Эрдэм шинжилгээний өгүүлэл

Lower Cretaceous Ostracods from the Undurbogd Region (Southern Mongolia): Implications for Biostratigraphy and Paleoenvironments

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Abstract

This study presents new findings on ostracod assemblages from the Lower Cretaceous deposits in the area surrounding Undurbogd mountain, southern Mongolia. Three species of the genus *Cypridea* — *C. copulenta*, *C. trita* Lubimova, 1956, and C. unicostata Galeeva, 1955— were identified from lacustrine sediments in the study area. In Biostratigraphy, the *Cypridea* assemblage indicates a Lower Cretaceous age for the sediments and correlates well with ostracod-based stratigraphic frameworks of other lacustrine successions in East Asia.

Morphological analysis reveals characteristic features common to *Cypridea* species, such as a rostrum, ventral rib, and distinct surface ornamentation including reticulation and spines. These features suggest adaptive responses to variations in salinity and hydrological conditions during deposition. Our study was indefined of *C. copulenta*, *C. trita*, and *C. unicostata* three species in Undurbogd area.

1. Introduction

Cretaceous deposits are widely distributed in the southern, southeastern, and south-central regions of Mongolia, whereas their occurrences in the Great Lakes Depression are relatively limited and poorly documented (Ariunchimeg et al., 2024). Lacustrine oil shales of Cretaceous age are extensively developed within the rift basins along the eastern and southeastern parts of Mongolia, adjacent to the Chinese border. These sedimentary successions represent an important component of the petroleum systems of East Asia (Yang et al., 1985; Graham et al., 2001; Johnson et al., 2003; Hasegawa et al., 2018).

Cretaceous deposits of Mongolia are known to yield abundant paleontological remains, including mollusks, ostracods, conchostracans, fishes, and charophytes (Martinson, 1973).

These fossils have been recovered from fine-grained sedimentary rocks, mainly claystone, silty claystone, and thinly laminated siltstone, which represent low-energy lacustrine deposits of the Shinekhudag Formation.

The Shinekhudag Formation conformably overlies the Lower Cretaceous Tsagaantsav Formation and is unconformably overlain by the Lower Cretaceous Khukhteeg Formation, with a total thickness of approximately 230–250 m.

Fossil assemblages from the Shinekhudag Formation include four species of *Lymnocyrena* (Mollusca), three species of *Cypridea*, two species of *Darwinula*, one species of *Rhinocypris* (Ostracoda), ten species of charophytes belonging to five genera, and the fish *Lycoptera fragilis* (Khand, 2011). Ostracods are small crustaceans belonging to the class Ostracoda within the subphylum Crustacea, characterized by a bivalved calcareous carapace. They inhabit a wide range of aquatic environments, including marine, brackish, and freshwater systems. Owing to their

abundance, morphological diversity, rapid evolutionary rates, and sensitivity to environmental changes, ostracods are of significant palaeoecological and biostratigraphic importance (Horne, 2009; Wang et al., 2015; Choi et al., 2021;(Wang & Zhong, 2022). More recent studies on ostracod taxonomy and palaeoenvironmental reconstruction have identified four species of *Cypridea*, along with one species each of *Yumenia*, *Scabriculocypris*, *Trapezoidella*, and *Candona*, and a newly described ostracod species *Vlakomia ulanense* from the Lower Cretaceous Shinekhudag Formation, contributing to the reconstruction of palaeoenvironmental conditions (Choi & Wang, 2023).

The aim of this study is to document the taxonomic composition of ostracods from the Lower Cretaceous lacustrine deposits around Mount Undurbogd in southern Mongolia.

The specific objectives are:

(1) to describe and illustrate the ostracod species preserved in the collected samples;

(2) to compare these taxa with previously known Early Cretaceous ostracod assemblages from Mongolia and neighboring regions;

(3) to evaluate their paleoenvironmental and biostratigraphic implications.

2. Geological background

The study area is located approximately 10 km northern of Undurbogd mountain in Bayn-Ovoo sum, Umnugobi province, southern Mongolia (N 42°02'35", E 105°54'12.1") (Figure 1). The type section of the Shinekhudag Formation is situated in the Undurbogd area (Khand, 1995). Lithologically, the Shinekhudag Formation consists mainly of dark gray to bituminous (papery) shales interbedded with gray limestone, marl, greenish-gray to dark-gray argillite, and clayey–carbonate shales. The total thickness of the formation in the study area is about 300 m.

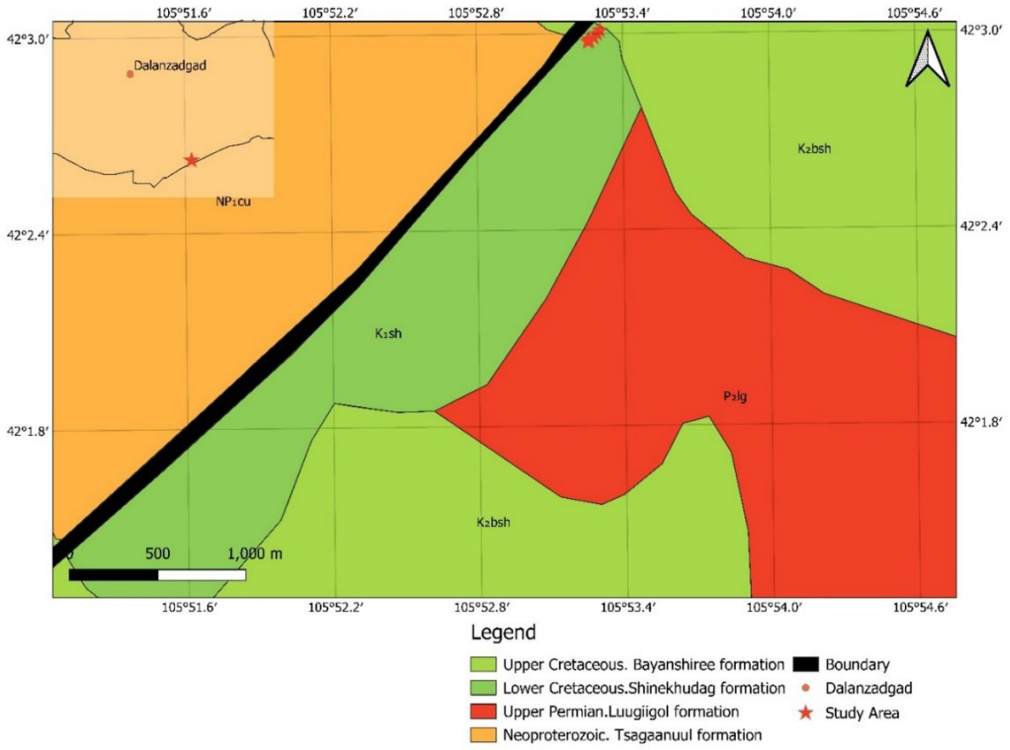

Figure 1. Geological map of the Undur Bogd area

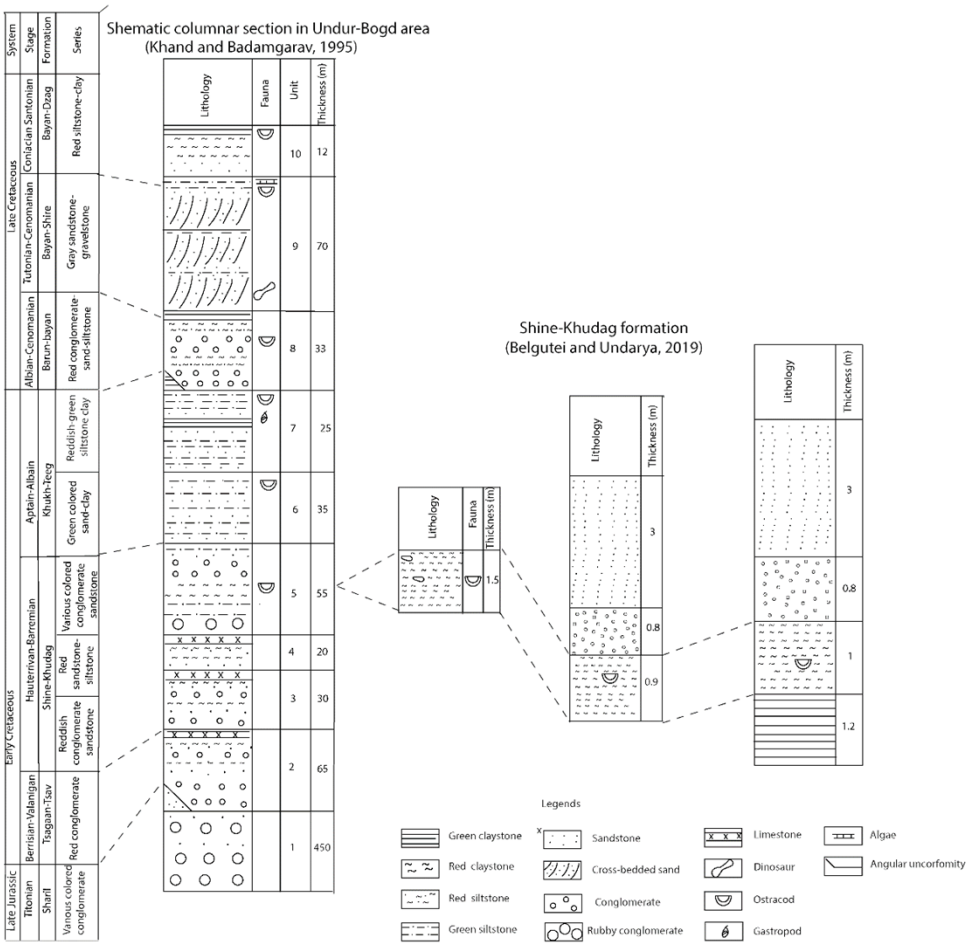

Figure 2. Correlation of the sections

3. Methods and Materials

Ostracod specimens analyzed in this study were collected from reddish-yellow silty claystone and clay layers of the Shinekhudag Formation during field investigations. In the field, eight partial stratigraphic sections were measured and described around the locality where ostracods were discovered. Field documentation included detailed lithologic descriptions, photographic records, and GPS coordinates for each measured section.

Sediment samples collected from six measured stratigraphic sections were processed to extract ostracod fossils. Bulk samples (200–500 g) were soaked in water for 24 h to allow disaggregation, then gently washed through a 250 μm mesh sieve to avoid damaging ostracod valves. Residues were dried at low temperature and examined under a binocular microscope. Microfossils were picked, sorted, and labeled according to their taxonomic groups.

Approximately 200 well-preserved ostracod valves were recovered, of which 100 specimens were selected for detailed taxonomic study based on preservation quality. The selected specimens were examined using a scanning electron microscope (SEM) at magnifications of 250–500 μm at the Joint Lab-

oratory for Paleontological Research, Mongolian University of Science and Technology, and Nagoya University (Japan).

Morphological descriptions, including external ornamentation, were recorded following the taxonomic methodology of (Sames.,2011). Muscle scar patterns were not clearly observable in the selected specimens and therefore were not included in the taxonomic analysis. Taxonomic identifications were made by comparison with published descriptions of relevant *Cypridea* species.

A composite stratigraphic column of the Shinekhudag Formation was constructed based on previous studies (Khand, 1995) and the eight field sections measured during this study, using Adobe Illustrator (Figure 2). Photographic plates illustrating ostracod morphology and surface ornamentation were prepared using CorelDRAW software.

The higher-level classification adopted in this study follows the system proposed by Morkhoven (1962), with subsequent revisions for non-marine ostracods (Hou et al., 2002; Sames, 2011). Family- and genus-level taxonomy follows the concepts established in earlier studies (Szczechura, 1978; Galeeva, 1955), as well as later works dealing with Cretaceous representatives of *Cypridea* (Sames, 2011).

Systematic Paleontology

Class Ostracoda Latreille, 1802

Order Podocopida Sars, 1866

Suborder Cypridocopina Baird, 1845

Superfamily Cypridoidea Baird, 1845

Family Cyprideidae Martin, 1940

Genus Cypridea Bosquet, 1852

Cypridea copulenta Lubimova, 1956

Plate I, fig.1-6

Cypridea copulenta Lubimova, 1956, p.81, pl. 17, figs 3a, 6.

Holotype. VNIGRI collection No. 271-13; Mongolian People's Republic (MPR), Tsagaan Region; Upper Cretaceous, Sainshand Formation.

Diagnosis. Carapace medium to large in size (1.24 mm long, 0.73 mm high, 0.64 mm wide), with the greatest height situated anteriorly near the rostral area. The right valve exceeds the left in size and overlaps it along the entire margin. The anterior end is elevated and bears a distinct, well-developed rostrum, while the posterior end is smoothly rounded. The dorsal margin is nearly straight, and the ventral margin is slightly concave at mid-length. The external surface

Description. Carapace large, elongate, and irregularly ovate, with maximum height anteriorly and greatest thickness at mid-length (occasionally slightly posterior). The right valve markedly overlaps the left, producing a rounded outline except at the posteroventral angle, where a small, smooth, triangular plate-like projection is developed. The anterior end is high, slopes posteriorly, is ventrally rounded, and terminates in a well-developed rostral prominence. The posterior end is lower and rounded—uniformly rounded in the left valve, more oblique in the right—with a weak triangular platform in its lower part. The dorsal margin is straight, slightly inclined posteriorly, and situated within a shallow depression formed by the somewhat elevated dorsal parts of the valves. The ventral margin is straight or slightly concave medially; a faint, low rib extends along the ventral side of the right valve.

Measurements (mm). UB201909-10, Sample-10 UB-201909-02, UB-201909-03, UB-201909-04,

length 1.21–1.34; anterior height 0.73–0.83; posterior height 0.64–0.73; maximum thickness 0.54–0.64.

Remarks. Variation is expressed in the degree of development of reticulation and spines on the valve surface, in the size of the posteroventral triangular platform, and in the prominence of the rostral process. Minor variation also occurs in the height of the anterior end.

Comparison. *Cypridea copulenta* resembles *C.unicocosta* from the Dzunbayan Formation Mongolia in possessing a ventral rib on the right valve, but it differs in lacking a well-developed rib on the

left valve, in having weaker conical spines, and in lacking a distinct triangular platform in the posteroventral corner. It further differs from *C. coronata* G.A. (Dzunbayan Formation, Mongolia) in the absence of stellate coronas at the spine tips and in lacking a dorsal rib on the right valve. Although the absence of a dorsal rib agrees with the comparison provided by Lubimova 1956, this character may be partially affected by the preservation quality of the specimens.

Geographic distribution and stratigraphic range. Mongolia, Southern Gobi, Upper Cretaceous, Sainshand Formation.

Material. Twenty-eight well-preserved open carapaces of *Cypridea copulenta* were studied. Only adult individuals (both males and females) were encountered; juvenile forms are absent.

Cypridea trita Lubimova, 1956

Plate I, fig. 7-12.

1956 *Cypridea trita* Lubimova, p. 29, pl. 6, figs. 1a–b.

1979 *Cypridea trita*, Geology, p. 254, fig. 6.

1982c *Cypridea trita*, Paleontology, 62, figs. 6, 7.

1956. *Cypridea trita* Lubimova — *Trudy Inst. Geol.* AN SSSR, ser. 65, p. 76, pl. IV, fig. 18.

1978. *Cypridea trita* Lubimova — Szczechura, *Acta Palaeontologica Polonica*, vol. 23, no. 1, p. 95, pl. 13, figs 1a–b.

Holotype. VNIGRI collection No. 738-7; Mongolian People's Republic (MPR), Southern Gobi; Lower Cretaceous, Tsagaantsav Formation.

Diagnosis. Carapace subcircular to subovate in outline, attaining its greatest height near the anterodorsally margin. The left valve is slightly larger than the right and overlaps it along the free margin. The anterior end bears a well-defined rostrum, whereas the posterior end is broadly rounded. The dorsal margin is straight, and the ventral margin is gently concave medially. The external surface displays a distinct polygonal reticulation pattern composed of 4–5-sided meshes, each bearing minute spinose projections. Fine pore canals are developed along both the anterior and posterior margins. Average valve dimensions are approximately 0.99 mm in length, 0.57 mm in height, and 0.38 mm in width.

Description. Carapace elongate, irregularly ovate, with maximum height in the anterior third and greatest convexity at mid-length. The left valve overlaps and completely embraces the right valve. The anterior end is high and rounded, slightly sloping dorsally, and bears a modest rostral projection ventrally. The posterior end is distinctly lower, smoothly arched; in some specimens, the upper posterior portion shows a weak slope. The dorsal margin is straight, slightly inclined posteriorly, and merges smoothly with the rounded anterior and posterior margins. The ventral margin is straight to faintly concave. Valve surface covered with fine quadrangular reticulation; meshes small and uniform. Sparse, low tubercles are observed near the anterior and posterior extremities. The pore-canal zone is narrow and best developed at the anterior and posterior ends.

Measurements (mm). UB-201909-01, UB-201909-02, UB-201909-03, UB-201909-04, length 1.21–1.34; anterior height 0.73–0.83; posterior height 0.64–0.73; maximum thickness 0.54–0.64.

Holotype: length 1.02; height (anterior) 0.54; height (posterior) 0.41; maximum thickness 0.38. In additional specimens, length varies 0.99–1.05; anterior height 0.54–0.57; thickness 0.38–0.42.

Remarks. The degree of reticulation development and the inclination of the anterior and posterior slopes vary slightly among specimens.

Comparison. In general morphology and surface sculpture, *Cypridea cf. trita* resembles *C. simplex* Gal. from the Dzunbayan Formation (Dzunbayan and Baynshiree areas, Mongolia), *C. unicostata* Gal. from the Dzunbayan Formation, *C. pria sp.* nov. from the Tsagaantsav Formation (Southern Gobi), and *C. profusa* sp. nov. from the Sainshand Formation (Kharganat area). Distinctions from these taxa are discussed in the respective species descriptions.

Geographic distribution and stratigraphic range. Mongolia, Southern Gobi; Lower Cretaceous, Tsagaantsav Formation.

Material. Approximately 30 specimens, including a limited number of closed carapaces and disarticulat-

ed valves, mostly well preserved, were studied.

Cypridea unicostata Galeeva, 1956

Plate I, fig.13-18.

1955. *Cypridea unicostata* — Galeeva, p. 34, pl. 4, figs a–g.

1974. *Cypridea unicostata* — Hao Yichun et al., p. 34, pl. 9, figs 1a–g.

1980. *Cypridea (Cypridea) cf. unicostata* — Ye Chunming, p. 184, pl. 2, fig. 23.

1981. *Cypridea (Cypridea) aff. unicostata* — Zhao Xide, p. 70, pl. 1, fig. 7.

1984. *Cypridea unicostata* — Li Youzhu & Zhao Xinyu, p. 191, pl. 2, figs 7–10.

1985b. *Cypridea (Cypridea) unicostata* — Zhang Xijun, p. 148, pl. 1, fig. 6.

1985a. *Cypridea (Cypridea) unicostata* — Zhang Xijun, p. 83, pl. 10, figs 7a–c.

1985. *Cypridea (Cypridea) unicostata* — Wang Dexian et al., p. 154, pl. 4, figs 4–6.

1985. *Cypridea unicostata* — Yang Youquan, p. 217, pl. 3, fig. 11.

1985. *Cypridea unicostata* — Shou Shoucheng, p. 571, pl. 2, fig. 8.

Holotype. Specimen No. 200-16, VNIGRI collection; Mongolia (MPR), Dzunbayan soum; Lower Cretaceous, Dzunbayan Formation.

Paratype (original material). Specimen No. 738-37, VNIGRI collection; Mongolia (MPR), Ilgis Depression, Lower Cretaceous, Dzunbayan Formation,

Diagnosis. Galeeva: Carapace subovate, elongate, with the greatest height situated anteriorly. The dorsal margin is straight to slightly arched, whereas the ventral margin is nearly straight. The external surface is characterized by distinct quadrangular reticulation. The left valve bears a faint longitudinal rib along the ventral margin, which is absent in the right valve. The posterior end is ornamented with small spinose tubercles, while the anterior end terminates in a short, well-defined rostrum. Straight pore canals occur along the ventral and posterior margins. Valve dimensions: 1.06 mm in length, 0.67 mm in height, and 0.48 mm in width.

Description. Carapace elongate, asymmetrically ovate, with maximum height anteriorly and greatest width posteriorly. Left valve slightly larger, overlapping the right tightly. The anterior end is high and broad, dorsally rounded; the posterior end is narrower, lower, and evenly rounded distally. Ventral margin straight, slightly expanded anteriorly and posteriorly. Dorsal margin nearly straight, gently arched toward both ends. The posterior surface exhibits a shallow external depression. The dorsal region displays moderately developed, quadrangular reticulation. Anterior and posterior areas bear small tubercles or short spines, sparsely distributed; in some specimens, spines are poorly developed. A narrow, low longitudinal rib extends along the ventral margin of the left valve, absent in the right. The vestibular zone is well developed, with thin, linear canals clearly visible at both anterior and posterior ends.

Comparison. By carapace shape and ornamentation, *Cypridea unicostata* resembles *C. copulenta* and *C. spinigera* but differs in having more distinct spines in the anterior and posterior regions. It is distinguished from *C. trita* by the presence of a strong anterior depression and a well-developed longitudinal rib along the ventral margin of the left valve. The species also resembles *C. dunkeri* J. (Jones, 1885) from the Upper Cretaceous of England, but differs in possessing a taller carapace, a less straight dorsal margin, and weaker reticulation. From *C. prava* described from the Dzunbayan Formation of South Gobi, *C. unicostata* differs in its weaker reticulation, more prominent dorsal margin, a distinct posterior depression, and the presence of a longitudinal rib on the left valve.

Geographic distribution and stratigraphic range. Mongolia (MPR) —Dzunbayan, Sainshand, Tugurigi, and Kherlen districts; Lower Cretaceous, Dzunbayan Formation

Material. Approximately 30 specimens, well-preserved complete carapaces and disarticulated valves.

Measurements (mm). Length 0.86–0.96; height 0.52–0.58; width 0.37–0.43.

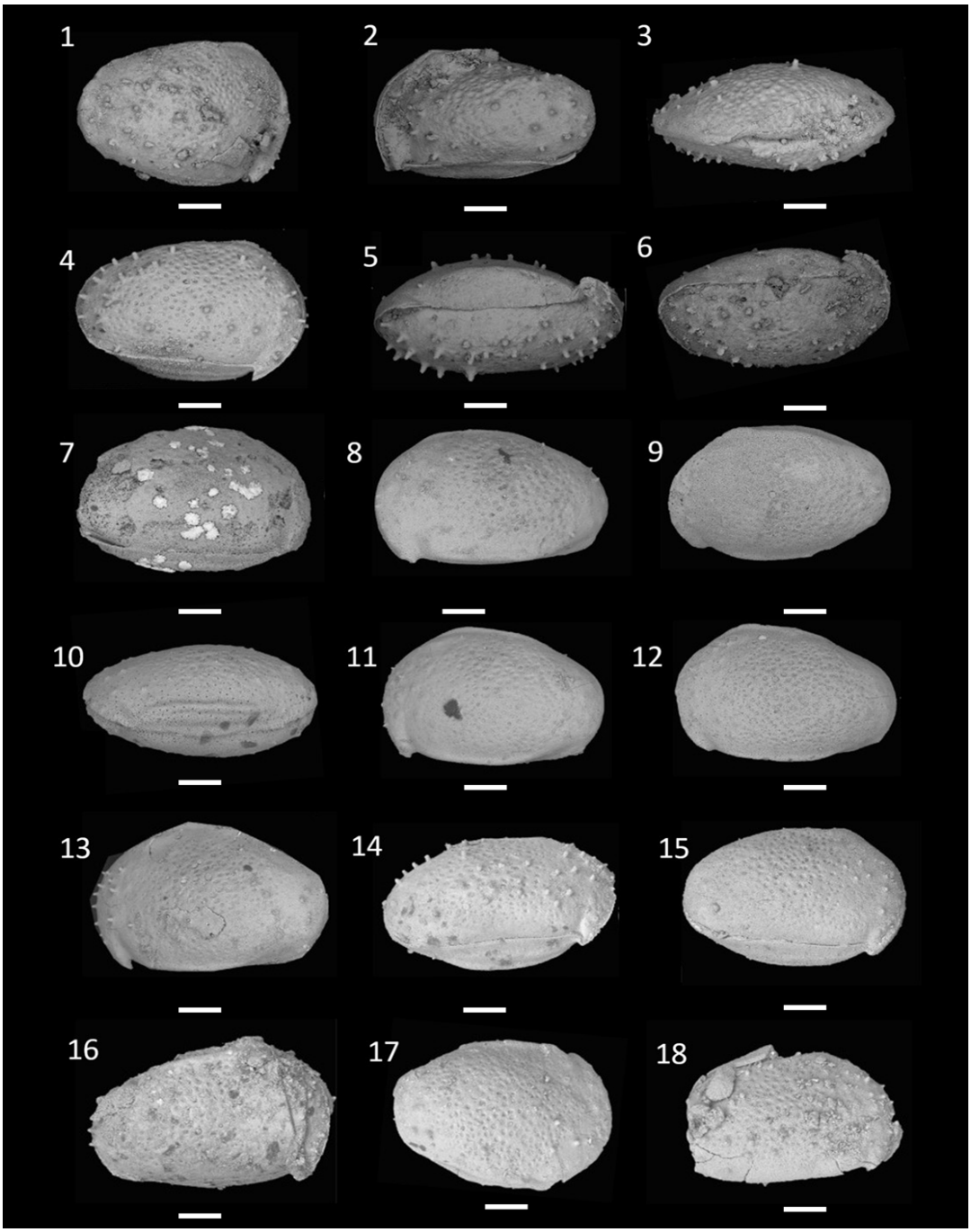

Plate I. Cypridea copulenta Lubimova, 1956. (1-6) Adult carapace, Geological cross section 6, Sample 12: (1), (4) Right view of carapace, (2) Left view of carapace, (3) Ventral view (anterior end to the left), (5), (6) Dorsal view (anterior end to the left) Cypridea trita Lubimova, 1956. (7-12) Left view of carapace, Geological cross section 7, Sample 10, (10) ventral view (anterior end to the left). Cypridea unicostata Galeeva, 1956. (13) Right view of carapace (14-18) Left view of carapace, Geological cross section 8, Sample 14. Scale bars = 250-500 μm.

4. Results

Representatives of the family Cyprideidae are known from Europe, Asia, Africa, North and South America, and Mongolia, and they range from the Middle Jurassic to the Late Cretaceous. (Neustrueva et al., 2005). The genus *Cypridea* is a widely distributed non-marine ostracod group that occurs in lacustrine deposits ranging in age from the Late Jurassic to the Eocene, with its greatest abundance and diversity during the Early Cretaceous (Coimbra, 2020).

In neighboring regions, numerous *Cypridea* species have been reported from Upper Jurassic to Lower Cretaceous strata of Russia, including the Turgino–Kharanor Basin, Turga River area, Western and Eastern Urulyungev Basins, Vasilievsky Khutor, Southern Argun Basin, Tseren, Tungus Torum, Garda, Elizavetinskaya Basin, and Semen localities, as well as from the Onon Basin, Mangut, Ulkhun-Partiya, and Narasun (Sinitsa, 2018).

In China, only *Cypridea unicostata* has been described from the Hauterivian–Barremian deposits of several formations, including the Jiufotang, Saihantala, Xiguayuan, Guantou, Fengtai, Dahuichang, Lianmuqin, and Lizitou formations (Yang et al., 1985;Gou et al., 1986;Hou, 2002). Additionally, *C. trita* has been reported from Lower Cretaceous strata of the Jirim area in Inner Mongolia, and *C. copulenta* from the Alxa Gobi region of Inner Mongolia (Hou, 2002)

In Mongolia, *C. copulenta* was first described from the Cenomanian-aged Sainshand Formation of the Upper Cretaceous, and *C. trita* from the Valanginian–Barremian-aged Tsagaantsav Formation (Lubimova, 1956). Meanwhile, *C. unicostata* was identified from the Goterivian–Barremian Dzuunbayan Formation (Galeeva, 1955). Subsequent studies (Scoblo, 1980) have examined ostracod assemblages from the Lower, Middle, and Upper Cretaceous successions specifically from the Tsagaantsav, Shinekhudag, and Khukhteeg formations,

Our present study confirms the occurrence of *C. copulenta*, *C. trita* ., and *C. unicostata* from the Shinekhudag Formation in the Undurbogd area, southern Mongolia. The assemblage composition and morphological features of the specimens show strong correlation with those of coeval Early Cretaceous ostracod faunas reported from neighboring regions of East Asia. This biostratigraphic consistency suggests that the sedimentary sequence around Undurbogd mountain was deposited during the Barremian-lower Aptian part of the Shinekhudag formation.

5. Discussion

Stable isotope analyses of ostracod shells from the Hilse Basin in northern Germany have demonstrated that fluctuations in water level directly influence salinity: salinity increases with rising water levels and decreases when water levels fall (Arp & Mennerich, 2008). Previous studies have shown that the genus *Cypridea* inhabited non-marine, mainly freshwater to slightly brackish lacustrine environments (Horne, 1995, 2002;Sames, 2011). Moreover, *Cypridea* is known to have produced desiccation-resistant eggs, an adaptation allowing survival through dry periods and water-level fluctuations (Horne, 2002; Horne & Martens, 1998). Such physiological adaptations indicate that *Cypridea* species were well suited to ephemeral or seasonally variable aquatic habitats, typical of semi-arid climates.

Investigations of Lower Cretaceous ostracod assemblages from northern, central, and southern Lebanon revealed that smooth- and ornamented-shelled *Cypridea* species are the most common taxa. These species were mostly preserved within organic-rich, fine-grained sediments, suggesting deposition under low-oxygen conditions; however, their biology implies they could not have lived in strongly reducing, anoxic bottom waters. Therefore, it is inferred that they inhabited oxygenated, shallow marginal lake environments or the upper, better-oxygenated water layers of lacustrine systems (Hajj, 2021)

In the nearby Yixian Formation of China, Cypridea occurrences differ between two depositional intervals. The Jianshangou Member, representing a permanent lake environment, contains *Cypridea* together with *Darwinula leguminella* and *Metacypris jianshangouensis*, both species characterized by brood pouches that suggest adaptation to stable aquatic

conditions. In contrast, the overlying Jingangshan Member is dominated by two *Cypridea* species, while members of the Darwinuloidea and Cytheroidea superfamilies are absent, indicating deposition in ephemeral, short-lived water bodies (Wang et al., 2013). Similarly, in the eastern Oshikh Valley area of Mongolia, ostracod assemblages from the Shinekhudag Formation include *Cypridea*, implying temporary, seasonally developed lacustrine settings (Choi & Wang, 2023).

In the present study, three *Cypridea* species *C. copulenta*, *C. trita*, and *C. unicostata* were identified from lacustrine deposits of the Lower Cretaceous Shinekhudag Formation in the Undurbogd area, southern Mongolia. Comparison with previous studies provides important insights into the palaeoenvironmental conditions of this basin.

Cypridea copulenta, originally described from the Cenomanian-aged Sainshand Formation (Lubimova, 1956), is indicative of a stable, weakly brackish lacustrine environment. Its smooth, thick walled carapace suggests deposition under relatively constant physical and chemical conditions with low environmental stress and stable salinity.

Cypridea trita, first reported from the Valanginian–Barremian Tsagaantsav Formation (Galeeva, 1955), inhabited transitional lacustrine – deltaic settings. Its small size and thin-shelled morphology indicate adaptation to more variable hydrological conditions, possibly reflecting periodic fluctuations in water level and increased seasonality under semi-arid and warm climatic regimes.

Cypridea unicostata, identified from the Goterivian–Barremian Dzuunbayan Formation, represents shallow, freshwater lake environments with low salinity and high oxygen levels. Its distinctly costate ornamentation likely served as a morphological adaptation to such conditions (Yang et al., 1985; Hou, 2002). Collectively, the occurrence of these three *Cypridea* species in the Shinekhudag Formation suggests deposition in a fluctuating lacustrine environment during the Early Lower Cretaceous, under semi-arid climatic conditions characterized by variable water levels and periodic desiccation. The combined morphological and ecological evidence supports the interpretation of a dynamic paleo lake system influenced by climatic seasonality and episodic hydrological changes in southern Mongolia.

6. Conclusion

The present study documents three species of the genus *Cypridea* belongs to *C. copulenta*, *C. trita*, and *C. unicostata* from the Lower Cretaceous deposits in the Undurbogd area, southern Mongolia. Biostratigraphically, the occurrence of these species indicates that the sedimentary succession around Mount Undurbogd was deposited during the Barremian-lower Aptian part of the Shinekhudag formation. The identified *Cypridea* assemblage corresponds well with coeval ostracod faunas in other East Asian basins, further supporting this age interpretation.

Palaeoenvironmental analysis based on the morphological characteristics and ecological preferences of these species suggests that the Undurbogd lacustrine system developed under semi-arid and warm climatic conditions, characterized by fluctuating water levels and alternating wet and dry periods. Thus, the *Cypridea* assemblage from the Shinekhudag Formation reflects deposition in a dynamic, seasonally variable lacustrine environment during the Barremian-lower Aptian part of the Shinekhudag formation in southern Mongolia.

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