cf. *karsteni* (Stieler, 1920), k36i; 4, *O.* (*Venezoliceras*) aff. *bituberculatum* Collignon, 1966, k36j; 5, *Epicheloniceras* sp., k3a; 6, *Oxytropidoceras* (*Venezoliceras*) aff. *bituberculatum* Collignon, 1966, k36e, all scale bars: 1 cm.

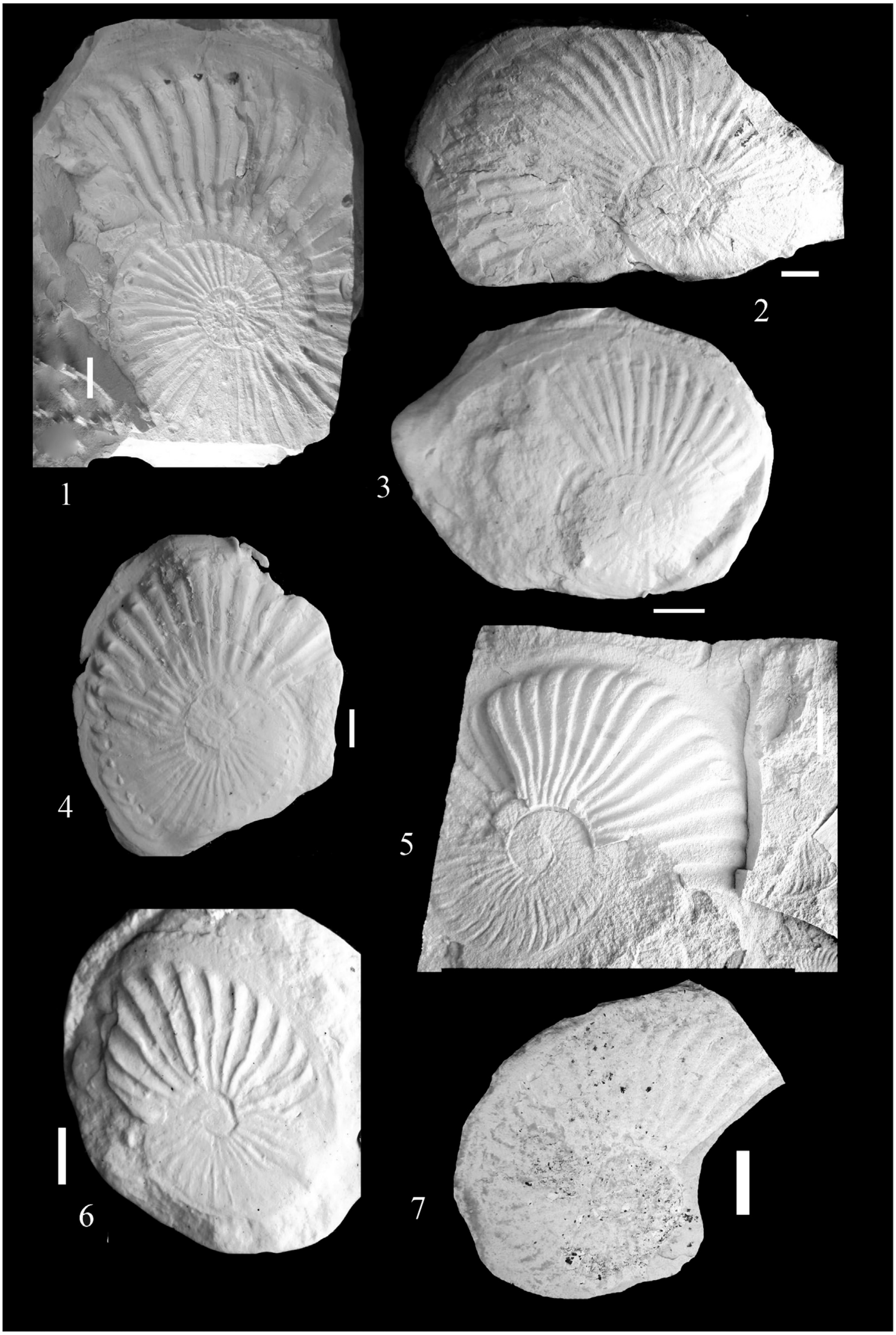

Fig. 12. 1, *Oxytropidoceras* (*Venezoliceras*) aff. *bituberculatum* Collignon, 1966, k36k; 2, *O.* (*Mirapelia*) aff. *buarquianum* (White, 1887), k30c; 3, *O.* (*Venezoliceras*) cf. *bituberculatum* Collignon, 1966, k36f, 4, *O.* (*Venezoliceras*) cf. *bituberculatum* Collignon, 1966, k36b; 5, *O.* (*Mirapelia*) aff. *buarquianum* (White, 1887), k30d; 6, *O.* (*Mirapelia*) sp., k29a; 7, *O.* (*Mirapelia*) cf. *mirapelianum* (d'Orbigny, 1850), k28e-3, all scale bars: 1 cm.

Table 1
Aptian and Albian biozonation (Reboulet et al., 2018).

Stage		Zones	Subzones
Albian	upper	*Mortoniceras briacense*	
		Mortoniceras perinflatum	
		Mortoniceras rostratum	
		Mortoniceras fallax	
		Mortoniceras inflatum	
		Mortoniceras pricei	
		Dipoloceras cristatum	
	middle	*Euhoplites lautus*	
		Euhoplites loricatus	
		Hoplites dentatus	*Hoplites spathi*
			Leyelliceras lyelli
	lower	*Douvilleiceras mammillatum*	*Lyelliceras pseudolyelli*
		Leymeriella tardefurcata	
Aptian	upper	*Hypacanthohoplites jacobi*	
		Acanthohoplites nolani	*Diadochoceras nodosocostatum*
		Parahoplites melchioris	
		Epicheloniceras martini	*Epicheloniceras buxtorfi*
			Epicheloniceras gracile
			Epicheloniceras debile
	lower	*Dufrenoyia furcata*	*Dufrenoyia dufrenoyi*
			Dufrenoyia furcata
		Deshayesites deshayesi	*Deshayesites grandis*
		Deshayesites forbesi	*Roloboceras hambrovi*
		Deshayesites oglanlensis	*Deshayesites luppovi*

3.1. *Lower upper Aptian*

3.1.1. *Dufrenoyia aff. furcata Zone*

This zone is in the lowermost part of the Kazhdumi Formation indicated by the presence of *Cheloniceras* sp. and *Dufrenoyia* aff. *furcata.* It is probably the equivalent of the *Dufrenoyia furcata* Zone, the uppermost zone of the lower Aptian (Reboulet et al., 2018). The thickness of deposits of this zone is about 18 m. The occurrence of the *furcata* Zone is geographically widespread in the Tethyan Province, stretching eastward from the Americas to include western Europe.

3.1.2. *Epicheloniceras sp. Zone*

The lowermost upper Aptian ammonite zone of *Epicheloniceras martini* (the *Epicheloniceras martinioides* Zone of Casey 1961) is indicated by the occurrence of *Epicheloniceras* sp. This zone and some of the subzones established by Casey (1961) are of widespread occurrence ranging from North Africa (Memmi 1999) to Mangyschlak (Kazakhstan) (Kopaevich et al., 1999) and the Caucasus (Kotetishvili et al., 2000) in the Tethyan area. It occupies the 10 m interval in the Kazhdumi section below the occurrence of *Parahoplites* sp.

3.1.3. *Parahoplites sp. and "Acanthoplites nolani" Zones*

The two zones, if fully present, cannot be separated in the absence of *Acanthoplites.* Together they occupy a thickness of about 25 m in the Kazhdumi section. The occurrence of *Parahoplites* sp. indicates the *Parahoplites melchioris* Zone of the Mediterranean Tethyan Province (Reboulet et al., 2018). Casey (1961) recognised two subzones within his *Parahoplites nutfieldiensis* Zone, a lower one in which *P. nutfieldiensis* is common and an upper one characterised by *Parahoplites cunningtoni.* The English succession indicates that *P. melchioris* is restricted to this upper subzone. The upper boundary of the *Parahoplites* sp. Zone in the Kazhdumi Formation cannot be determined. It should be noted that the systematic and stratigraphic position of "*Acanthoplites*" *nolani* (*Nolaniceras* of Casey) has been questioned by Bulot et al. (2014). However, it is clear that there is an interval between that characterised by *Parahoplites* and the first general occurrence of *Hypacanthoplites,* which is occupied by the genus *Nolaniceras* (Kamyabi Shadan, 2014, Fig. 9, 6A,B) characterized by *Nolaniceras* aff. *nolani* as indicated by Ruffell and Owen (1995), marking the evolutionary trend from *Parahoplites* to *Hypacanthoplites.*

3.1.4. *Hypacanthoplites sp. Zone*

The occurrence of *Hypacanthoplites* in the Kazhdumi Formation indicates the presence of the uppermost ammonite zone of the Aptian. The thickness of this zone in the section is 20 m. It indicates the *Hypacanthoplites jacobi* Zone of authors (Reboulet et al., 2018). However, as Mutterlose et al. (2003) indicated, the occurrences of *Hypacanthoplites jacobi* in Germany is up to lower Albian *Leymeriella acuticostata* Subzone (the *Leymeriella tardefurcata* Zone of Russian etc. authors). A lower interval characterised by *Hypacanthoplites* is present but might correspond to the lowermost zone of the Albian characterised by *Proleymeriella.* The problem of determining the succession in areas in which the early forms of leymeriellids are absent but are characterised by early *Hypacanthoplites*, causes problems in determining the global Aptian–Albian boundary. This situation has been discussed by Casey (1999), Kennedy et al. (2000) and Owen (2002).

3.2. *Lower Albian*

3.2.1. *Douvilleiceras mammillatum and Lyelliceras pseudolyelli Zones*

These two uppermost lower Albian ammonite zones are represented in the Kazhdumi section by ammonites but cannot be separated vertically. The base of combined zone is defined by occurrence of *Douvilleiceras* aff. *mammillatum* in sample number 19, followed shortly above by *Douvilleiceras mammillatum* aff. *aequinodum*; the latter species is also reported by Bulot (2010) from this section. The combined thickness is about 19 m. We use here the conventional restricted concept of the *mammillatum* Zone used by Reboulet et al. (2018) and not the *mammillatum* Superzone recognised by Owen (1999). *Douvilleiceras* occurs already in the *acuticostata* Subzone of the *Leymeriella tardefurcata* Zone (Kennedy and Kollmann, 1979; Owen, 1999; Kennedy et al., 2000) and ranges into the lower middle Albian *Lyelliceras lyelli* Subzone.

Following Amedro (1992), Latil (1994) recognised the *Lyelliceras pseudolyelli* Subzone at the summit of the lower Albian, characterised by transitions from *Tegoceras* to the lowermost middle Albian *Lyelliceras lyelli.* Both intervals are of geographically widespread occurrence from northern South America eastward to Africa and Madagascar to India and northward into the European faunal Province.

3.3. Middle Albian

3.3.1. *Lyelliceras lyelli* Zone

Not proven by ammonites in the Kazhdumi section, but might be present in the interval between 145 and 180 m. The Zone is represented to the south in Zululand (Kennedy and Klinger, 2008) and Madagascar (Collignon, 1963) as well as to the north.

3.3.2. *Oxytropidoceras* spp. Zone

The genus *Oxytropidoceras* (if *Mirapelia* is assumed as a subgenus of *Oxytropidoceras*) appears above the base of lower Albian, but *Oxytropidoceras s. str.* is appearing at the base of middle Albian, and is extinct in the upper Albian, above the *Dipoloceras cristatum* Zone. Many middle Albian species belonging to the genus *Oxytropidoceras* have been used as index species for regional biozonations, in California (Amédro and Robaszynski, 2005), Texas (Young, 1966), Brazil (Bengtson, 1983), Madagascar (Collignon, 1963 and 1978), Angola (Cooper, 1982; Tavares et al., 2007).

Owen (1996) introduced the *Oxytropidoceras* spp. Zone. Bulot and Latil (In Reboulet et al., 2011) have proposed to subdivide the middle Albian 'into a lower *L. lyelli* Zone and an upper *Oxytropidoceras* spp. Zone. This division was first agreed for the "Tethyan Province" during the London meeting (Rawson et al., 1999) to be used in parallel with the hoplitid zones of the "European Province". But subsequent meetings made no reference to the proposal and continued using only the "European Province" zonation'. Gale et al. (2011) recognise a *Lyelliceras lyelli* Zone and a *Oxytropidoceras* (*O.*) *roissyanum* Zone as possible divisions of the middle Albian in southeast France.

On this basis, an *Oxytropidoceras* spp. Zone is suggested for the interval between the first and last occurrences of the genus *Oxytropidoceras* in the studied section, assigning it to the upper middle Albian.

3.4. Upper Albian

There appears to be a major hiatus at the top of the middle Albian strata, before the lower upper Albian deposits. This hiatus suggests the *Dipoloceras cristatum* tectonic event of possible global extent indicated by Owen (1971).

3.4.1. *Hysteroceras* sp. Subzone

Hysteroceras species has been used to characterize biozone and/or subzone in the lower part of upper Albian. According to Lopez-Horgue et al. (2009), the *Hysteroceras varicosum* Zone includes the *Hysteroceras choffati, Hysteroceras orbignyi,* and *Hysteroceras varicosum* Subzones, overlying the *Dipoloceras cristatum* Zone, and underlying the *Mortoniceras inflatum* Zone (Owen, 1999; Owen and Mutterlose, 2006; Wiedmann and Owen, 2007) or is considered as an equivalent of the *Mortoniceras pricei* zone (Reboulet et al., 2014). This biozone is known in the uppermost part of the Kazhdumi Formation and the lowermost part of the Sarvak Formation.

4. Conclusions

Representatives of different genera and species of families Brancoceratidae Spath, 1923, Lyelliceratidae Spath, 1921, Douvilleiceratidae Parona and Bonarelli, 1897, Deshayesitidae Stoyanow, 1949, Parahoplitidae Spath, 1922 are reported from the Kazhdumi Formation in the Tange Maghar. These are as follows:

Cheloniceras sp., *Douvilleiceras* aff. *mammillatum*, *D. mammillatum* aff. *aequinodum*, *Dufrenoyia* aff. *furcata*, *Epicheloniceras* sp., *Hypacanthoplites* sp., *Hysteroceras* sp., *Leylliceras* aff. *pseudolyelli*, *Oxytropidoceras* (*Mirapelia*) aff. *buarquianum*, *O. (Mirapelia)* aff. *mirapelianum*, *O. (Mirapelia)* cf. *mirapelianum*, *Oxytropidoceras* sp., *O.* (*Venezoliceras*) aff. *bituberculatum*, *O.* (*Venezolicera*) cf. *karsteni*, and *O.* (*Venezoliceras*) sp.

The following biozones are suggested on the basis of the ammonite assemblages:

Dufrenoyia aff. *furcata* Zone (uppermost lower Aptian).

Epicheloniceras sp. Zone (lowermost upper Aptian).

Parahoplites sp. and *"Acanthoplites nolani"* zones (upper Aptian).

Hypacanthoplites sp. Zone (uppermost Aptian—lowermost lower Albian).

Douvilleiceras mammillatum and *Lyelliceras pseudolyelli* zones (uppermost lower Albian).

Oxytropidoceras spp. Zone (middle Albian).

Hysteroceras sp. Subzone (lower upper Albian).

An early Aptian to late Albian age is proposed for the Kazhdumi Formation. Correlation of the Hoplitinid biozones between the Boreal and north Tethyan realm, and the south Tethyan domain is discussed.

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References

Abdollahi, E., Vahidinia, M., Parvanehnejad Shirazi, M., 2014. Biostratigraphy of the Kazhdumi Formation Tang-e-Maghar Section, NW of Behbahan based on Planktonic Foraminifera. Journal of Paleontology 2 (1), 49—62 (in Persian, with English Abstract).

Alavi, M., 2004. Regional stratigraphy of the Zagros Fold-Thrust Belt of Iran and its proforeland evolution. American Journal of Science 304, 1—20.

Aly, M.F., 2006. Aptian cephalopod fauna from Gabal Abu Ruqum, north Sinai, Egypt. Egyptian Journal of Paleontology 6, 89—125, 7 pls.

Aly, M.F., Abdel Gawad, G.L., 2001. Early Cretaceous ammonites of Gebel Lagama, North Sinai, Egypt. Palaeontographica Abteilung A 262, 25—52.

Amédro, F., 1992. L'Albien du Bassin Anglo-Parisien: ammonites, zonation phylétique, Séquences. Bulletin des Centres de Recherche-Exploration-Production Elf-Aquitaine 16, 187—233.

Amédro, F., Robaszynski, F., 2005. Corrélation des successions de l'Albien par les ammonites entre la Province Nord-Pacifique et les Provinces européenne et arctique du Domaine boréal: zonation, eustatisme et paléobiogéographie. Geobios 38 (5), 585—607.

Arthur, M.A., Jenkyns, H.C., Brumsack, H.J., Schlanger, S.O., 1990. Stratigraphy, geochemistry and paleoceanography of organic carbon-rich Cretaceous sequences. In: Ginsburg, R.N., Beaudoin, B. (Eds.), Cretaceous Resources, Events, and Rhythms. Kluwer, Dordrecht, pp. 75—119.

Asadi, A., Majidifard, M.R., Vaziri, S.H., Yousefi Rad, M., 2016. Albian ammonites of the Kazhdumi Formation in the Nar section, east of Bushehr (Zagros Zone). Geoscience 25 (98), 199—212 (in Persian, English Abst.).

Avram, E., 1999. The *Deshayesites* Kazansky, 1914, (Ammonoidea) representatives in Romania, a link between the West-European and Caspian assemblages of this

genus. In: Oloriz, F., Rodriguez-Tovar, F.J. (Eds.), Advancing Research on living and fossil cephalopods. Kluwer Academic, Plenum Publishers, New York, pp. 437–462.
Baraboshkin, E.J., 1996. The Russian Platform as controller of the Albian Tethyan/Boreal ammonite migration. Geologica Carpathica 47, 274–284.
Barragán, R., Rojas-Consuegra, R., Szives, O., 2011. Late Albian (Early Cretaceous) ammonites from the Provincial Formation of central Cuba. Cretaceous Research 32, 447–455.
Barragán, R., Moreno-Bedmar, J.A., Gonzáles-Arreola, C., 2016. Aptian ammonites from Mazapil, Zacatecas State (north-central Mexico) studied by Burckhardt in 1906: A revision. Carnets de Géologie 16 (14), 355–367.
Baudin, F., 2005. A late Hauterivian short-lived anoxic event in the Mediterranean Tethys: the "Faraoni event". Comptes Rendus Geoscience 337, 1532–1540.
Ben Chaabane, N., Khemiri, F., Soussi, M., Latil, J.-L., Robert, E., Belhajtaher, I., 2019. Aptian-Lower Albian Serdj carbonate platform of the Tunisian Atlas: Development, demise and petroleum implication. Marine and Petroleum Geology 101, 566–591.
Bengtson, P.K., 1983. The Cenomanian-Coniacian of the Sergipe Basin. Fossils and Strata 12, 1–78.
Birkelund, T., Hancock, J.M., Hart, M.B., Rawson, P.F., Remane, J., Robaszynski, F., Schmid, F., Surlyk, F., 1984. Cretaceous stage boundaries - proposals. Bulletin of the Geological Society of Denmark 33, 3–20.
Bogdanova, T.N., 1983. *Deshayesites tuarkyricus* Zone; the lowermost zone of the Aptian in Turkmenistan. Annual issue of the All-Union Paleontological Society [Ezhegodnik Vsesoyuznogo Paleontologicheskogo Obshchestva] 26, 128–147 (in Russian).
Bogdanova, T.N., 1991. New ammonite species from the Lower Aptian of Turkmenia. Annual issue of the All-Union Paleontological Society [Ezhegodnik Vsesoyuznogo Paleontologicheskogo Obshchestva] 34, 77–98 (in Russian).
Bordenave, M.L., Burwood, R., 1990. Source rock distribution and maturation in the Zagros orogenic belt: Provenance of the Asmari and Bangestan reservoir oil accumulations. Advances in Organic Geochemistry 16 (1–3), 369–387.
Bordenave, M.L., Burwood, R., 1995. The Albian Kazhdumi Formation of the Dezful Embayment, Iran, one of the most efficient petroleum generating systems. In: Katz, B. (Ed.), Petroleum Source Rocks Series, CaseBook in Earth Sciences. Springer, Berlin, pp. 183–207.
Bordenave, M.L., Hegre, J.A., 2005. The influence of tectonics on the entrapment of oil in the Dezful embayment, Zagros fold belt, Iran. Journal of Petroleum Geology 28, 339–368.
Bordenave, M., Hegre, J., 2010. Current Distribution of Oil and Gas Fields in the Zagros Fold Belt of Iran and Contiguous Offshore as the Result of the Petroleum Systems. Geological Society, London, Special Publications, pp. 291–353.
Breistroffer, M., 1947. Sur les zones d'ammonites dans l'Albien de France et d'Angleterre. Travaux du Laboratoire de Géologie de la Faculté des Sciences de l'Université de Grenoble 26, pp. 1–88.
Brinkmann, R., 1937. Biostratigraphie des Leymeriellenstammes nebst Bemerkungen zür Paläogeographie des Nordwestdeutschen Alb. Mitteilungen aus dem Geologischen Staatsinstitut in Hamburg 16, 1–18.
Buch, L. Von, 1848/1850. Über Ceratiten. Physikalische Mathematische Abhandlungen der Köeniglichen. Akademie der Wissenschaftenzu Berlin, (issued in parts in 1848, published 1850), pp. 1–33. Taf. 1 – 7.
Bulot, L.G., 2010. Systematic palaeontology of Aptian and Albian ammonites from southwest Iran. Geo Arabia, Special Publication 4 (2), 167–194.
Bulot, L.G., Kennedy, W.J., Jaillard, E., Robert, E., 2005. Late Middle-early Late Albian ammonites from Ecuador. Cretaceous Research 26, 450–459.
Bulot, L.G., Latil, J.-L., Hairabian, A., Fournillon, A., 2014. New insight on the genus *Nolaniceras* Casey, 1961 (Ammonoidea, Cretaceous) and its consequences on the biostratigraphy of the Aptian Stage. In: Proceedings of the Geologists' Association 125, pp. 227–232.
Casey, R., 1960. A Monograph of the Ammonoidea of the Lower Greensand. Part 1. Palaeontographical Society Monograph, pp. 1–44.
Casey, R., 1961. The stratigraphical palaeontology of the Lower Greensand. Palaeontology 3, 487–621.
Casey, R., 1965. A Monograph of the Ammonoidea of the Lower Greensand. Part 6. Palaeontographical Society Monograph, pp. 399–546.
Casey, R., 1980. A Monograph of the Ammonoidea of the Lower Greensand. Part 9. Palaeontographical Society Monograph, pp. 633–660.
Casey, R., 1999. The age of the Argiles à Bucaillella of Normandy, the systematic position of the Cretaceous ammonite genera *Bucaillella* and *Arcthoplites*, and the delimitation of the Aptian/Albian boundary. Cretaceous Research 20, 609–628.
Chihaoui, A., Jaillard, E., Latil, J.-L., Zghal, I., Susperregui, A.S., Touir, J., Ouali, J., 2010. Stratigraphy of the Hameima and lower Fahdene Formations in the Tadjerouine area (Northern Tunisia). Journal of African Earth Sciences 58, 387–399.
Collignon, M., 1962. Atlas des fossiles caractéristiques de Madagascar (Ammonites), vol. IX. Aptien, Service Géologique, Tananarive, 64 pp.
Collignon, M., 1963. Atlas des fossiles caractéristiques de Madagascar (Ammonites), vol. X. Albien. Service Géologique, Tananarive, 184 pp.
Collignon, M., 1966. Les Céphalopodes crétacés du Bassin côtier de Tarfaya. Notes et Mémoires du Service des Mines et de la Carte géologique du Maroc, 148 pp.
Collignon, M., 1978. La partie moyenne du Crétacé de Madagascar entre l'Aptien et le Coniacien. In: Reyment, R.A., Thomel, G. (Eds.), Evénements de la partie moyenne du Crétacé, vol. IV. Annales Muséum d'Histoire Naturelle Nice (1976), xv.1- xv. l5.
Collignon, M., 1981. Albian-Cenomanian Fauna of the Kazhdumi Marl Formation, Fars Khuzestan, Iran. Documents des Laboratoires de Geologie, Lyon - Hors Serie 6, 251–291.
Cooper, M.R., 1982. Lower Cretaceous (Middle Albian) ammonites from Dombe Grande, Angola. Annals of the South African Museum 89, 265–314.
d'Orbigny, A., 1840-1842. Paléontologie française: description zoologique et géologique de tous les animaux mollusques et rayonnés fossiles de France. Terrains Crétacés. 1. Céphalopodes, 1-120 (1840), 121-430 (1841), 431-662 (1842).
d'Orbigny, A., 1850. Prodrome de Paléontologie stratigraphique universelle des animaux mollusques et rayonnés, vol. 2. Masson, 428 p.
Druschitz, V.V., Kudryutzeva, M.P., 1960. Atlas of Lower Cretaceous Fauna of the Northern Caucasus and Crimea. Trudy Vsesoyuznogo Nauchno-Issledovatelskogo Geologicheskogo Instituta, Moscow.
Enson, K.V., 2009. Correlation of Aptian–Albian Sediments in the Central Part of North Caucasus and Ciscaucasia. Paper 2: Stratigraphy Moscow University Geology Bulletin 64 (4), 256–261.
Erba, E., 1996. The Aptian stage. Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, Science de la Terre 66, 31–43.
Gale, A.S., Bown, P., Caron, M., Crampton, J., Crowhurst, S.J., Kennedy, W.J., Petrizzo, M.R., Wray, D.S., 2011. The uppermost Middle and Upper Albian succession at the Col de Palluel, Hautes-Alpes, France: An integrated study (ammonites, inoceramid bivalves, planktonic foraminifera, nannofossils, geochemistry, stable oxygen and carbon isotopes, cyclostratigraphy). Cretaceous Research 32, 59–130.
Ghazban, F., 2007. Petroleum Geology of the Persian Gulf. Tehran University and National Iranian Oil Company, Tehran.
Giraud, F., Kassab, W.H., Robert, E., Jaillard, E., Spangenberg, J.E., Masrour, M., Hammed, M.S., Aly, M.F., El Hariri, K., 2021. Integrated stratigraphy of the latest Barremian-early Albian interval in the western part of the Tethyan margin: new data from the Essaouira-Agadir Basin (Western Morocco). Newsletters on Stratigraphy 54 (1), 43–78.
Hancock, J.M., 1991. Ammonite scales for the Cretaceous System. Cretaceous Research 12, 259–291.
Hart, M., Amedro, F., Owen, H., 1996. The Albian stage and substage boundaries. Bulletin de l'institut Royal des Sciences Naturelles de Belgique, Science de la Terre 66, 45–56.
Heydari, E., 2008. Tectonics versus eustatic control on supersequences of the Zagros Mountains of Iran. Tectonophysics 451, 56–70.
Hoedemaeker, PhJ., 1990. The Neocomian boundaries of the Tethyan Realm based on the distribution of ammonites. Cretaceous Research 11, 331–342.
Hoedemaeker, Ph J., Bulot, L., 1990. Preliminary ammonite zonation for the Lower Cretaceous of the Mediterranean region. Geologie Alpine 66, 123–127.
Hoedemaeker, PhJ., Rawson, P.F., 2000. Report on the 5th International Workshop of the Lower Cretaceous Cephalopod Team (Vienna, 5 September 2000). Cretaceous Research 21, 857–860.
Hoedemaeker, P.J., Company, M., Aguirre-Urreta, M.B., Avram, E., Bogdanova, T.N., Bujtor, L., Bulot, L., Cecca, F., Delanoy, G., Ettachfini, M., Memmi, L., Owen, H.G., Rawson, P.F., Sandoval, J., Tavera, J.M., Thieuloy, J.P., Tovbina, S.Z., Vasicek, Z., 1993. Ammonites zonation for the Lower Cretaceous of the Mediterranean region; basis for the stratigraphic correlation within IGCP Project 262. Revista Espanola de Paleontologia 8 (1), 117–120.
Hoedemaeker, PhJ., Cecca, F., Avram, E., Company, M., Delanoy, G., Erba, E., Ettachfini, M., Faraoni, P., Kakabadze, M., Landra, G., Marini, A., Memmi, L., Pallini, G., Rawson, P.F., Ropolo, P., Sandoval, J., Tavera, J., Vasicek, Z., 1995. Report on the 3rd workshop on the standard Lower Cretaceous ammonite Zonation of the Mediterranean region. Memorie Descrittive Della Carta Geologica d'Italia 51, 213–215.
Hoedemaeker, PhJ., Reboulet, S., Aguirre-Urreta, M.B., Alsen, P., Aoutem, M., Atrops, F., Barragan, R., Company, M., Gonzalez, C., Klein, J., Lukeneder, A., Ploch, I., Raisossadat, N., Rawson, P.F., Ropolo, P., Vasicek, Z., Vermeulen, J., Wippich, M.G.E., 2003. 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.
James, G.A., Wynd, J.G., 1965. Middle East, Stratigraphic nomenclature of Iranian Oil Consortium Agreement Area. American Association of Petroleum Geologists Bulletin 49, 2182–2245.
Kamyabi Shadan, H., 2014. Biostratigraphy and lithostratigraphy of the Kazhdumi Formation in the Izeh zone. PhD thesis (Unpublished). Shahid Beheshti University, Tehran, Iran, 743p. (in Persian with English Abstract.).
Kawabe, F., Takashima, R., Wani, R., Nishi, H., Moriya, K., 2003. Upper Albian to Lower Cenomanian biostratigraphy in the Oyubari area, Hokkaido, Japan: toward a Cretaceous biochronology for the North Pacific. Acta Geologica Polonica 53 (2), 81–91.
Kemper, E., 1967. Die älteste ammoniten fauna im Aptium nordwest-Deutschlands. Paläontologische Zeitschrift 41, 119–131.
Kemper, E., 1971. Zur Gliederung und Abgrenzung des norddeutschen Aptium mit Ammoniten. Geologisches Jahrbuch 89, 359–390.
Kemper, E., 1973. The Aptian and Albian stages in north west Germany. In: Casey, R., Rawson, P.F. (Eds.), The Boreal Lower Cretaceous. Seel House Press, Liverpool, pp. 327–344.

Kemper, E., 1976. Geologischer Führer durch die Grafschaft Bentheim und die angrenzenden Gebiete, mit einem der Abriß d. emsländischen Unterkreide, 206 pp. Bentheim-Nordhorn.
Kemper, E., 1982. The Ammonites of the Upper Aptian and Lower Albian of Northwest Germany. Geologisches Jahrbuch Hannover A 65, 553–577.
Kemper, E., 1995. Die Entfaltung der Ammoniten und die Meeresverbindungen im Borealen unter-und Mittel- Apt. Geologisches Jahrbuch A141, 171–199.
Kennedy, W.J., Kollmann, H.A., 1979. Lower Albian Ammonites from the Tannheim Formation near Losenstein, Upper Austria. Beiträge zur Paläontologie von Österreich 6, 1–12.
Kennedy, W.J., Gale, A.S., Bown, P.R., Caron, M., Davey, J.R., Gröcke, D., Wray, D.S., 2000. Integrated stratigraphy across the Aptian-Albian boundary in the Marnes Bleues, at the Col de pré-Guittard, Arnayon (Drôme), and at Tartonne (Alpes-de-Haute-Provence), France: a candidate Global Boundary Stratotype Section and Boundary Point for the base of the Albian Stage. Cretaceous Research 21, 591–720.
Kennedy, W.J., Latil, J.-L., 2007. The Upper Albian ammonite succession in the Montlaux section, Hautes-Alpes, France. Acta Geologica Polonica 57 (4), 453–478.
Kennedy, W.J., Klinger, H.C., 2008. Cretaceous faunas from Zululand and Natal, South Africa. The ammonite subfamily Lyelliceratinae Spath, 1921. African Natural History 4, 57–111.
Kennedy, W.J., Reyment, R.A., Mac Leod, N., Krieger, J., 2009. Species discrimination in the Lower Cretaceous (Albian) ammonite genus (*Knemiceras* von Buch, 1848). Palaeontographica Americana 290 (1–3), 1–61.
Kennedy, W.J., Fatmi, A.N., 2014. Albian ammonites from northern Pakistan. Acta Geologica Polonica 64 (1), 47–98.
Kennedy, W.J., Gale, A.S., Huber, B.T., Petrizzo, M.R., Bown, P., Barchetta, A., Jenkyns, H.C., 2014. Integrated stratigraphy across the Aptian/Albian boundary at Col de Pré-Guittard (southeast France): A candidate Global Boundary Stratotype Section. Cretaceous Research 51, 248–259.
Kennedy, W.J., Gale, A.S., Huber, B.T., Petrizzo, M.R., Bown, P., Jenkyns, H.C., 2017. The global boundary stratotype section and point (GSSP) for the base of the Albian stage, of the Cretaceous, the Col de Pré-Guittard section, Arnayon, Drôme, France. Episodes 40 (3), 177–188.
Khalili, M., 1976. The biostratigraphic synthesis of Bangestan Group in southwest Iran, Iranian Oil Operating Companies. Geological and Exploration Division, Report 1219, 76 p.
Kheradpir, A., 1975. Stratigraphy of the Khami Group in southwest Iran, Iranian Oil Operating Companies. Geological and Exploration Division, Report 1235, 67 pp.
Kopaevich, L.F., Alkeseev, A.S., Baraboshkin, E.Y., Beniamovskii, V.N., 1999. Cretaceous sedimentary units of Mangyshlak Peninsula (western Kazakhestan). In: Crasquin-Soleau, S., De Wever, P. (Eds.), Peri-Tethys: stratigraphic correlation 3, Geodiversita, 21, pp. 407–419.
Kotetishvili, E., Kakabadze, M., Kakabadze, I., 2000. Steps in Evolution of the Early Cretaceous ammonites of Georgia. Proceedings of the Academy of Sciences of Georgian SSR. Geological Institute, New Series [Trudy Akademya Nauk Gruzinskoi SSR, A. Djanelidze Geologiskii Institut, Novya Serie] 115, 76–85 (in Russian, with English abstract).
Latil, J.-L., 1994. Les Lyelliceratinae Spath, 1921 (Ammonitina, Ammonoidea) de l'Albien inférieur et moyen dans le bassin de Paris et sur les bordures du bassin vocontien: Stratigraphie, Paléobiogéographie et Taxonomie. Géologie Alpine Mémoire H.S. 20, 327–381.
Latil, J.-L., 2005. Preliminary data on the Lower Albian ammonite succession in the North West of Tunisia and adjacent areas of Algeria: the Hameima section. In: Arnaud-Vanneau, A., Zghal, I. (Eds.), Aptian-Turonian events in central Tunisia. Géologie Alpine, Série spéciale “Colloque et excursions”, vol. 5, pp. 60–63.
Latil, J.-L., 2011. Early Albian ammonites from Central Tunisia and adjacent areas of Algeria. Revue de Paléobiologie, Genève 30, 321–429.
Latil, J.-L., Jaillard, E., Bardet, N., Raisossadat, N., Vincent, P., 2021. The Albian-Cenomanian transition in a shelf-basin transect: Biostratigraphy, sedimentology and paleontology of Jebel Mghila, Central Tunisia. Cretaceous Research 124, 1–35, 104809.
Leckie, R.M., Bralower, T.J., Casham, R., 2002. Oceanic anoxic events and plankton evolution: biotic response to tectonic forcing the mid-Cretaceous. Paleoceanography 17, 1–29.
Lopez-Horgue, M.A., Owen, H.G., Aranburu, A., Fernandez-Mendiola, A., Garcia-Mondejar, J., 2009. Early late Albian (Cretaceous) of the central region of the Basque Cantabrian Basin, northern Spain: biostratigraphy based on ammonites and orbitolinids. Cretaceous Research 30, 385–400.
Luber, T.L., Bulot, L.G., Redfern, J., Nahim, M., Jeremiah, J., Simmons, M., Bodin, S., Frau, C., Bidgood, M., Masrour, M., 2019. A revised chronostratigraphic framework for the Aptian of the Essaouira-Agadir Basin, a candidate type section for the NW African Atlantic Margin. Cretaceous Research 93, 292–317.
Macleod, J.H., 1970. Geological Compilation map of Kuh-E Safid. 1/100 000 scales. Geological and Exploration division, Iranian Oil Operating Companies, Tehran, Iran.
Macleod, J.H., Akbari, Y., 1970. Geological Compilation map of Behbahan. 1/100 000 scales. Geological and Exploration division, Iranian Oil Operating Companies, Tehran, Iran.
Mandov, P.G., Nikolov, T., 1992. Les successions d'ammonites et la subdivision des étages du Crétacé inférieur téthysien. In: Kollmann, H., Zapfe, H. (Eds.), New aspect on Tethyan Cretaceous Fossil Assemblages, 223-230, Schriftenreihe der Erdwissenschaftlichen Kommissionen der Österreichischen Akademie der Wissenschaften. Band 9, Vienna.
Matrion, B., 2010. Les ammonites. In: Colleté, C., coord (Eds.), Stratotype Albien. Museum Nationale d'Histoire naturelle, Paris. Biotope, Mèze; BRGM, Orléans, pp. 99–193.
Martín-Martín, J.D., Gomez-Rivas, E., Bover-Arnal, T., Travé, A., Salas, R., Moreno-Bedmar, J.A., Tomás, S., Corbella, M., Teixell, A., Vergés, J., Stafford, S.L., 2013. The Upper Aptian to Lower Albian syn-rift carbonate succession of the southern Maestrat Basin (Spain): Facies architecture and fault-controlled stratabound dolostones. Cretaceous Research 41, 217–236.
Marcinowski, R., Naidin, D.P., 1976. An Upper Albian ammonite fauna from Crimea. Acta Geologica Polonica 26, 83–118.
Marcinowski, R., Wiedmann, J., 1985. The Albian ammonite fauna of Poland and its paleogeographical significance. Acta Geologica Polonica 35, 199–218.
Medina, F.A., Riccardi, A.C., 2005. Desmoceratidae, Silesitidae and Kossmaticeratidae (Ammonitida) from the Upper Aptian-Albian of Patagonia (Argentina). Revue de Paléobiologie 24 (1), 251–286.
Memmi, L., 1999. L'Aptien et L'Albien de Tunisie. Biostratigraphie à partir des ammonites. Bulletin de la Societe Geologique de France 170 (3), 303–309.
Mikhailova, I.A., Saveliev, A.A., 1989. The Albian Stage In: Zones of Cretaceous system in USSR, Lower series. In: Prozorovsky, V.A. (Ed.), Proceedings of the Interdepartmental Stratigraphic Committee of the USSR [Trudy Mezhvedomstwennogo Stratigarficheskogo Komiteta S.S.S.R.] 20, St. Petersburg, pp. 141–217 (in Russian).
Moreno-Bedmar, J.A., Company, M., Bover-Arnal, T., Salas, R., Delanoy, G., Maurasse, F.J.-M.R., Grauges, A., Martinez, R., 2010. Lower Aptian ammonite biostratigraphy in the Maestrat Basin (Eastern Iberian Chain, Eastern Spain). A Tethyan transgressive record enhanced by syn-rift subsidence. Geológica Acta 8, 281–299.
Moreno-Bedmar, J.A., Barragán Manzo, R., Company Sempere, M., Bulot, L.G., 2013. Aptian (Lower Cretaceous) ammonite biostratigraphy of the Francisco Zarco Dam stratigraphic section (Durango State, northeast Mexico). Journal of South American Earth Sciences 42, 150–158.
Moreno-Bedmar, J.A., Mendoza-Rosales, C.C., Minor, K.P., Delanoy, G., Barragán, R., González-León, O., 2015. Towards an Aptian (Lower Cretaceous) ammonite biostratigraphy of the Mina Texali section, Central Atlantic province (Puebla State, Central Mexico). Cretaceous Research 54, 203–211.
Moreno-Bedmar, J.A., Robert, E., Matamales-Andreu, R., Bover-Arnal, T., 2017. Review of the early Albian ammonites of the Montmell Formation near Marmellar (Salou-Garraf Basin, Tarragona, Catalonia, Spain). Carnets de Géologie/Notebooks on Geology (1), 1–10. Article 17.
Mosavinia, A., Wilmsen, M., Aryai, A., Chahida, M.R., Lehmann, J., 2007. Mortoniceratina (Ammonitina) From the Upper Albian (Cretaceous) of The Aitamir Formation, Koppeh Dagh Mountains, NE Iran. Neues Jahrbuch für Geologie und Paläontologie - Abhandlungen 246 (1), 83–95.
Mosavinia, A., Lehmann, J., Wilmsen, M., 2014. Late Albian ammonites from the Aitamir Formation (Koppeh Dagh, northeast Iran). Cretaceous Research 50, 72–88.
Motiei, H., 1993. Treatise on the geology of Iran, Stratigraphy of Zagros. Geological Survey of Iran, Tehran, p. 497 (in Persian).
Moullade, M., Granier, B., Tronchetti, G., 2011. The Aptian Stage: Back to fundamentals. Episodes 34 (3), 149–156.
Mutterlose, J., Bornemann, A., Luppold, F.W., Owen, H.G., Ruffell, A., Weiss, W., Wray, D., 2003. The Vöhrum section (northwest Germany) and the Aptian/Albian Boundary. Cretaceous Research 24, 203–252.
Nazeri Tahroodi, N., Ghotbi Ravandi, M., Housieni Raviz, S.M.R., Ghafari, M., 2013. Study of Kazhdumi formation suture lines Ammonites in the north-east of Shiraz (Tarbur-e-Paeen section). In: Proceeding of 32nd National and 1st International Geoscience Congress Fundamental Geology. Geological Survey of Iran, Mashhad, Iran, p. 229, 16-19 Feb. 2014.
Nowrouzi, M., 2005. Biostratigraphy of Kazhdumi Formation based on calcareous nannofossils. unpublished MSc thesis. Shahid Behshti University, 130 pp.
Obata, I., Futakami, M., 1992. Some selected ammonites from the Aptian and Albian Miyako Group, Japan. Lower Cretaceous ammonites from the Miyako Group. Part 8. Bulletin of the National Science Museum Series A (Zoology) C 18 (3), 79–100.
Obata, I., Futakami, M., 2009. Supplementary description of the ammonoids from the Barremian to the Albian of the Choshi Peninsula, Japan. Cretaceous Research 30, 253–269.
Owen, H.G., 1971. Middle Albian Stratigraphy in the Anglo-Paris Basin. Bulletin of the British Museum of Natural History (Geology) (8), 1–164.
Owen, H.G., 1973. Ammonite faunal provinces in the Middle and Upper Albian and their palaeogeographical significance. In: Casey, R., Rawson, P.F. (Eds.), The Boreal Lower Cretaceous Geological Journal Special Issue 5. Seel House Press, Liverpool, pp. 145–154.
Owen, H.G., 1988. The Ammonite zonal sequence and ammonite taxonomy in the *Douvilleiceras mammillatum* SuperZone (Lower Albian) in Europe. Bulletin of the British Museum. Natural History. Geology Series 44 (3), 177–231.
Owen, H.G., 1996. Boreal and Tethyan Late Aptian to Late Albian ammonite zonation and palaeobiogeography. Mitteilungen aus dem Geologisch-Palaontologischen Institut der Universitat Hamburg 77, 461–481.
Owen, H.G., 1999. Correlation of Albian European and Tethyan ammonite zonations and the boundaries of the Albian Stage and substages: some comments. Scripta Geologica - Special Issues 3, 129–149.

Owen, H.G., 2002. The base of the Albian Stage; comments on recent proposals. Cretaceous Research 23, 1–13.
Owen, H.G., Mutterlose, J., 2006. Late Albian ammonites from offshore Suriname: implications for biostratigraphy and palaeobiogeography. Cretaceous Research 27, 717–727.
Pérez, E., Cooper, M.R., Covacevich, V., 1999. Aptian ammonite-based age For the Pabellon Formation, Atacama region, Northern Chile. Revista Geologica de Chile 17 (2), 181–185.
Quenstedt, F.A., 1846-1849. Petrefactenkunde Deutschlands, 1. Abteilung, 1. Band, Cephalopoden. XXVI + 581 pp.; Tübingen (Fues).
Rahaghi, A., 1984. The stratigraphic value of larger Foraminifera from the Campanian to Miocene in Iran. In: Oertli, H. (Ed.), Benthos' 83: Paris, Second International Symposium on Benthic Foraminifera, pp. 519–524.
Raisossadat, S.N., 2004. The Family Deshayesitidae in the Kopet Dagh Basin, north-east Iran. Cretaceous Research 25, 115–136.
Raisossadat, S.N., 2006. The Family Parahoplitidae in the Sanganeh Formation of the Kopet Dagh Basin, north-eastern of Iran. Cretaceous Research 27, 907–922.
Rawson, P.F., 1981. Early Cretaceous ammonite biostratigraphy and biogeography. In: House, M.R., Senior, J.R. (Eds.), The Ammonoidea, The evolution, classification, mode of life and geological usefulness of a major group, Systematics Association, Special Volume 18. Academic Press, London, pp. 499–529.
Rawson, P.F., 1996. The Barremian Stage. In: Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, Sciences de la Terre, 66, pp. 25–30.
Rawson, P.F., Hoedemaeker, P.J., Aguirre-Urreta, M.B., Avram, E., Ettachfini, M., Kelly, S.R.A., Klein, J., Kotetishvili, E., Owen, H.G., Ropolo, P., Thomson, M.R.A., Wippich, M., Vasicek, Z., 1999. Report on the 4th International Workshop of the Lower Cretaceous Cephalopod Team (IGCP-Project 362). Scripta Geologica - Special Issues 3, 3–13.
Reboulet, S., Hoedemaeker, Ph.J., Aguirre-Urreta, B., Alsen, P., Atrops, F., Baraboshkin, E.Y., Company, M., Delanoy, G., Dutour, Y., Klein, J., Latil, J.-L., Lukeneder, A., Mitta, V., Mourgues, F.A., Ploch, I., Raisossadat, N., Ropolo, P., Sandoval, J., Tavera, J.M., Vasicek, Z., Vermeulen, J., 2006. Report on the 2nd international meeting of the IUGS lower Cretaceous ammonite working group, the "Kilian Group" (Neuchâtel, Switzerland, 8 September 2005). Cretaceous Research 27, 712–715.
Reboulet, S., Klein, J., Barragán, R., Company, M., González-Arreola, C., Lukeneder, A., Raissossadat, S.N., Sandoval, J., Szives, O., Tavera, J.M., Vasícek, Z., Vermeulen, J., 2009. Report on the 3rd International Meeting of the IUGS Lower Cretaceous Ammonite Working Group, the "Kilian Group" (Vienna, Austria, 15th April 2008). Cretaceous Research 30, 496–502.
Reboulet, S., Rawson, P.F., Moreno-Bedmar, J.A., Aguirre-Urreta, B., Barragán, R., Bogomolov, Y., Company, M., González-Arreola, C., Idakieva Stoyanova, V., Lukeneder, A., Matrion, B., Mitta, V., Randrianaly, H., Vasícek, Z., Baraboshkin, E.J., Bert, D., Bersac, S., Bogdanova, T.N., Bulot, L.G., Latil, J.-L., Mikhailova, I.A., Ropolo, P., Szives, O., 2011. 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, 786–793.
Reboulet, S., 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., Raissossadat, S.N., Rawson, P.F., Tavera, J.M., 2014. 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, 126–137.
Reboulet, S., Szives, O., Aguirre-Urreta, B., Barragán, R., Company, M., Frau, C., Kakabadze, M.V., Klein, J., Moreno-Bedmar, J.A., Lukeneder, A., Pictet, A., Ploch, I., Raisossadat, S.N., Vašíček, Z., Baraboshkin, E.J., Mitta, V.V., 2018. Report on the 6th International Meeting of the IUGS Lower Cretaceous Ammonite Working Group, the Kilian Group (Vienna, Austria, 20th August 2017). Cretaceous Research 91, 100–110. https://doi.org/10.1016/j.cretres.2018.05.008.
Renz, O., 1982. The Cretaceous Ammonites of Venezuela. Birkäuser Verlag, Basel, 132 pp.
Rey, J., Moreno-Bedmar, J.-A., Bilotte, M., Martinez, R., 2013. Nouvelles données paléontologiques et stratigraphiques au passage Aptien-Albien dans les Pyrénées ariégeoises (France). Notebooks on Geology. Carnets de Géologie, pp. 67–81. Article 2013/01 (CG2013_A01).
Robert, E., Bulot, L.G., Jaillard, E., Peybernès, B., 2002. Proposition d'une nouvelle biozonation par ammonites de l'Albien du bassin andin (Pérou). Comptes Rendus Palevol, Académie des Sciences 1, 267–275.
Robert, E., Latil, J.-L., Bulot, L.G., 2009. Albian ammonite faunas from South America: the genus *Tegoceras* Hyatt, 1903. Revue de Paléobiologie, Genève 28 (1), 43–51.
Ruffell, A.H., Owen, H.G., 1995. The Sandgate Formation of the M20 Motorway near Ashford, Kent and its correlation. Proceedings of the Geologists' Association 106, 1–9.
Saveliev, A.A., 1973. Lower Albian stratigraphy and ammonites of the Mangyshlak (*Leymeriella tardefurcata* and *Leymeriella regularis* zones). Proceedings of All-Union Science-Research Geological Institute [Trudy Vsesoyuznogo Nauchno-Issledovatelskogo Geologo-Razvedochnogo Instituta] 323, 1–340 (in Russian).
Saveliev, A.A., 1992. Lower Albian ammonites of Mangyshlak, their phylogeny and importance for Albian zonal stratigraphy of South of the USSR (*Cleoniceras mangyschlakense* Superzone), 223 pp., Saint Petersburg. (in Russian).
Schlotheim, E.F. Von., 1813. Beiträge zur Naturgeschichte der Versteinerungen in geognostischer Hinsicht. Leonard's Taschenbuch für die gesammte Mineralogie 7, 3–134.
Setudehnia, A., 1978. The Mesozoic sequence in southwest Iran and adjacent areas. Journal of Petroleum Geology 1, 3–42.
Seunes, J., 1887. Sur quelques ammonites du Gault. Bulletin de la Société Géologique de France 3ème Série 15, 557–571.
Seyed-Emami, K., 1977. Scaphiten aus dem Oberen Alb und Cenoman der Umgebung von Esfahan (Zentral Iran). Mitteilungen der Bayerischen Staatssammlung für Palaontologie und Historische Geologie 17, 125–136.
Seyed-Emami, K., 1980. Parahoplitidae (Ammonoidea) aus dem Nordost und Zentraliran. Neues Jahrbuch für Geologie und Paläontologie - Monatshefte 12, 719–733.
Seyed-Emami, K., 1995. Lyelliceratidae und Brancoceratidae (Ammonoidea) aus dem tieferen Mittelalb (Kreide) bei Soh, Zentraliran. Neus Jahrbuch für Geologie und Paläontologie Monatshefte 1995, 430–440.
Seyed-Emami, K., Immel, H., 1995. Ammoniten aus dem Alb (Kreide) von Shir-Kuh (N Yazd, Zentraliran). Paläontologische Zeitschrift 69, 377–399.
Seyed-Emami, K., Immel, H., 1996. Ammoniten aus dem Alb (höhere Unterkreide) des Zentralirans. Palaeontographica Americana 241, 1–26.
Sharifi, J., Vahidinia, M., Mahmudy-Gharaie, M.H., Raisossadat, S.N., Kamyabi Shadan, H., 2019. New findings in Aptian-Albian boundary interval of the Kazhdumi Formation; Zagros Basin. In: Proceeding of the 12th Symposium of Iranian Paleontological Society, pp. 69–76, 7-8-March, Geological Survey of Iran, North East Territory, Mashhad, Iran (in Persian with English Abstract).
Spath, L.F., 1923-1943. A monograph of the Ammonoidea of the Gault, 787 pp. 1-72 (1923); 73-110 (1925a); 111-146 (1925b); 147-186 (1926); 187-206 (1927a); 207-266 (1928); 267-311 (1930a); 313-378 (1931); 379-410 (1932); 411-442 (1933); 443-496 (1934); 497-450 (1937); 541 (1939a); 609-668 (1941); 669-720 (1942); 721-287 (1943), Palaeontographical Society Monograph.
Sowerby, J. de C., 1836. Appendix A: Descriptive notes respecting the shells figured in pl. 11-23, (pp. 335–348). In: Fitton, W.H. (Ed.), Observations on some of the strata between the Chalk and the Oxford Oolite in the south-east of England, Transactions of the Geological Society of London (series 2) 4, pp. 103–390.
Stieler, K., 1920. Über sogennante Mortoniceraten des Gault. Zentralblatt für Mineralogie. Geologie und Paläontologie, pp. 292–400, 345/352.
Szabo, F., Kheradpir, A., 1978. Permian and Triassic stratigraphy, Zagros basin, southwest Iran. Journal of Petroleum Geology 1, 57–82.
Szives, O., 2007. Albian stage. In: Szives, O., Csontos, L., Bujtor, L., Fozy, I. (Eds.), Aptian-Campanian Ammonites of Hungary, vol. 57. Geologica Hungarica, Series Palaeontologica, pp. 1–187.
Takashima, R., Sano, S.I., Iba, Y., Nishi, H., 2007. The first Pacific record of the Late Aptian. Journal of the Geological Society, London 164, 333–339.
Tavares, T., Meister, C., Duarte-Morais, M.L., David, B., 2007. Albian ammonites of the Benguela Basin (Angola): a biostratigraphic framework. South African Journal of Geology 110 (1), 137–156.
Vasicek, Z., 1995. Aptian and Albian ammonites in the western Carpathians (the Czech and Slovak Republics). Memorie Descrittive Della Carta Geologica d'Italia 51, 167–171.
Wiedmann, J., Owen, H.G., 2007. Ammonite biostratigraphy of the Albian in the Kirchrode II borehole, Hannover, Germany. Cretaceous Research 28, 921–938.
White, C.A., 1887. Contribuições à paleontologia do Brazil. Arquivos do Museu nacional Rio de Janeiro 7, 1–273.
Young, K., 1966. Texas Mojsisoviczinae (Ammonoidea) and the Zonation of the Fredericksburg. Geological Society of America Memoir 100, 1–225.