



Original article

Preliminary results of biostratigraphic studies of Lower Cretaceous sediments in the Ergel-Khaliv area, SE Mongolia

Luvsantseden Uranbileg^{1*}, Sukhbat Purevsuren¹, Byambaa Purevsuren¹, Batkhuyag Enkhbaatar¹, Batsaikhan Buyantegsh¹, Bayasгаа Ganzorig¹, Enkhtaivan Zorig¹, Jalbaa Undarya²

¹Division of Paleobotany and Paleozoology, Institute of Paleontology, Mongolian Academy of Sciences, Ulaanbaatar, 15160, Mongolia

²Department of Geology and Hydrogeology, School of Geology and Mining Engineering, Mongolian University of Science and Technology, Ulaanbaatar 14191, Mongolia

*Corresponding author. E-mail: uranbileg7010@gmail.com

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ABSTRACT

The research area is located in the territory of Khatanbulag soum, Dornogovi province, in the Great Gobi Province (coordinates: 108°25'39.04"E and 43°10'11.43"N). Here, the authors studied the composition of sediments that had previously been classified as Lower Cretaceous Khukhteeg Formation, forming Mt. Ergel-Khaliv during earlier mapping work. The authors revealed fossils of faunas and floras, processing some data of biostratigraphic survey works taken on fossil-bearing sediments of the area. The fieldwork was conducted in April 2019 by researchers from the Institute of Paleontology, Mongolian Academy of Sciences. The area is very rich in fossils of mollusca, therefore, the local communities named it Dun-Ovoo (Conch hill). During the previous studies, the sediments outcropping around the Ergel-Khaliv were classified as Khukhteeg Formation (K₁ht, Aptian-Albian) based on lithological characteristics and comparing them to the type section of the Khukhteeg Formation sediments. Our research revealed biostratigraphic basements and recorded previous data of collected fossils two types of mollusca; we have studied plant fossils, turtles, ostracods, fish and dinosaur bones had been revealed at first in that area. The results of the research work, the fossils that found in the mountain, were amended by more and new types and families of fauna and flora and their constituents. These new findings were helpful in the precise determination of the age of the sediments and provided some information on the paleoenvironmental conditions of the sedimentation period.

Keywords: Biostratigraphy, Formation, sedimentation, fossils

INTRODUCTION

Location and geomorphology of the site: The Ergel-Khaliv fossil-bearing area is located in 80 km to the North of Mongolia's southern border, in more than 60 km south-west of Khatanbulag, Dornogovi province, and 100 km to the East of Khanbogd, Umnugovi province (Fig. 1). In general, the surface of the site is elevated

from up to 1,000 meters above sea level, with a relatively flat landscape characterized by minor hills and plains. The Mt. Ergel-Khaliv consists mainly of low hills with flat tops, which are composed of the Lower Cretaceous sediments. The minor hills and ridges are characterized by significant outcrops which are separated by a number of narrow and dry streams. Fig. 2 shows

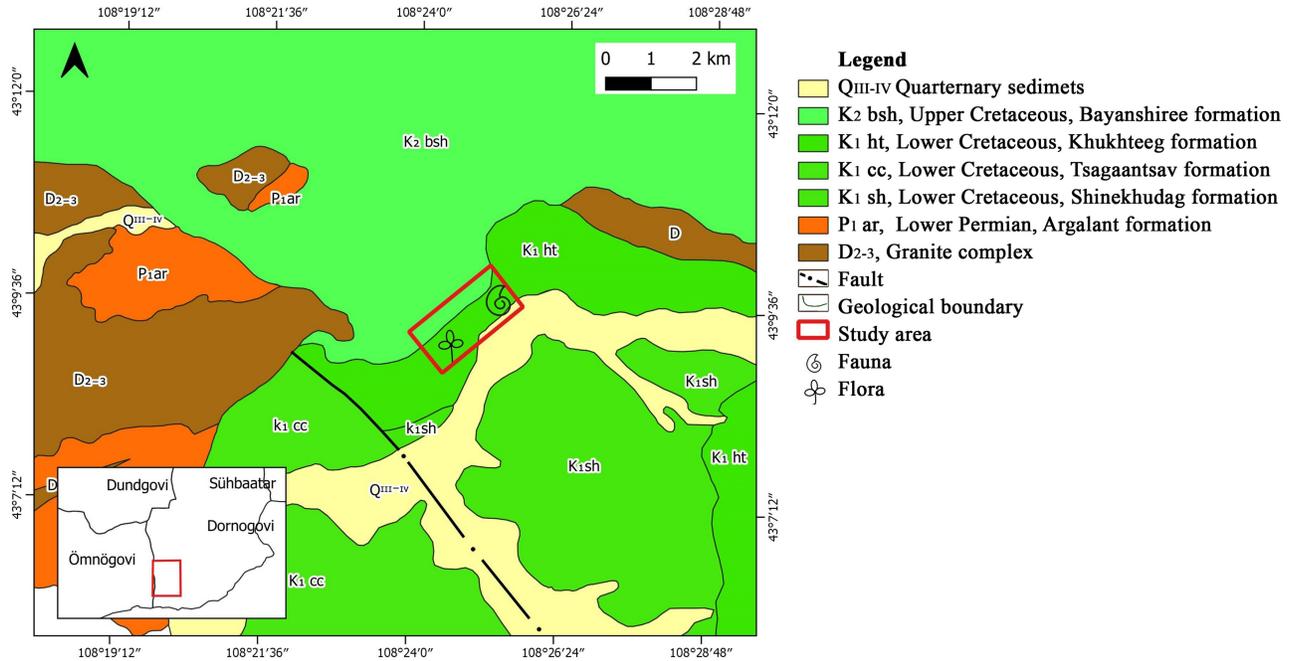


Fig. 1. Location of the Ergel-Khaliv area on geological map



Fig. 2. Typical view of landscape and sedimentary outcrops in the Ergel-Khaliv area

a panoramic view of the fossil-bearing site and outcrops of the surface.

PREVIOUS STUDIES

Khukhteeg Formation (K_1ht). Initially, the sediments of Khukhteeg Formation are equivalent to Upper part of Zuunbayan Formation (Turishchev, 1955) in the eastern Mongolia. The Khukhteeg Formation sediments cover unconformably the Shinekhudag

Formation and are covered by the Upper Cretaceous sediments of Sainshand Formation unconformably, too, at the Khukhteeg hill in territory of Undurshil soum, Dundgovi province. The Khukhteeg sediments are composed of greenish gray mudstone, siltstone, sandstone, limestone and conglomerate beds containing fossils of mollusca. The measured thickness of the sediments ranges between 250 and 470 m. These sediments were identified and

classified into the Lower Cretaceous (Aptian-Albian), and named after the hill (Khukhteeg hill) by Martinson and Shuvalov (1973). Further, the researchers determined the basic section of the formation sediments, on the Khukhteeg hill site. Later the sediments were studied by Goldenberg et al. (1978) in the area of Tsogt-Ovoo soum Umnugovi province; and in some areas of southern soums of Dornogovi province, as adequate sediments (Goldenberg et al., 1978; Burenkhoo et al., 1995; Bumburuu et al., 1999; Bayartsengel et al., 2015) of the Khukhteeg Formation, which were described as gray and yellowish-gray in color, and forming partially weathered light yellow surface. In these areas, the researchers (Goldenberg et al., 1978) have found common features that the sediments have peaty or sooty signs and grayish color pattern in most part of their distribution. Usually the sediments of the Khukhteeg Formation are overlain by the Upper Cretaceous terrigenous sediments of the Bayanshiree Formation (K₂bs) with angular unconformably. The previous researchers (Rozhdestvenskiy, 1955; Martinson, 1961; Marinov and Khasin, 1973; Martinson and Shuvalov, 1973; Makhbadar, 2012) compared Khukhteeg Formation sediments, their lithological and first paleontological studies with the Lower Cretaceous Aptian-Albian stages which spread around the Mt. Ergel-Khaliv. Before this research work the Ergel-Khaliv area for biostratigraphic research had not been done in that time.

GEOLOGICAL SETTINGS AND STRATIGRAPHY OF THE ERGEL-KHALIV AREA

We conducted fieldworks within the distribution area of the Lower Cretaceous sediments, around of the Mt. Ergel-Khaliv. The key section is located in the southern part of the Mt. Ergel-Khaliv. However, there has not been established continuous cross section on the site (due to discontinuous outcrops), but the layers are clearly visible in the ascending order and can be detected along with some parallel profiles in cross direction to the outcrop strike.

Tentatively we classify this is lower Cretaceous. However, it is not clear that the correlation with

the Bayanshiree Formation which covers this sediment. In the future, it will have to be clarified and investigated purposely.

The layers forming the outcropping the Lower Cretaceous sediments are generally observed as a monoclinic setting, which is common in the Mesozoic sediments, and the layers are dipping to NW and N at 5-15° with an average at 10°. A fairly complete geological section of the sediments was documented in the central part of the monoclinic structure (Fig. 2), and the thickness of the sediment gradually decreases along strike, but lacking of complete sections on the both margins.

According to the description, the sediment is generally composed of multi-colored sandstone, siltstone, mudstone, conglomerate and green and yellow clay, coaly mudstone, and brown coal seams. The complete section is shown in Fig. 3, and the visible thickness of the layers is presented in the figures. The sediments are divided into the following three packages. Lower - clayey siltstone package (Fig. 4); Mid - coal-bearing package (Fig. 5); and Upper - sandstone-clayey package (Fig. 6). The descriptions of the packages are presented below.

Lower: Clayey-siltstone package (Fig. 4) is quite weathered and its rocks are fragile (Fig. 4) having fragmentary partings forming minor monocline ridges, and they are usually composed of multi-colored clay, siltstone, and rarely thin layers of sandstone, which separated by three thin (20 to 35 cm thick), plate-shaped siltstone layers. In the lower part of the sediment package, there were observed *Ginkgoaleans*. Measured thickness is 151.9 m.

Mid: Coal-bearing package (Fig. 5) is started of light yellow, weathered yellowish-gray and yellowish-green clay layers. Usually, the sediment package is composed of gray, bluish gray mud, coaly mudstone and siltstone, containing 4 coal seams (layers), of which thickness ranges from 2 m up to 18 m. Further, in the ascending order of the section, there are observed fine layers of light gray, dark gray, brownish-yellow, weathered yellow clay, and rarely bluish-gray shale. Also, there are observed number of thin layers of massive, well cemented

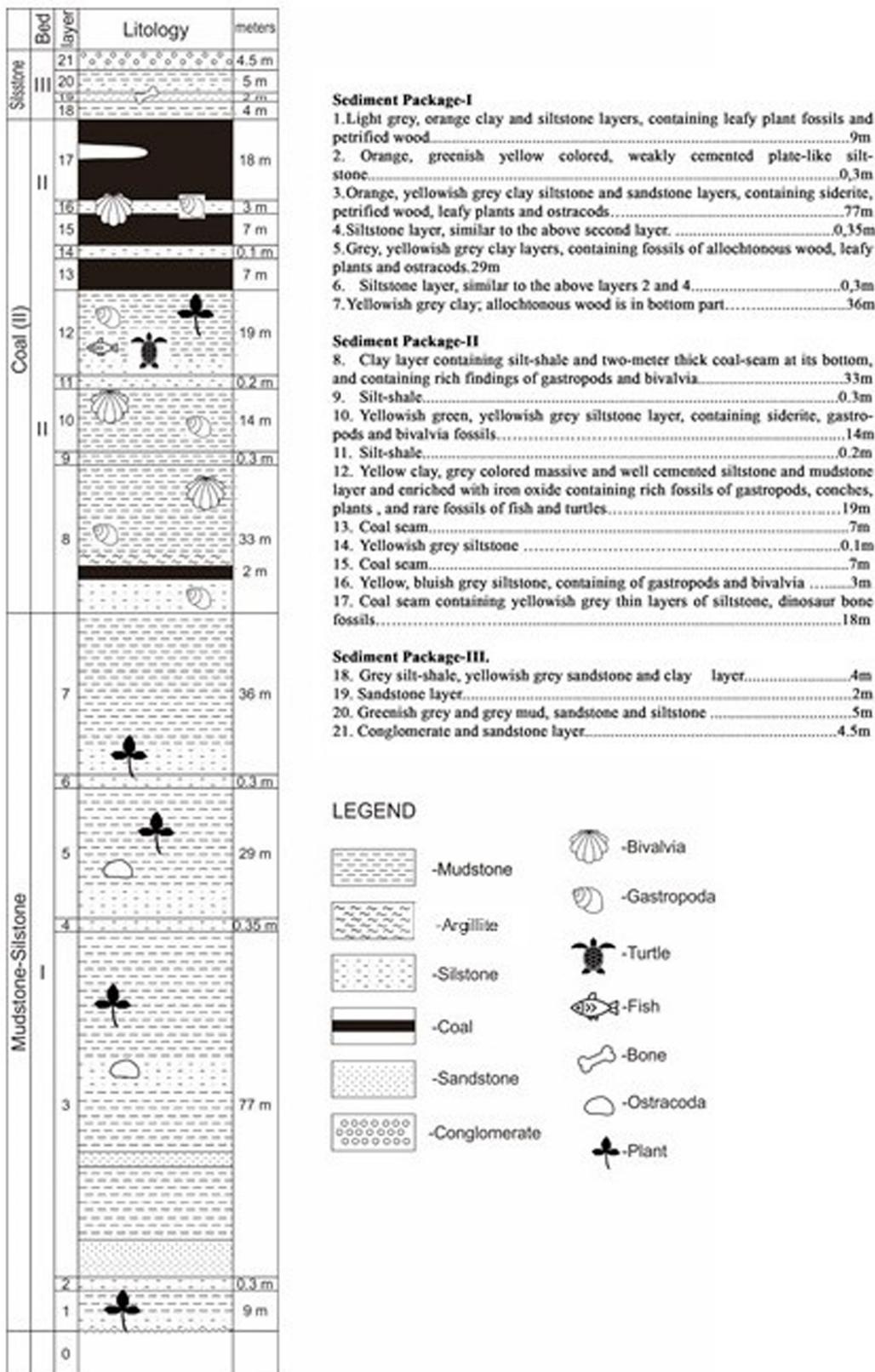


Fig. 3. Section of Lower Cretaceous sediments in the Ergel-Khaliv area



Fig. 4. View on sediments outcrop of the Lower: Clay-siltstone package



Fig. 5. Outcrop of Mid Coal-bearing package

and homogenous bluish gray siltstone, and containing very thin abundant layers of gypsum (thickness ~1 cm) in lower and middle parts of the sediment package. And the intermediate rock partings that located between Coal seam 1 (lower) and Coal seam 2 (second from bottom) contain siderite.

There were found and described fossils of two-shell mollusca (*Bivalvia*) and spiral shaped conchs (*Gastropoda*) and rarely backbones of fish and head and major prints of coepts of fish, and fragments of turtle and fossils of ostracods. Furthermore, we found prints of continental

leafy plants and remainders of dinosaurs from upper part of the sediment package. The Fig. 5 shows the outcrop of the mid coal-seam package. Measured thickness is 101.6 m.

Upper: Sandy-Clay package (Fig. 6) starts mainly with yellowish, greenish gray, gray shale siltstone and continues in ascending order with pre-dominated polymictic sandstone, and in quite top part of the package, violet colored thin and siltstone layer. The sediments have a monoclinic structure. There were revealed allochthonous bone fragments of probable



Fig. 6. Upper Sandstone-Clay package of the section



Fig. 7. View on sediment boundary that is described as existing between sediments of the Lower and Upper Cretaceous

carnivore reptilians from the bottom part of this sediment. Measured thickness is 15.5 m.

The upper part of the section is confined to the gravelite, medium grained and surrounded conglomerate, of which thickness is up to 6 m, and the upper part is covered by Quaternary loose sediments, forming flat surface. The thickness of the sediments decreases to westward or to direction of the western end of the hill and paleontological findings be depleted, simultaneously the coal outcrops being reduced. However, in the eastern and northeastern limbs of the hill, the coal seams were relatively greater and content of gastropod and conch fossils were more abandoned. According to results of our measurements, the

total thickness of the Lower Cretaceous sediments is c. 269 m. The thickness of the red sediments of the overlying Bayanshiree Formation (?) is 10 to 15 m. Fig. 7 depicts the contact line between sediments of the Lower and Upper Cretaceous.

Paleontological findings and age determination for the sediments in the Ergel-Khaliv area

A/. Plants (Appendix 1. Figs. 1-10 in Plate I). It was assumed that the findings of the mega flora revealed in the section were largely determined by the exposed species: ginkgoaleans and conifers at the peak of their development. And also, there were occurred few remainders of

bamboo and Cycadales, and many more seeds. In summary, there were observed from the lower part of the section Lower Cretaceous Barremian-Aptian plants like as *Sphenobaiera* cf. *longifolia* (Pomel) Florin, *Sphenobaiera* sp., *Pityophyllum* sp. and from upper part of the section plants of species such as *Acrostichopteris* cf. *vachrameevii* E. Lebedev, *Brachyphyllum* sp., *Nillsonia* sp., *Podozamites* cf. *eichwaldii* (?) Heer, *Podozamites* sp., *Swedenborgia* sp., *Ixostrobus* sp. (Durante et al., 2009; Vahrameev, 1990; Krassilov, 1982). It should be noted that the species *Acrostichopteris vachrameevii* (Lebedev, 1974), which refers to the Lower Albanian period, was not very abundant in Mongolia. The lower part (Fig. 3)

of the section composed of siltstone-clayey layers contain petrified tree trunks up to 1.75 m in size and allochthonous tree fragments of different sizes (Fig. 8).

B/. Mollusca-conchs are (Appendix 2. Figs. 1-9 in Plate II) well-preserved and in Mid coal-bearing package, which have the richest fossils (Fig. 9), as mentioned above, in siltstone and mudstone layers, belonging to the genus and species of gastropods mainly *Viviparus robustus* Martinson, *Campeloma yihsiensis* Grabau, *C. mongolica* Martinson, *Lioplax* sp. and two-shelled gastropods like as an *Unio pygmaeiformis* Martinson (Martinson, 1961; Barsbold, 1972; Martinson and Shuvalov, 1973).



Fig. 8. View of petrified wood with a diameter of 1.75 m from the bottom of the lower sediment package (Scale for wood: 1:0.25)



Fig. 9. View of mollusca-bearing siltstone and mudstone beds (hammer for scale) outcrops located in the upper part of coal-bearing sediment package (scale for molluscs 1:2)

The identified molluscs (gastropod and bivalves) groups were mostly widespread in the mid and late time periods of Lower Cretaceous.

C/. Fishes are (Appendix 2. Figs. 10-12 in Plate II) found from continental sediments that had been accumulated during the Lower Cretaceous period on the territory of Mongolia. The period was sometimes referred to as the 'Lacustrine basin phase' (Berkey and Morris, 1927). In this regard, ancient species of the *Lycoptera* genus, which are widespread in the Early the Cretaceous sediments are found in most of East Asia, such as Mongolia, China, and

Trans-Baikal (Svichenskaya, 1954; Sychevskaya, 2004). There are found a few fossils of spine bones of the above mentioned *Peipiaosteus*-type fish from upper-mid layers of lower package belonging to the Ergel-Khaliv section. Also, there were revealed well preserved few spinal chords of *Lycoptera*-type fish in core of drill hole No. ZK-0001, from depth at the same level with the above mentioned stratum (Fig. 10). And this type of *Lycoptera* could not be determined at the species level due to their storage. Basically, these kinds of fishes were widely distributed in the Early Cretaceous lacustrine basins.



Fig. 10. View of drill core showing dark gray fish chord-bearing mudstone from the mid of sediment package on the northwestern limb of the Ergel-Khaliv section. Scale: 1:1

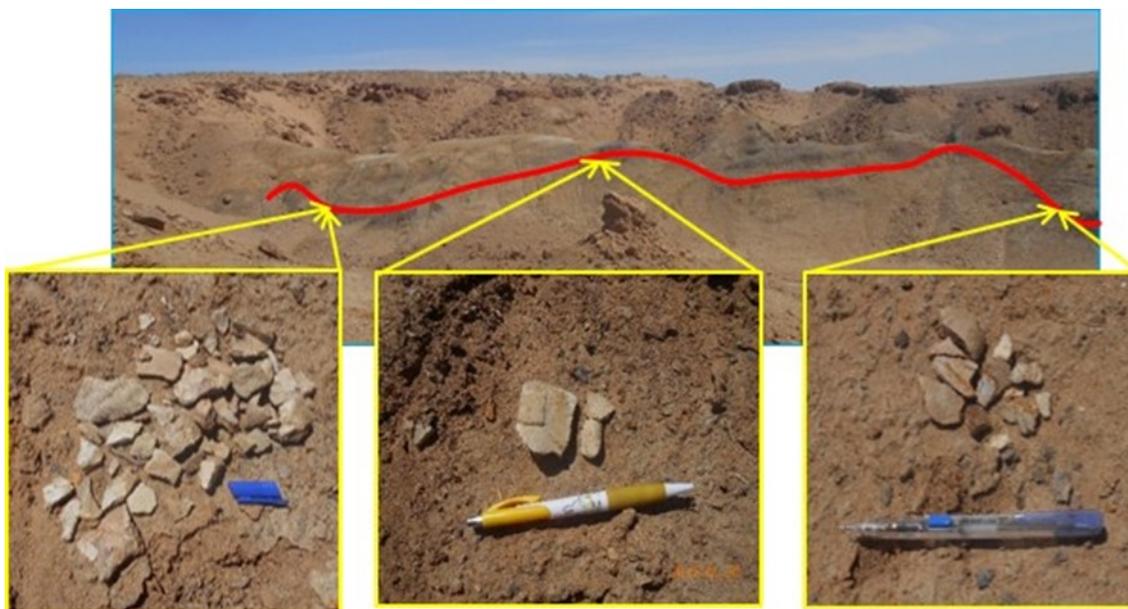


Fig. 11. Location of turtle fossils, Northwestern part of the Ergel-Khaliv section

D/. Turtles (Appendix 2. Fig. 13 in Plate II) are preserved in sediments of Neogene to Jurassic age in Mongolia. During previous research turtles were discovered and described as two small and medium sized genus and two species. The *Hangaiemys leptis* Sukhanov emend Narmandakh, species found in our study were relatively widespread during the Early Cretaceous period (Sukhanov and Narmandakh, 2006). The following figure shows the middle

part of the section, where the turtle fragments were discovered (Fig. 11).

E/. Dinosaurs are (Appendix 2. Figs. 14-17 in Plate II) as a result of the study, we represented that some findings that can be belonged to the species that had existed for the Early Cretaceous or Mid package of the Lower Cretaceous and those findings depends on the upper layers of coal-bearing mid package sediments of the Lower Cretaceous. The location, where few



Fig. 12. Location, where some fossilized fragments of dinosaur are revealed

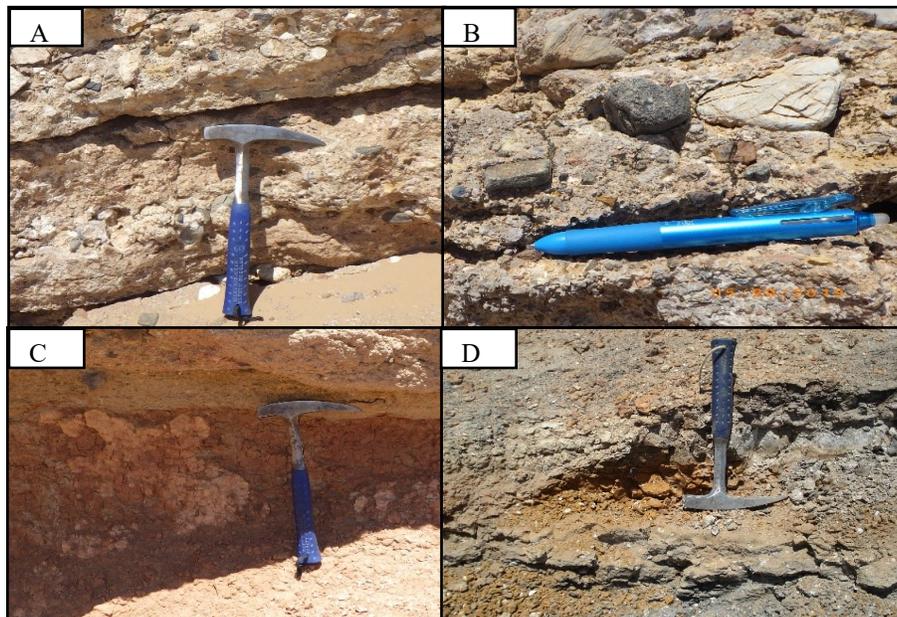


Fig. 13. A and B -shows pebble size conglomerate; C - view of red colored clay beds; D -shows gray, dark gray and yellowish gray massive clay bed

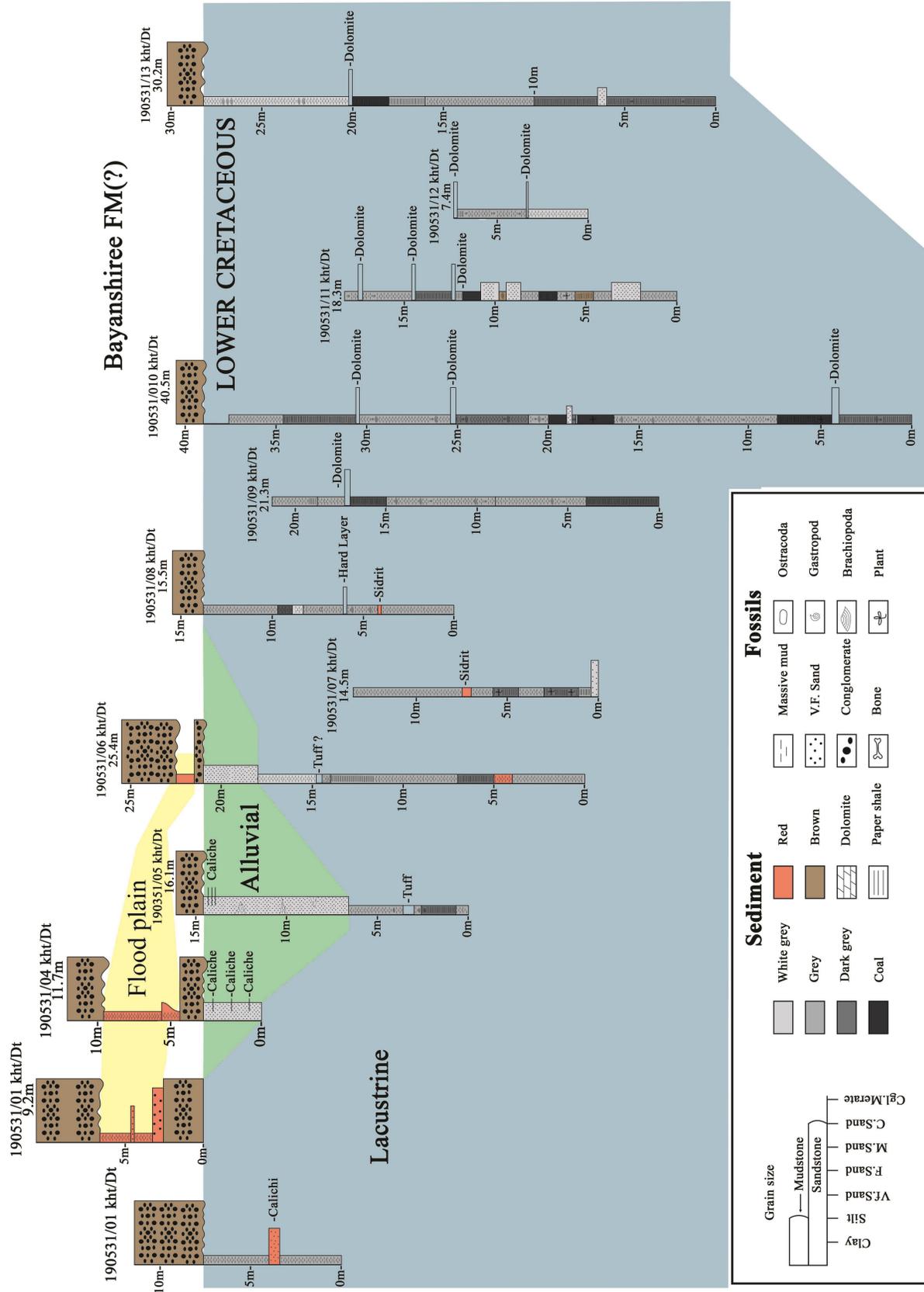


Fig. 14. Sedimentological sections across key outcrops of the Ergel-Khaliv's Lower Cretaceous sediments.

fossil fragments are revealed from the sediments that could be belonged to dinosaur species of *Psittacosaurus* (Osborn, 1924) and other carnivores are shown on the map, see Fig. 12. Unfortunately the fossils could not be determined at the genus level due to poor preservation.

F/. Ostracods are (Appendix 2. Figs 18-20 in Plate II) abandoned in the coal-bearing sediment package of mid package of the section. And the researchers have determined that these fossils belong to *Cypridea copulenta* Lubimova, *Limnocypridea grammi* Lubimova and *Lycocypris infantilis* Lubimova indicating they belong to the mid to late part of the Lower Cretaceous Barremian stage.

DISCUSSION

Sediment accumulation and Paleoenvironment: The Lower Cretaceous sediments of the section are lithologically composed of mainly clay, fine-grained siltstone and rarely conglomerate layers (Fig. 13).

The study area had been represented by continental, freshwater lacustrine basin during the most time of the Early Cretaceous, which was evidenced by number of fossils such as molluscs, ostracods, fish and turtles. And it could be considered that the plant cover that spread throughout the shores of the lake had been moved and accumulated forming coal seams during the sediment accumulation. The Fig. 14 shows the partial sections of sedimentology. The external morphology and color differences of the two types of conchs and snails, especially gastropod snails, which are the major findings of paleontology, are evidencing sometimes happened sharp temperature changes. The *Hangaiemys leptis* turtle is medium in size and is believed to point to a fresh, gentle and stable aquatic environment. Also, one of the criteria for a freshwater environment was evidenced by fish fossils.

CONCLUSION

The main result of the study was the findings and the age determination for many classes and groups of animals and plant fossils from the Ergel-Khaliv area. They had been existing,

spreading there for quite a long geological time, during the Lower Cretaceous, Barriamian-Lower Aptian stages. This may indicate the need for further review of the summaries determining the Lower Cretaceous sediments of the site, into Aptian-Albian sediments of the Khukhteeg Formation. Also, the sediments contain fossils such as molluscs, fish, amphibians (turtle) and continental leaf plants, which are important for the paleo-ecosystem studies evidencing of their accumulation on lake shores. And this circumstance will be background for further studies. Many of the results are being the preliminary determination of the paleoenvironmental conditions during the sediment accumulation. One of the data from the research suggests that there is a possibility for further studies on paleosoil, here. In addition, the section is considered as an important object of comparative biostatigraphy of the Lower Cretaceous coal-bearing sediments in Mongolia. The Ergel-Khaliv (or Dun-ovoo) section may be the subject of further research, possibly affecting the boundaries of the Lower and Upper periods of the Cretaceous.

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Appendix 1.



Plate I. Figs 1-10: 1-*Acrostichopteris* cf. *vachrameevii* E. Lebedev, Lower Cretaceous, Lower Albian; 2-*Sphenobaiera* cf. *longifolia* (Pomel) Florin, Lower Cretaceous, Barriaman-Aptian; 3 and 4: *Sphenobaiera* sp.; 5-*Podozamites* sp.; 6-*Podozamites* cf. *eichwaldii* (?) Heer, Middle Jurassic-Lower Cretaceous, Barriaman; 7-*Swedenborgia* sp., Lower Cretaceous; 8-*Brachyphyllum* sp., Lower Cretaceous; 9 and 10: *Ixostrobus* sp., Middle Jurassic-Lower Cretaceous.

Appendix 2.

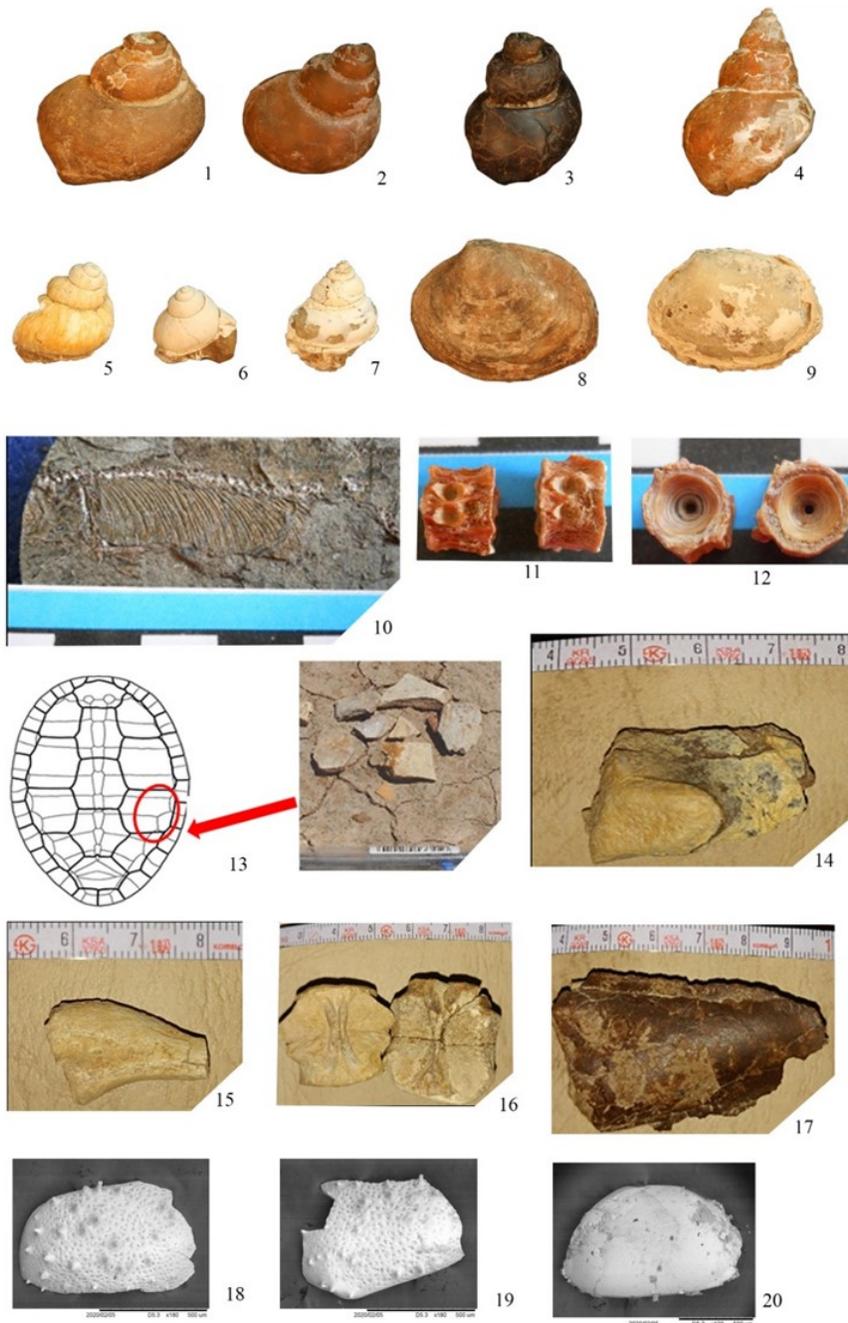


Plate II. Figs. 1-20. 1-3: *Viviparus robustus* Martinson, Lower Cretaceous, Barremian; 4-*Campeloma yihsiensis* Grabau, Lower Cretaceous, Barremian; 5 and 6: *C. mongolica* Martinson, Lower Cretaceous, Barremian-Aptan; 7: *Lioplax* sp.; 8 and 9: *Unio pygmaeiformis* Martinson, Lower Cretaceous, Barremian; 10-*Lycoptera* sp., Lower Cretaceous; 11 and 12: *Peipiaosteus* sp., Lower Cretaceous; 13: *Hangaemys leptis* Sukhanov emend Narmandakh, Lower Cretaceous; 14, 17: Dinosaur bone fossil-15 and 16: *Psittacosaurus* sp., Lower Cretaceous, Aptian-Albian (?); 18-20- Ostracods: 18-*Cypridea copulenta* Lubimova; 19-*Limnocypridea grammi*, Lubimova; and 20- *Lycopteroocypris infantilis* Lubimova, Lower Cretaceous, Barremian.