Doklady Earth Sciences, Vol. 389A, No. 3, 2003, pp. 317–321. Translated from Doklady Akademii Nauk, Vol. 389, No. 4, 2003, pp. 501–505.

GEOLOGY

Age of Phosphorites from the Khubsugul Basin (Mongolia)

Yu. E. Demidenko, E. A. Zhegallo, P. Yu. Parkhaev, and Yu. V. Shuvalova

Presented by Academician B.S. Sokolov October 30, 2002

Received November 27, 2002

The age of phosphorites from the Khubsugul Basin, which is now estimated to be the Late Vendian–Cambrian, has been debated in geological publications for a long time. New paleontological data provide, at last, reliable evidence favoring the Tommotian age of the Khesen productive formation.

Phosphorite-bearing sequences were discovered in the Lake Khubsugul area by Soviet geologists in the mid-1960s [1]. It appeared that the Khubsugul Basin represents one of the largest phosphorite basins of the world. The almost half-century-long study resulted in the establishment of its geological structure and detailed mapping, as well as stratigraphic subdivision and paleontological substantiation of sequences in the basin [2–8].

In the present-day tectonic structure of northern Mongolia, the Khubsugul Basin represents a synclinorium composed of Upper Riphean–Cambrian sequences. These sequences are represented by the thick Darkhat (probably Upper Riphean) and Khubsugul (Vendian–Lower Cambrian) terrigenous–carbonate groups. The latter group is overlain by the Lower Cambrian Ukhutologoi tuffaceous–terrigenous formation (Fig. 1). The Khubsugul Group consists of three (Ongolik, Khesen, and Erkhelnur) formations. The Khesen phosphorite-bearing formation includes lower carbonate (limestones and calcareous shales), middle productive (with several phosphorite levels), and upper carbonate (limestones and dolomites) members.

The sediments are relatively impoverished in organic remains. Therefore, the age of the Khesen Formation is mainly based on its position in the section taking into account the following facts: the underlying Ongolik Formation encloses the Yudomian microphytoliths [8], whereas the overlying Erkhelnur Formation has several levels with the Atdabanian trilobites and archaeocyatheans [2, 6, 8]. Microphytolith assemblages have been recorded [9] in all three members of the Khesen Formation (Fig. 1), whereas spherical zooproblematics and bacteria are registered only in its middle member [8]. Most of the forms discovered are known from the uppermost Precambrian–lowermost Cambrian sequences, but *Tasmanites* and *Osagia senta* are missing from the pre-Tommotian rocks [8]. Although no organic remains were previously known in the lower member of the Khesen Formation, its age was usually considered as Tommotian [8, 10, 11].

We studied samples from Borehole C-128 drilled at the watershed between the Kherbistuin-Gol and Ongolik-Gol rivers crossing the Khubsugul phosphorite deposit. The cores were obtained from the Khubsugul geological–prospecting team of V/O *Zarubezhgeologiya.*

The borehole penetrated the rock succession with an overturned attitude (Fig. 2): the Ongolik Formation (interval 0–138 m), member 1 of the Khesen Formation (138.0–321.0 m), member 2 of the Khesen Formation (321.0–451.4 m), and member 3 of the Khesen Formation (451.4–467.0 m). The sample from the lower part of member 1 (depth 198 m) yielded small shelly fossils: mollusks *Oelandiella korobkovi* Vost, hyoliths *?Doliutus* sp., hyolithelmintes *Hyolithellus* sp. and Hyolithellidae gen. et sp. indet., and *Chancelloria* sp. (Fig. 3). They are poorly preserved. Therefore, it is difficult to accomplish a more precise determination.

The reliable finds of *Oelandiella korobkovi* are known from the Tommotian rocks in the middle course of the Lena River [12] and Tommotian layers of western Mongolia [13]. This species occurs also in the *Purella antiqua* Zone, representing the uppermost unit of the Nemakit-Daldyn Horizon of the Siberian Platform [14].

Paleontological Institute, Russian Academy of Sciences, Profsoyuznaya ul. 123, Moscow, 117647 Russia; e-mail: juliad@paleo.ru

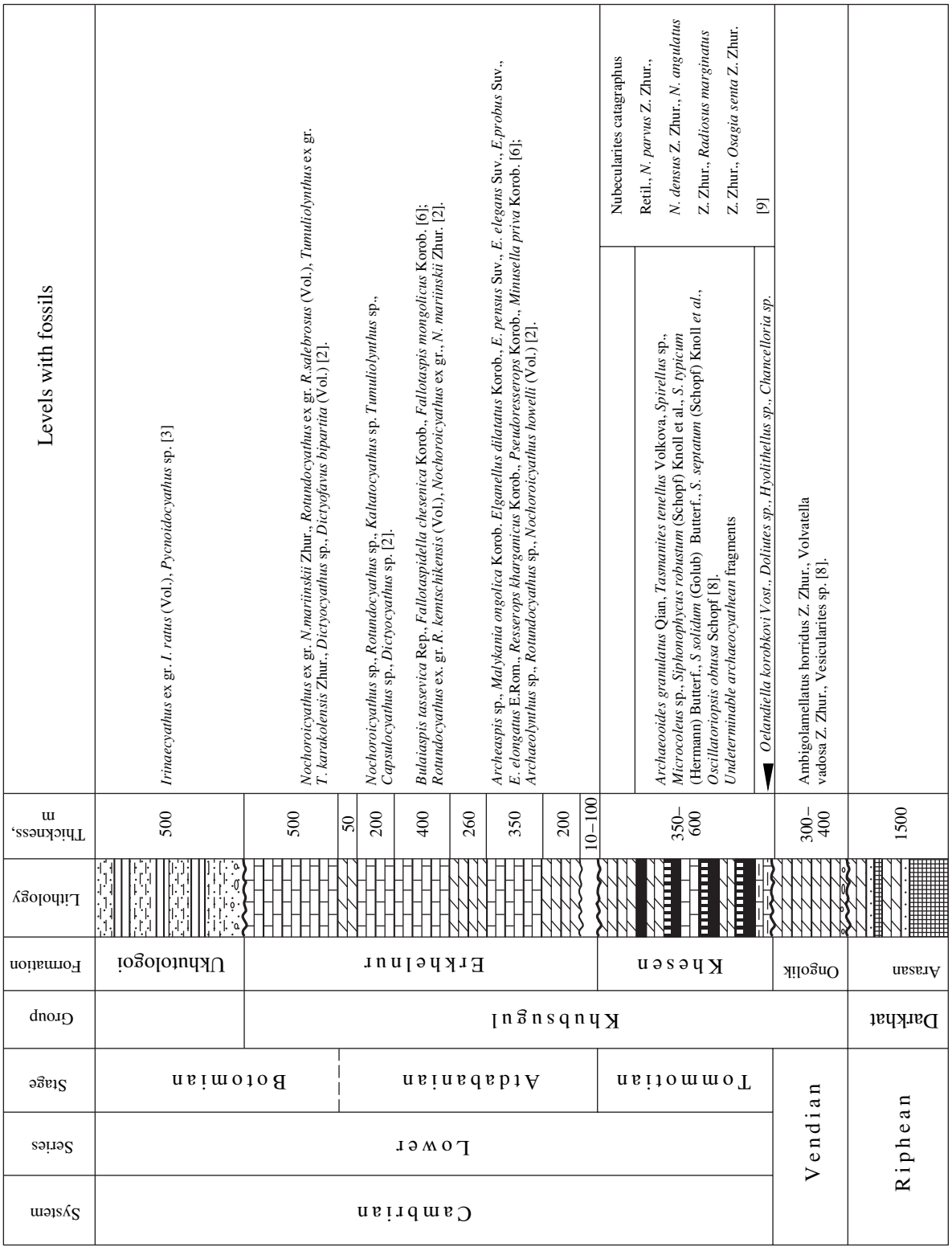

Fig. 1. Composite stratigraphic section of Vendian–Cambrian sediments of the Khubsugul phosphorite basin. The black triangle designates the level with discovered Tommotian small shelly fossils.

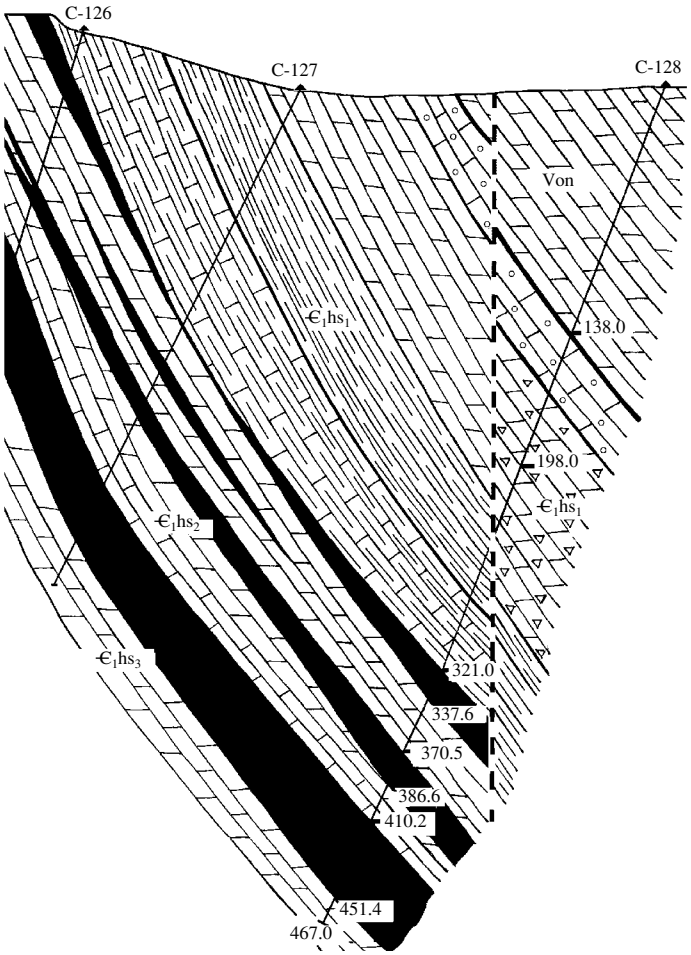

Fig. 2. Vendian–Cambrian succession in the watershed between the Kherbistuin-Gol and Ongolik-Gol rivers and location of Borehole S-128 (based on materials of the Khubsugul geological–prospecting team of V/O *Zarubezhgeologiya*). Stratigraphic units: (Von) Ongolik Formation; ($\epsilon_1 hs_1$) Khesen Formation, lower member; ($\epsilon_1 hs_2$) Khesen Formation, middle member; ($\epsilon_1 hs_3$) Khesen Formation, upper member (numbers in brackets designate depths in meters). The attitude is overturned. The dotted line shows the fault.

Representatives of the genus *Doliutus* Miss. et Sys. have been recorded in the Lower Cambrian rocks of the Siberian Platform. The oldest finds of these hyoliths have been known since mid-Tommotian time, and they are most abundant in the Atdabanian and Botomian [12]. The genus *Hyolithellus* Billings is characterized by wide stratigraphic and geographic ranges. It has been registered, in particular, in the Nemakit-Daldynian–Toyonian rocks of Siberia, Tommotian–Botomian sequences of Mongolia, and basal Meishucunian of China (?Nemakit-Daldynian–Tommotian). The *Chancelloria* forms have a wide stratigraphic range, particularly in the Lower Cambrian. Confident finds of them are known from the Nemakit-Daldynian–Tommotian sequences of the Siberian Platform (the *Purella antiqua, Nochoroicyathus sunnaginicus*, and *Docidocyathus regularis* zones), Botomian rocks of Mongolia, and Atdabanian–Botomian sections of China and southern Australia.

Thus, all discovered small shelly fossils (except for the genus *Doliutus*) are typical of the Vendian–Cambrian boundary layers [14] occurring in the *Purella antiqua* and *Nochoroicyathus sunnaginicus* zones, the boundary between which corresponds in the southern Siberian Platform to the Nemakit-Daldynian–Tommotian contact. Nevertheless, the occurrence of *?Doliutius* sp. in the shelly fossil assemblage indicates its Tommotian age. Hence, the entire Khesen Formation, including its lower member, should be referred to the Tommotian Stage. In addition, finds of archaeocyathean fragments (Fig. 4) in the middle phosphorite-bearing member preclude the Precambrian age of the formation.

Thus, the Tommotian age of the Khubsugul phosphorites assumed in [10, 11] is confirmed. This is in agreement with the concept that the narrow geological time interval corresponding to the Tommotian Age rep-

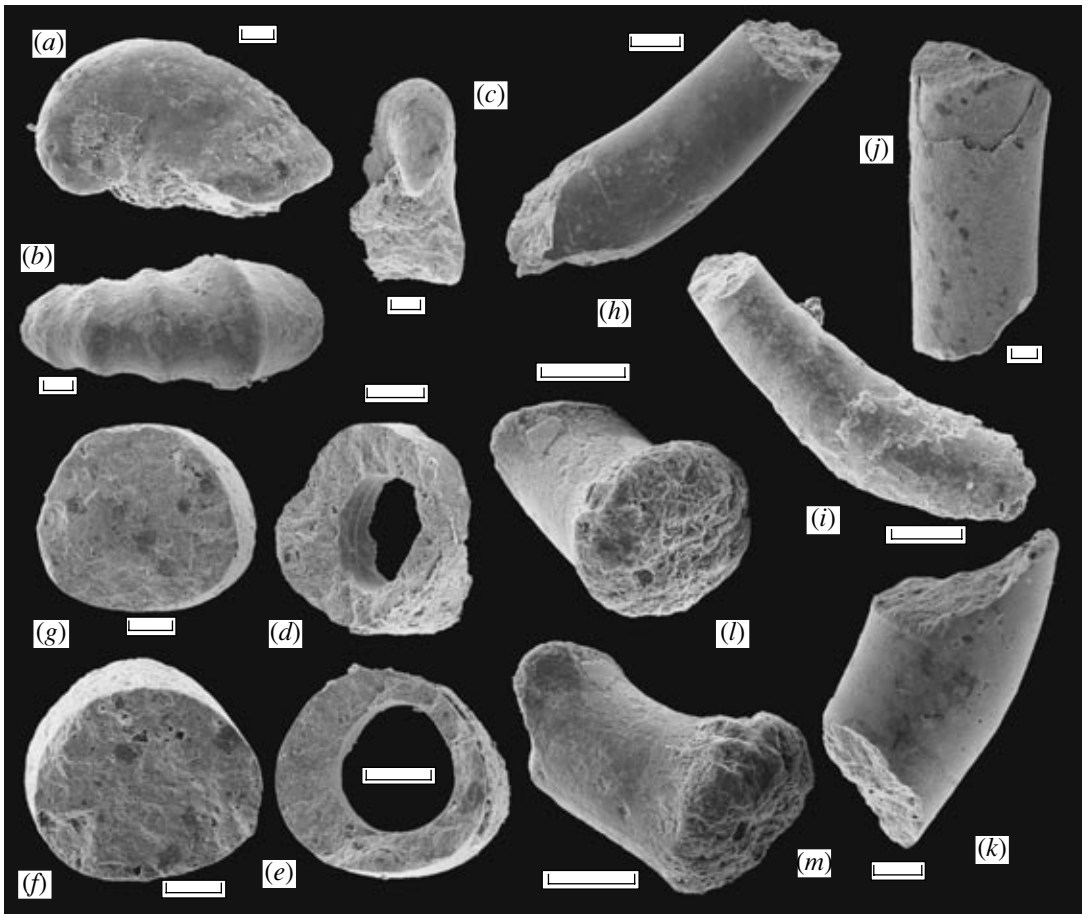

Fig. 3. Tommotian assemblage of small shelly fossils from the lower member of the Khesen Formation in the Khubsugul phosphorite-bearing basin: (*a–c*) *Oelandiella korobkovi* Vostokova, 1962, (*d, e, j, k*) *Hyolithellus* sp, (*f, g*) *?Doliutus* sp., (*h, i*) Hyolithellidae gen. et sp. indet., (*l, m*) *Chancelloria* sp. (scale bar 100 μm).

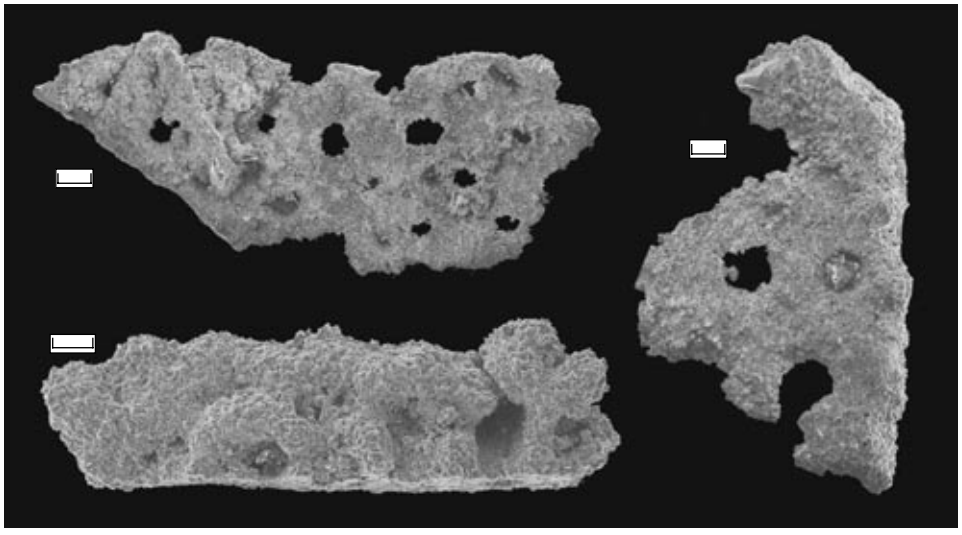

Fig. 4. Fragments of Archaeocyathean skelet from the middle member of the Khesen Formation of the Khubsugul phosphorite basin (scale bar 100 μm).

resented the most important ancient phosphate-accumulation epoch [8, 10, 11, 15].

REFERENCES

1. Donov, N.A., Edemskii, E.V., Emel'yanov, A.A., *et al.*, *Sov. Geol.*, 1967, no. 3, pp. 55–60.
2. Il'in, A.V. and Zhuravleva, Z.A., *Dokl. Akad. Nauk SSSR*, 1968, vol. 182, no. 5, pp. 1164–1166.
3. Il'in, V.B., *Biokhimiya i agrokhimiya mikroelementov Mn, Cu, Mo, B, Zn v yuzhnoi chasti Zapadnoi Sibiri* (Biochemistry and Agricultural Chemistry of Microelements Mn, Cu, Mo, B, and Zn in the Southern Part of Western Siberia), Novosibirsk: Nauka, 1973.
4. Il'in, A.V., *Drevnie fosforitonosnye basseiny* (Ancient Phosphorite-Bearing Basins), Moscow: Nauka, 1990.
5. Il'in, A.V. and Byamba, Zh., *Putevoditel' ekskursii "Fosfority Khubsugul'skogo basseina v MNR"* (Phosphorites of the Khubsugul Basin in Mongolia: Trip Guidebook), Moscow: Geol. Inst. Akad. Nauk SSSR, 1980.
6. Korobov, M.N., *Biostratigrafiya kembriya i miomernye trilobity nizhnego kembriya Mongolii* (Cambrian Biostratigraphy and Lower Cambrian Myomeric Trilobites in Mongolia), Moscow: Nauka, 1980, pp. 5–108.
7. Korobov, M.N., *Biostratigrafiya i polimernye trilobity nizhnego kembriya Mongolii* (Lower Cambrian Biostratigraphy and Polymeric Trilobites in Mongolia), Moscow: Nauka, 1989.
8. Zhegallo, E.A., Rozanov, A.Yu., Ushatinskaya, G.T., *et al.*, *Atlas of Microorganisms from Ancient Phosphorites of Khubsugul*, Huntsville: NASA/TP, 2000.
9. Zhuravleva, Z.A., *Izv. Akad. Nauk SSSR, Ser. Geol.*, 1974, no. 12, pp. 73–76.
10. Luvsandanzan, B. and Rozanov, A.Yu., *Dokl. Akad. Nauk SSSR*, 1984, vol. 277, no. 1, pp. 164–167.
11. Rozanov, A.Yu., *Sov. Geol.*, 1992, no. 1, pp. 79–81.
12. Rozanov, A.Yu., Missarzhevskii, V.V., Volkova, N.A., *et al.*, *Tommotskii yarus i problema nizhnei granitsy kembriya* (The Tommotian Stage and Problem of the Cambrian Lower Boundary), Moscow: Nauka, 1969.
13. Esakova, N.V. and Zhegallo, E.A., *Biostratigrafiya i fauna nizhnego kembriya Mongolii* (Lower Cambrian Biostratigraphy and Fauna in Mongolia), Moscow: Nauka, 1996.
14. Khomentovskii, V.V. and Karlova, G.A., *Stratigr. Geol. Korrelyatsiya,* 2002, vol. 10, no. 3, pp. 13–34.
15. Rozanov, A.Yu. and Zhegallo, E.A., *Litol. Polezn. Iskop.*, 1989, no. 3, pp. 67–82.