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LITHOSTRATIGRAPHY AND BIOSTRATIGRAPHY OF THE LOWER CRETACEOUS OF THE JALMAJIRD AREA (NORTHEAST OF KHOMEYN, CENTRAL IRAN BASIN), IRAN

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With 1 Figure, 2 Tables and 2 Plates

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Abstract
In order to study the lithostratigraphy and biostratigraphy of the Lower Cretaceous of the Jalmajird area (northeast of Khomeyn, central Iran) two sections were measured and sampled. The main part of the succession consists of gray-bluish thin-bedded to massive orbitolinid limestones which are of Barremian-Albian age. The Lower Cretaceous sediments overlie the Rhaetian-Middle Jurassic Shemshak Group with an angular unconformity. At the base of the succession a several meter thick transgressive unit of dark red to brown conglomerates and sandstones is developed which corresponds stratigraphically to the Sangestan Formation (sensu Nabavi, 1972). The Lower Cretaceous is disconformably overlain by the Early Cenomanian *Chrysalidina* Limestone. According to the stratigraphic distribution of benthic foraminifera and associated fossil assemblages the Lower Cretaceous deposits of the studied sections are divided into four biozones. The angular unconformity at the base of the Lower Cretacecous unit is attributed to the Middle Cimmerian orogenic event. The Early Cretaceous transgression in the study area is considered to have occurred during the Neocomian? – Barremian.

Key words: Lithostratigraphy, biostratigraphy, foraminifera, Lower Cretaceous, Central Iran,

1. Introduction

1.1 Geologic setting

The Central Iran Zone is a triangular block that is bounded to the east by the Lut Block, to the north by the Alborz Mountain Range and to the south and west by the Sanandaj – Sirjan thrust belt. In the Central Iran Zone the *Orbitolina* Limestone is one of the most important Lower Cretaceous rock units that has been studied with regard to different scientific aspects by several geologists: Mehrnush (1973), Nabavi (1972), Seyed-Emami (1980a,b) , Aghanabati (1974, 2004), Alavi (1972), Nabavi and Partoazar (1977 etc.). The present extent of these rocks demonstrates that the Early Cretaceous sea expanded over large parts of Central Iran. The Lower Cretaceous deposits show different types of contact with the underlying rock units. Generally, in areas where Lower Cretaceous deposits overlie Middle Jurassic and early Upper Jurassic units, there is an angular unconformity. The contact between the late Upper Jurassic and Lower Cretaceous is generally concordant and transitional. There is a controversial discussion among Iranian geologists

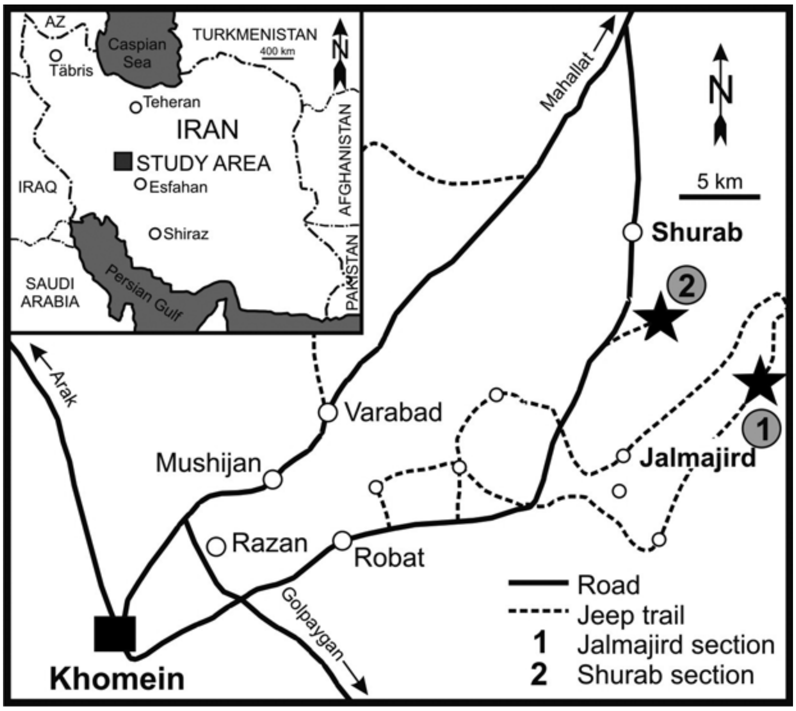

Fig.1: Map showing the locations of the studied sections.

whether the angular unconformity between Middle Jurassic and Lower Cretaceous deposits should be attributed to the Middle Cimmerian or Late Cimmerian orogenic event. The different age of the transgressive base of Cretaceous deposits (Tabas area: Aptian, Poshtbadam – Saghand area: Albian, Jandagh: Santonian) demonstrates that the Cretaceous sea has gradually progressed into Central Iran.

The Lower Cretaceous deposits of Central Iran show two completely different facies types. In large parts of Central Iran, the facies of Lower Cretaceous deposits indicate carbonate platforms. In basinal settings flysch type deposits occur which are represented by the Biabanak Shale Formation.

The carbonate platform facies of the Lower Cretaceous generally consists of three rock units:

1) Clastic deposits consisting of sandstone and conglomerate (Hauterivian – Barremian).

2) Carbonate deposits composed of thin-bedded to massive limestones which are dated as Barremian-Albian due to the occurrence of *Palorbitolina* and associated fossils. The *Orbitolina* Limestone of Central Iran was deposited in shallow and warm marine environments including reef environments of the Urgonian facies type.

3) Shale – marl deposits composed of dark shale and marl with various fossils, especially ammonites of the genus *Boudanticeras* which is representative of the Albian stage. Therefore, these shales are often called "Albian Shale". The most significant occurrence of the Albian Shale in Central Iran is in the west of the Chapduni fault which extends from south of Khor area to the Byazeh area and to the east of Yazd area. In some parts of Central Iran the "Albian Shales" are, however not preserved due to post-Albian erosion.

It is important to note that these three facies types of Lower Cretaceous deposits in Central Iran are not yet formally named. Nabavi (1972) informally called the clastic basal sediments, the *Orbitolina* Limestone and the Albian Shales in the Yazd Taft area "Sangestan Formation", "Taft Formation" and "Dareh-zanjir Formation". In the Khor area they are named "Noghreh Formation", "Shahkuh Formation" and "Bazyab Formation".

1.2 Study area

The Jalmajird area is part of the Central Iran Zone which is located in the north-east of Khomeyn (Fig.1). In this area the Cretaceous deposits are widely exposed. The oldest rocks exposed in the Jalmajird area are dark shales, sandstones and siltstones belonging to the Shemshak Group (Rhaetian-Middle Jurassic) which underlie the Lower Cretaceous deposits with an angular unconformity. In addition to the Shemshak Group and the Cretaceous formations, there are Quaternary deposits exposed in this area. So far the Lower Cretaceous of Central Iran has not been studied in detail concerning litho- and biostratigraphy. The stratigraphy of these deposits is exclusively based on geological mapping at a scale of 1:250000, sheet Golpayegan (Thiele et al. 1964) and geological mapping of 1:100000, sheet Mahallat (Zamani & Sheikholeslami, 2008). The aim of the present study is to establish a more detailed biostratigraphy of the Lower Cretaceous of the Central Iran by means of benthic foraminifera.

Geographic location of the sections (Fig 1):

1) The Jalmajird section is located about 39.5 km northeast of Khomeyn at the entrance of the Jalmajird valley (latitude: N 33°42'15", longitude: E 50°24'10")

2) The Shurab section is located 26 km northeast of Khomeyn, near to the village of Shurab-Paein (latitude: N 33°43'78", longitude: E 50°21'42").

2. Litho- and biostratigraphic analysis

2.1 Litho- and biostratigraphy of the sections

The lowermost samples studied in both sections are from the upper part of the dark shales and sandstones belonging to the Shemshak Group (Rhaetian-Middle Jurassic) and sampling continues to the *Chrysalidina* Limestone) Early Cenomanian.The total thickness of the Lower Cretaceous units is 224.6 m at the Jalmajird section. The rocks strike N 50-55 W and dip 28-30 towards NE. At the Shurab section the Lower Cretaceous is 251.4 m thick; the strike is N 55-60W and dip is 25-30 NE.

At both sections the Lower Cretaceous succession can be subdivided into a lower mixed siliciclastic-carbonate unit (lower part) and an upper carbonate unit (upper part):

a) Lower part

The lower part represents the transgressional base of the of Lower Cretaceous sequence and is composed of dark reddish-brown sandstones and conglomerates, light red calcareous sandstones and purple sandy dolomitic limestones (Tables 1, 2). This succession can be subdivided into four lithostratigraphic subunits. Due to the intensive colouration the lower part represents a marker horizon which is well traceable in the region. It overlies dark shales and sandstones of the Shemshak Group (Rhaetian-Middle Jurassic) with an angular unconformity and is conformably overlain by the upper part of Lower Cretaceous deposits (Barremian-Albian). The lower part is 52.8 m thick at the Jalmajird section and 62.1 m at the Shurab section.

Fossils are absent in the transgressive sequence. Considering that the first calcareous layers of the upper part yielded a microfauna of Barremian-Aptian age the lower part can be either attributed to the Barremian or Neocomian-Barremian interval.

b) Upper part

The upper part consists of carbonate deposits (dolomitic limestones, bioclastic and clayey limestones) which are rich in macro- and microbenthic fossils such as red and green algae, benthic foraminifera, pelecypods, bryozoa and gastropods. This unit is disconformably overlain by the Early Cenomanian *Chrysalidina* Limestone. Based on the present micropalaeontologic results the upper part is dated as Barremian-Albian. There is no indication of a sedimentary break or erosion within this carbonate succession. The upper part is 171.8 m thick at the Jalmajird section and is divided into 11 lithostratigraphic subunits (Table 1). At the Shurab section the thickness is 189.3 m and the succession is divided into 9 lithostratigraphic subunits (Table 2).

3. Biostratigraphic analysis

In total 322 rock samples were collected from the two studied sections. The microfossil determinations were carried out using an Olympus BH-2 binocular. Various publications (Kalantari 1972, 1992, Kheradpir 1975, Loeblich & Tappan 1988, Mehrnush & Partoazar 1977, Sampo 1969, Johnson 1961, Gollestaneh 1956, Bernaus et al. 2001, Antonietta 2004, Shakib 1994, Simmons 1994) were used for the determination of the microfossils and their biostratigraphic analysis. As fossils are absent in the lower part the biozonation is exclusively based on microfossils of the upper part of the sections. The foraminifera assemblages include many juvenile representatives of Orbitolinidae which could

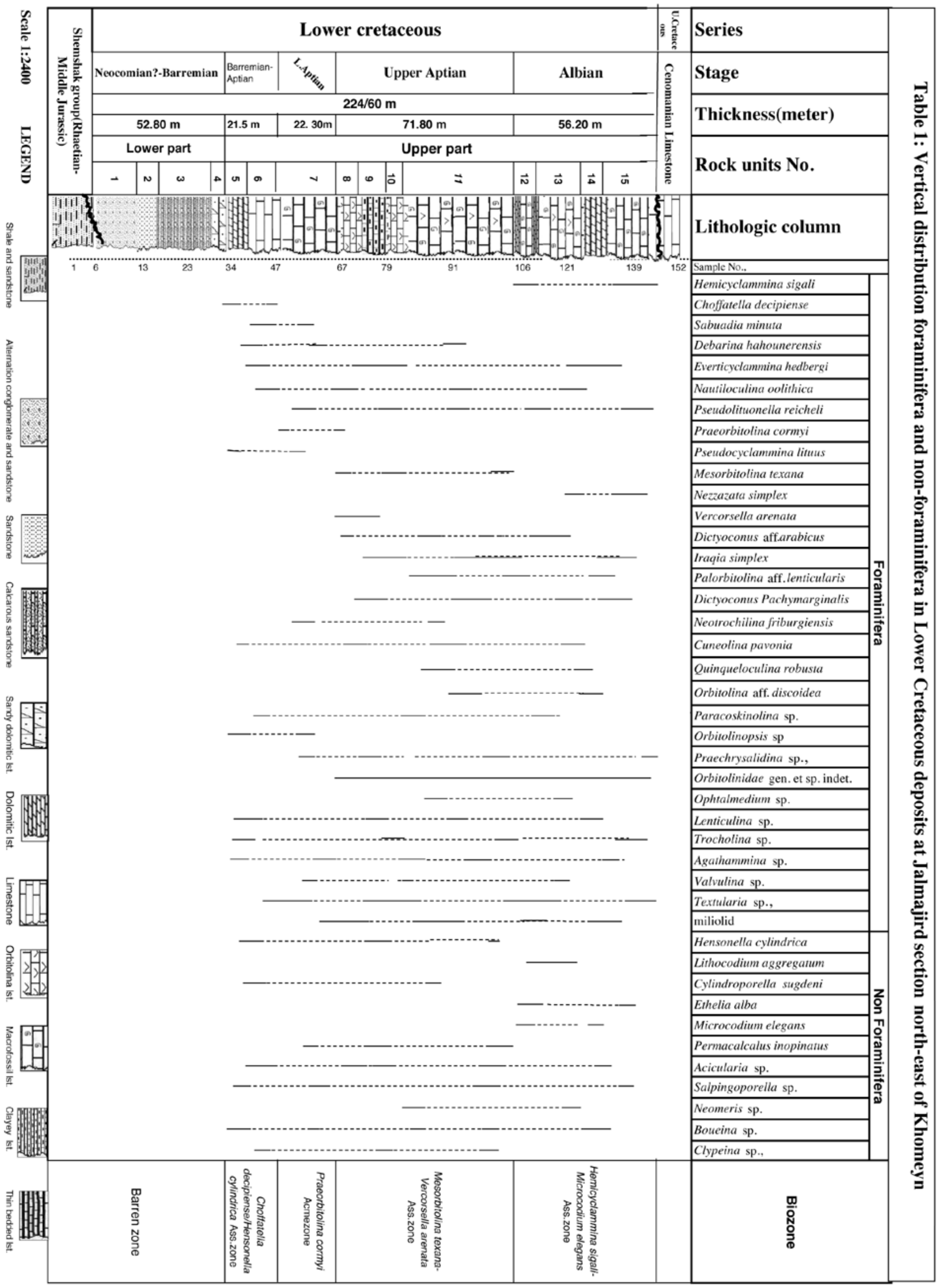

Table 1: Lithostratigraphy and distribution of foraminifera and associated microfossils in the Lower Cretaceous at the Jalmajird section northeast of Khomeyn.

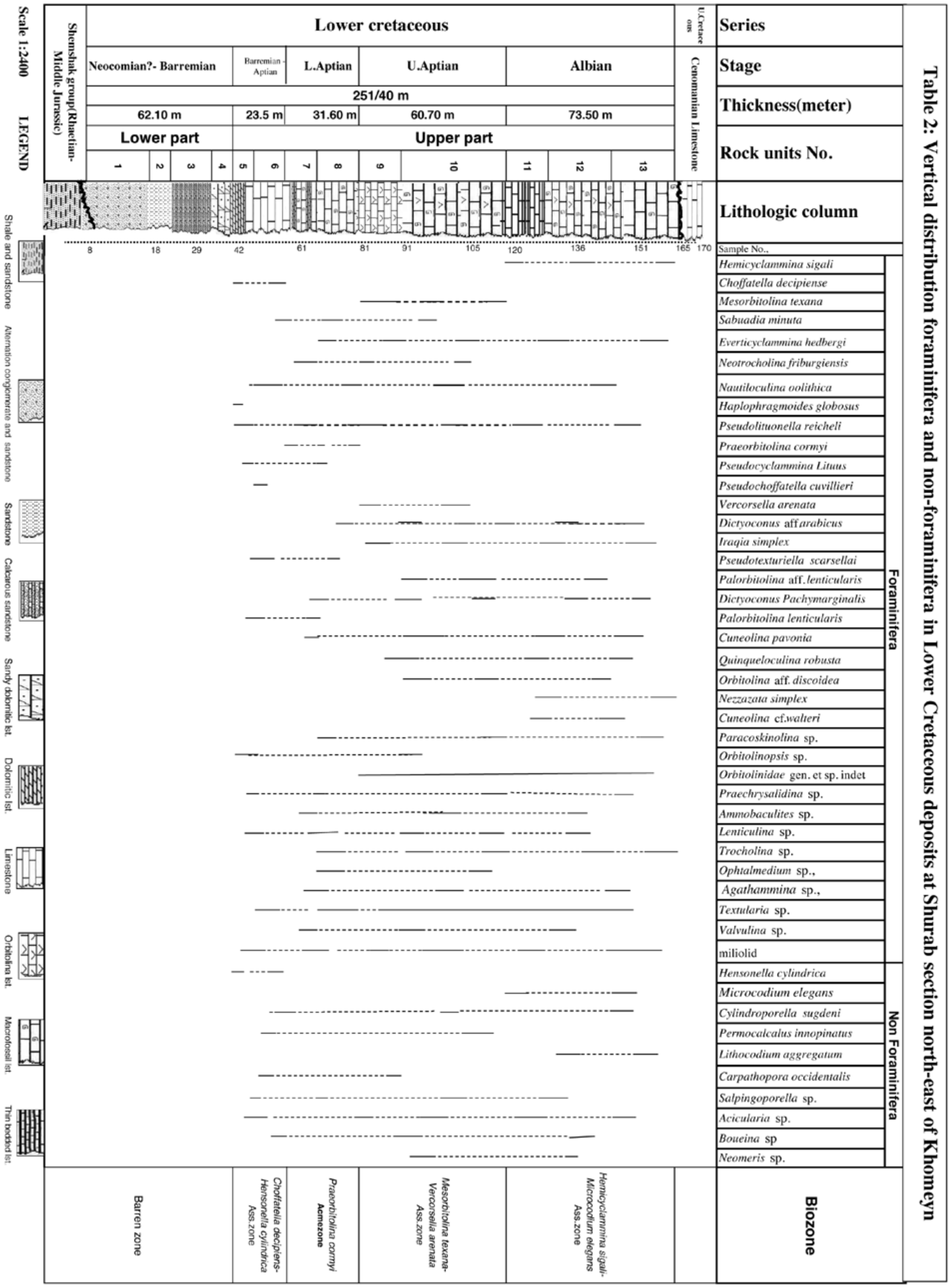

Table 2: Lithostratigraphy and distribution of foraminifera and associated microfossils in the Lower Cretaceous at the Shurab section northeast of Khomeyn.

not be determined at the genus and species level and were thus termed as "Orbitolinidae gen. et sp. indet.".

In total 32 genera and 25 species of benthic foraminifera, 12 genera and 7 species of calcareous algae as well as a number of other micro- and macrofossils were identified from the sections under study which indicate a Barremian - Aptian to Albian age.

3.1 Identified benthic foraminifera

Vercorsella arenata Arnaud-Vanneau, *Nautiloculina oolithica* Mohler, *Sabuadia minuta* (Hofker), *Everticyclammina hedbergi* Maync (Pl. 1, Fig. 1), *Haplophragmoides* cf. *globosus* Lozo (Pl. 2, Fig. 7), *Debarina hahounerensis* Fourcade, Raoult & Vila, *Pseudochoffatella* cf. *cuvillieri* Deloffre (Pl. 1, Fig. 10), *Choffatella decipiens* Schlumberger (Pl. 1, Fig. 9), *Pseudolituonella reicheli* Marie, *Cuneolina pavonia* d`Orbigny (Pl. 1, Fig. 11), *Dictyoconus aff. arabicus* Henson (Pl. 1, Fig. 3B), aff. *Orbitolina discoidea* Gras, *Praeorbitolina cormyi* Schroeder (Pl. 2, Fig. 5), *Pseudotexturiella* cf. *scarsellai* (De Castro) (Pl. 2, Fig. 10), *Palorbitolina lenticularis* (Blumenbach), *Pseudocyclammina lituus* (Yokoyama) (Pl. 1, Fig. 5), *Iraqia simplex* Henson (Pl. 1, Fig. 6), *Neotrocholina friburgiensis* Arnaud-Vanneau (Pl. 1, Fig. 2), *Nezzazata simplex* Omara, *Palorbitolina* aff. *lenticularis* (Blumenbach) (Pl. 2, Fig. 1), *Mesorbitolina texana* (Roemer) (Pl. 1, Fig. 4), *Hemicyclammina sigali* Maync (Pl. 2, Fig. 4), *Quinqueloculina robusta* Neagu (Pl. 1, Fig. 8), *Dictyoconus pachymarginalis* Schroeder (Pl. 1, Fig. 7), *Cuneolina* cf. *walteri* Applin (Pl. 2, Fig. 3), *Paracoskinolina* sp., *Orbitolinopsis* sp., *Praechrysalidina* sp., *Arenobulimina* sp., *Orbitolinidae* gen. et sp. indet., *Ammobaculites* sp., *Lenticulina* sp., *Trocholina* sp., *Ophtalmedium* sp., *Agathammina* sp., *Valvulina* sp., *Textularia* sp., miliolid foraminifera.

3.2 Identified non-foraminiferal fossils

Ostrea sp., Echinodermata, Ostracoda, Gastropoda, Bryozoa, Coral, worm fragments, calcareous algae: *Carpathopora occidentalis* Dragastan, *Microcodium elegans* Gluck, *Ethelia alba* (Pfender) (Pl. 2, Fig. 8), *Cylindroporella* sugdeni Elliott (Pl. 1, Fig. 12), *Hensonella cylindrica* Elliott (Pl. 1, Fig. 13), *Permocalculus inopinatus* Elliott (Pl. 2, Fig. 2), *Lithocodium aggregatum* Elliott (Pl. 2, Fig. 9), *Boueina* sp. (Pl. 2, Fig. 6), *Neomeris* sp., *Clypeina* sp., *Acicularia* sp., *Salpingoporella* sp..

Based on the first and last occurrences and the proposed stratigraphic range of the identified microfossils, four biozones are determined at both sections (Tables 1, 2):

1) *Choffatella decipiens* - *Hensonella cylindrica* Assemblage Zone

The thickness of this biozone is 21.5 m at the Jalmajird section and 23.5 m at the Shurab section. The base of this biozone corresponds to the first carbonate beds of the upper part, is defined by the first appearance of Barremian-Aptian index microfossils (*Choffatella decipiens* and *Hensonella cylindrica*) associated with *Haplophragmoides* cf. *globosus*, and its top is defined by the last appearance of *Choffatella decipiens*. The most characteristic microfossils associated with this biozone are as follows:

Haplophragmoides cf. *globosus*, *Psedochoffatella* cf. *cuvillieri*, *Sabuadia minuta*, *Palorbitolina lenticularis*, *Nautiloculina oolithica* (Pl. 1, Fig. 3A), *Choffatella decipiens, Pseudotexturiella scarsellai*, *Everticyclmmina hedbergi*, *Debarina hahounerensis*, *Hensonella cylindrical*, *Carpathoporella occidentalis*, *Orbitolinopsis* sp.

Considering the identified microfossil associations and particularly the presence of *Choffatella decipiens* and *Hensonella cylindrical* and *Palorbitolina lenticularis* which is reported from the Upper Barremian-Lower Aptian interval (Schroeder et al. 2010) the age of this biozone is suggested to be Upper Barremian – Lower Aptian.

2) *Praeorbitolina cormyi* Acmezone

The thickness of this biozone is 22.3 m at Jalmajird and 31.6 m at Shurab.

This biozone is based on the range of the Early Aptian index fossil *Praeorbitolina cormyi*. The most characteristic microfossils associated with this biozone are:

Pseudocyclammina lituus, Sabaudia minuta, Dictyoconus aff. *arabicus*, *Pseudolituonella reicheli*, *Neotrocholina friburgiensis*,, *Cuneolina pavonia*, *Everticyclammina hedbergi*, *Debarina hahounerensis*, *Pseudotexturiella* cf. *scarsellai*, *Permocalcalus inopinatus*, *Orbitolinopsis* sp.

Based on the presence of *Praeorbitolina cormyi,* the age of this biozone is suggested to be Early Aptian.

3) *Mesorbitolina texana* – *Vercorsella arenata* Assemblage zone

This biozone is 71.8 m thick at Jalmajird and 60.7 m at Shurab. The base of this biozone is defined by the first appearance of representatives of the genus *Palorbitolina* with the characteristic internal structure in association with *Mesorbitolina texana* and *Vercorsella arenata*. The top of this biozone corresponds to the last appearance of *Mesorbitolina texana*. The most characteristic microfossils associated with this biozone are:

Iraqia simplex, *Mesorbitolina texana*, *Dictyoconus pachymarginalis*, *Dictyoconus* aff. *arabicus*, *Cuneolina pavonia*, *Everticyclammina hedbergi*, *Quinqueloculina robusta*, *Neotrocholina friburgiensis*, *Palorbitolina* aff. *lenticularis*, *Orbitolinidae* gen. et sp. indet., *Carpathoporella occidentalis*, *Cylindroporella sugdeni*, *Permocalcalus inopinatus*.

The presence of *Palorbitolina* with real internal structure and the high abundance of *Mesorbitolina texana* suggest a Late Aptian age for this biozone.

4) *Hemicyclammina sigali* – *Microcodium elegans* Assemblage zone

The thickness of this biozone measures 56.2 m at the Jalmajird section and 73.5 m at the Shurab section. The base of this biozone corresponds to the first appearance of *Hemicyclammina sigali* associated with *Ethelia alba* and *Microcodium elegans* and its top is concordant with the last appearance of *Hemicyclammina sigali* and the appearance of the Cenomanian index microfossils *Nezzazatinella picardi*, *Chrysalidina* sp., *Pseudonummoloculina* sp.

The most characteristic microfossils associated with this biozone are:

Iraqia simplex, *Hemicyclammina sigali*, *Nezzazata simplex*, *Dictyoconus pachymarginalis*, *Dictyoconus* aff. *arabicus*, *Cuneolina pavonia*, *Everticyclammina hedbergi*, *Pseudolituonella reicheli*, *Quinqueloculina robusta*, *Cuneolina* cf. *walteri*, *Orbitolina* sp., *Lithocodium aggregatum*, *Ethelia alba*, *Microcodium elegans*.

Microfossils of this biozone, particularly the co-occurrence of *Ethelia alba*, *Microcodium elegans* and *Hemicyclammina sigali* indicate Albian age.

4. Conclusions

Microfossils from the Lower Cretaceous deposits of the studied sections indicate a Neocomian? - Barremian to Albian age. The Lower Cretaceous deposits overlie the Middle Jurassic Shemshak Group with an angular unconformity, and its upper boundary with the Cenomanian *Chrysalidina* limestone is a disconformity. The angular unconformity at the base of the Lower Cretaceous deposits is attributed to the Middle Cimmerian tectonic event (Aghanabati, 1974) which caused also local gaps in marine Upper Jurassic sediments of the studied area. The lower silciclastic part of the Lower Cretaceous sequence was deposited during the transgression of the sea which is reflected by the gradual decrease of continental siliciclastics and increase of marine carbonate sedimentation. Microfossil assemblages indicate that this transgression occurred during the Neocomian? – Barremian interval. According to the range of benthic foraminifera and associated fossils the Lower Cretaceous of the studied sections is subdivided into four biozones: 1) *Choffatella decipiens - Hensonella cylindrica* Assemblage Zone (Barremian-Aptian), 2) *Praeorbitolina* cormyi Acmezone (Lower Aptian), 3) *Mesorbitolina texana* -Vercorsella arenata Assemblage zone (Upper Aptian), 4) *Hemicyclammina sigali - Microcodium elegans* Assemblage zone (Albian).

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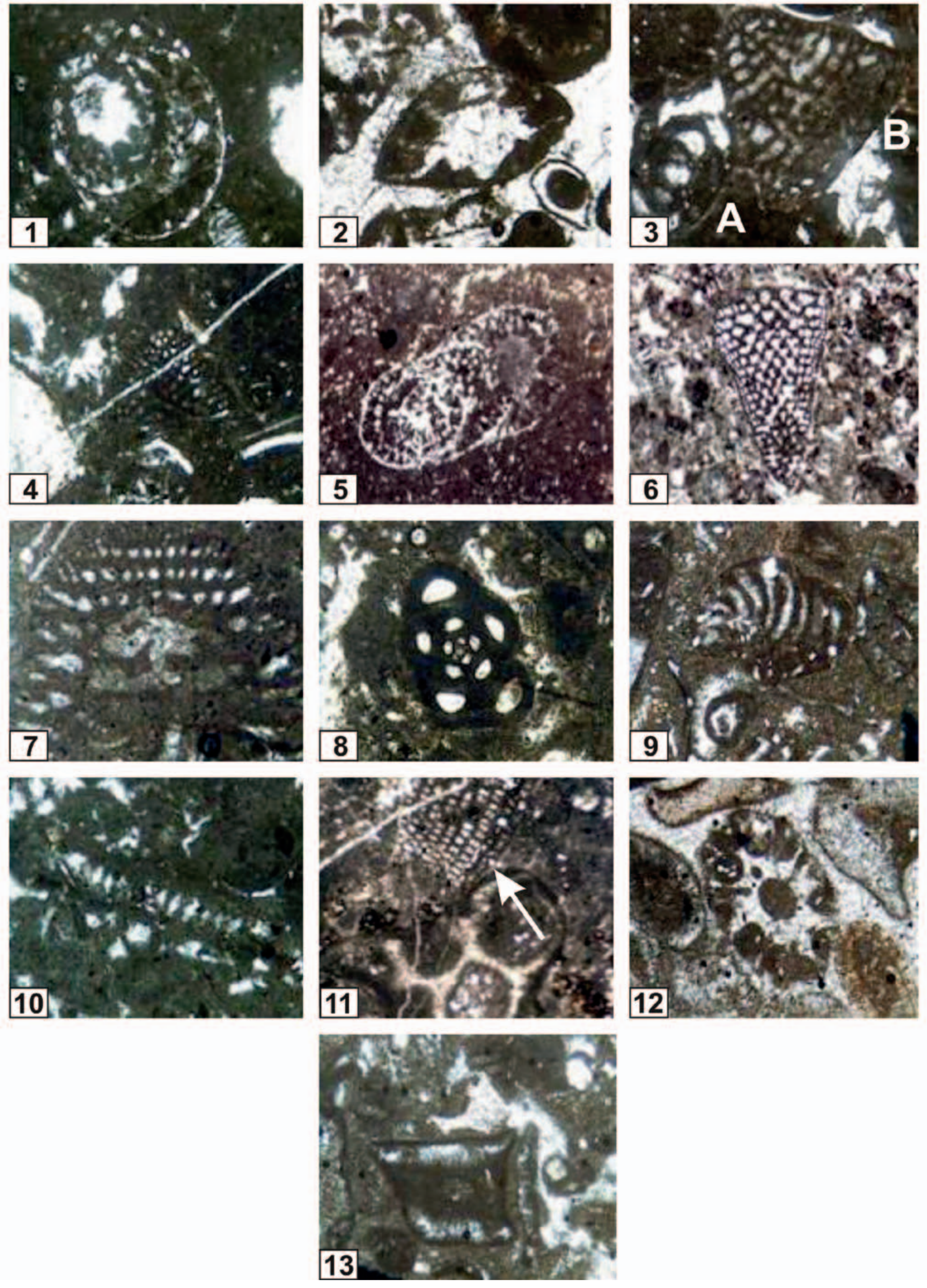
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Plate 1: Lower Cretaceous foraminifera of the Jalmajird and Shurab sections northeast of Khomeyn.

1 *Everticyclammina hedbergi* Maync (X40), Late Aptian, Shurab section;
2 *Neotrocholina friburgiensis* Arnaud-Vanneau (X40), Early Aptian, Jalmajird section;
3 A: *Nautiloculina oolithica* Mohler, B: *Dictyoconus* aff. *arabicus* Henson (X40), Late Aptian, Shurab section;
4 *Mesorbitolina texana* (Roemer) (X40), Late Aptian, Jalmajird section;
5 *Pseudocyclammina lituus* (Yokoyama) (X40), Early Aptian , Jalmajird section;
6 *Iraqia simplex* Henson((X30), Albian, Jalmajird section;
7 *Dictyoconus pachymarginalis* Schreoder(X40), Late Aptian, Jalmajird section;
8 *Quinqueloculina robusta* Neagu (X40), Albian, Jalmajird section;
9 *Choffatella decipiens* Schlumberger(X40), Barremian-Aptian, Shurab section;
10 *Pseudochoffatella* cf. *cuvillieri*, (X40), Barremian-Aptian, Shurab section;
11 *Cuneolina pavonia* d`Orbigny(X40), Albian, Jalmajird section;
12 *Cylindroporella* sugdeni Elliott (X40), Late Aptian, Jalmajird section;
13 *Hensonella cylindrica* (axial section) Elliott, (X40), Barremian-Aptian, Shurab section.

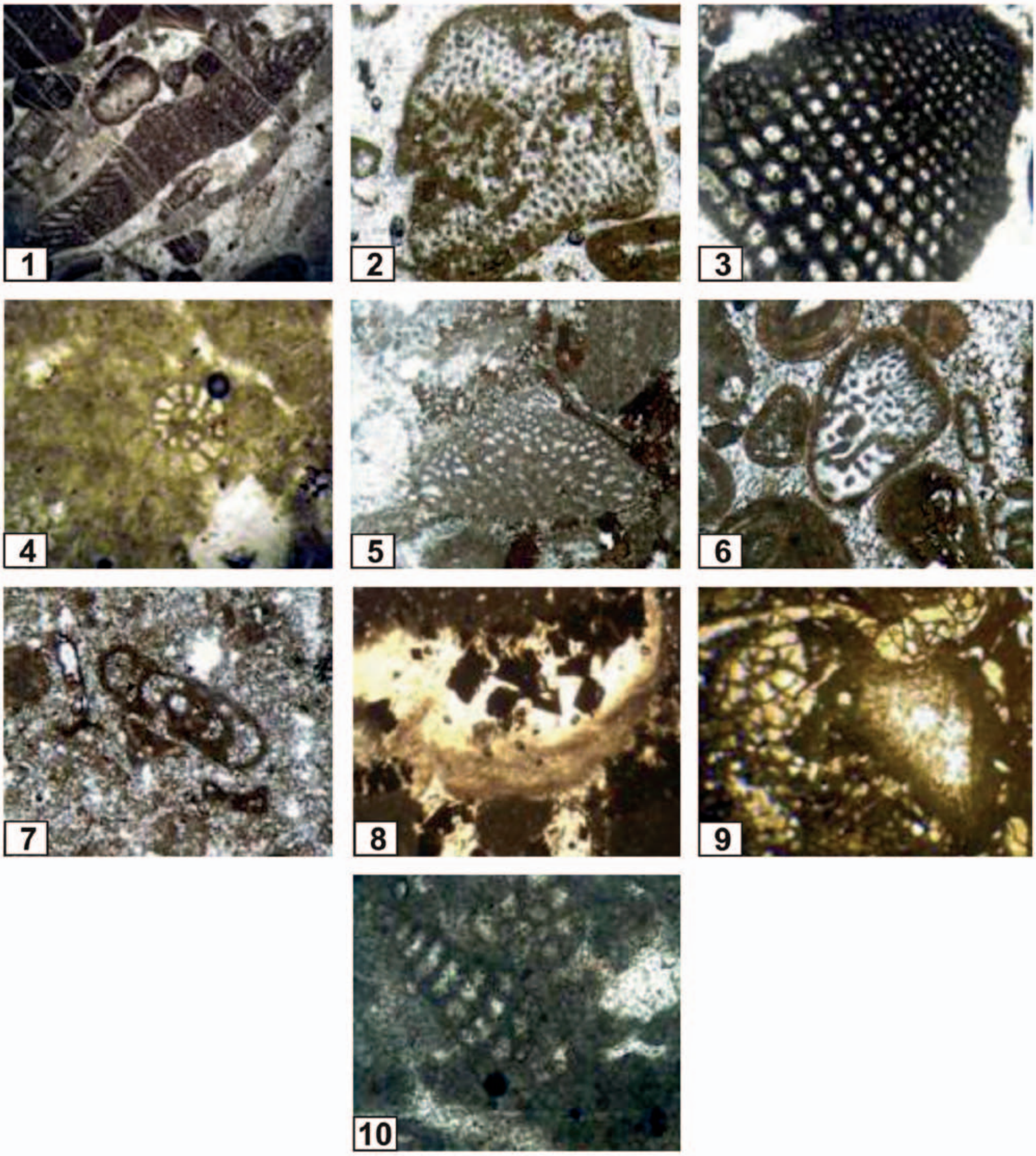

Plate 2: Lower Cretaceous foraminifera of the Jalmajird and Shurab sections northeast of Khomeyn.
1 *Palorbitolina* aff. *lenticularis* (Henson) (X40), Late Aptian, Jalmajird section;
2 *Permocalculus innopinatus* Elliott (X40), Late Aptian, Shurab section;
3 *Cuneolina* cf. *walterai* Applin (X40), Albian, Shurab section;
4 *Hemicyclammina sigali* Maync (X40), Albian, Jalmajird section;
5 cf. *Praeorbitolina cormyi* Schroeder (X40), Early Aptian, Jalmajird section;
6 *Boueina* sp. (X40), Albian, Shurab section;
7 *Haplophragmoides* cf. *globosus* Lozo (X40), Barremian-Aptian, Shurab section;
8 *Ethelia alba* Pfender (X40), Albian, Jalmajird section;
9 *Lithocodium aggregatum* Elliott (X15), Albian, Jalmajird section;
10 *Pseudotexturiella* cf. *scarselai* (De Castro) (X40), Early Aptian, Shurab section.

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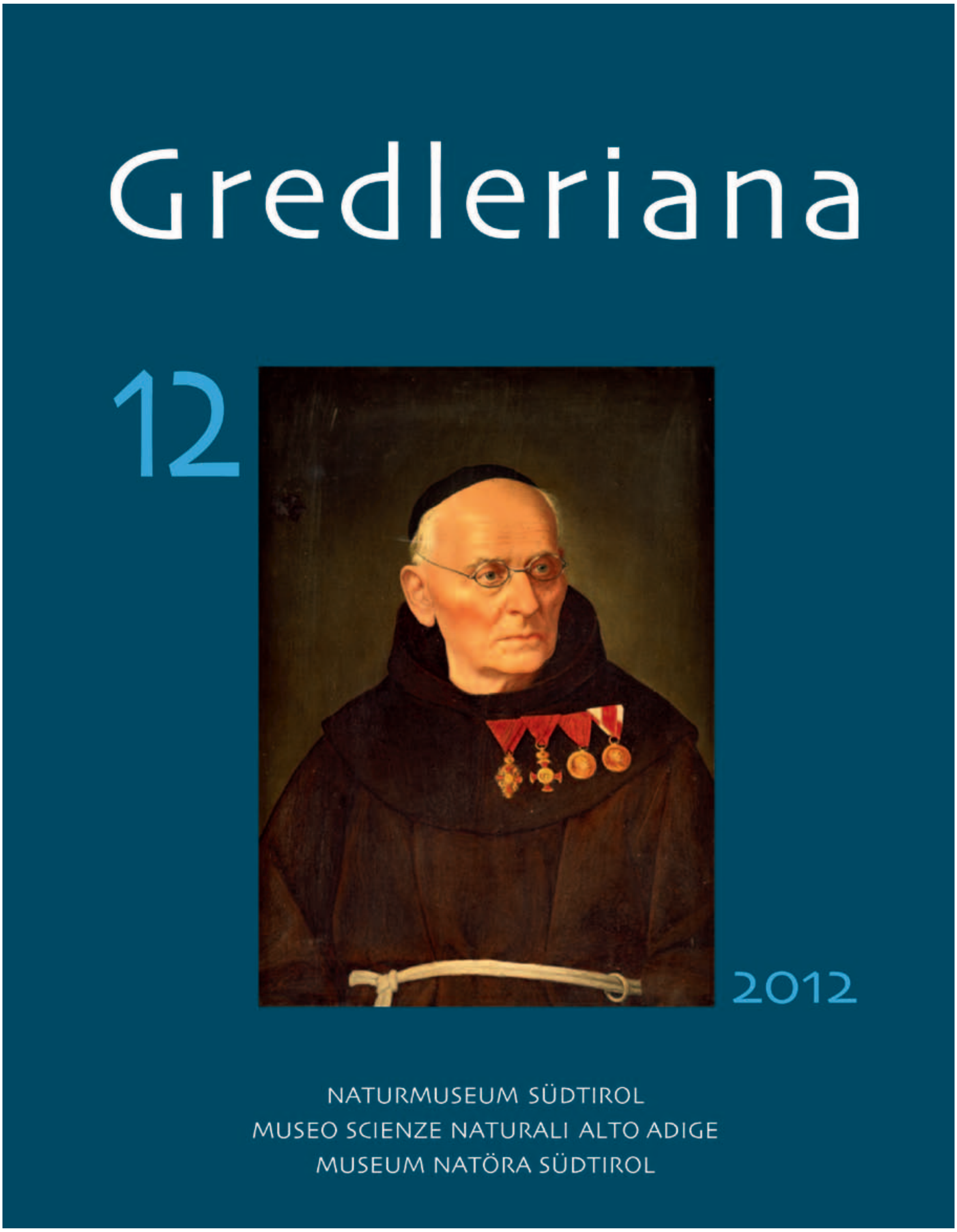

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