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Early Triassic (Olenekian) ammonoids from Khentey Province, Mongolia, and their paleobiogeographic significance

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Abstract. Early Triassic ammonoids (eight species of Kashmiritidae, Melagathiceratidae, Prionitidae, Flemingitidae ? and Palaeophyllitidae ?) from Mt. Saikhan Undur Ovoo area, Khentey Province, Mongolia are described in the first time. One new subgenus and one new species of the family Kashmiritidae (subgenus *Saikhanites* and species *Pseudoceltites* (*Saikhanites*) *khenteyensis*) are proposed. The fauna includes probable flemingitid ammonoids, common elements for Early Olenekian ammonoid faunas in both the Tethys and Boreal realms. The Early Olenekian age is also confirmed by the presence of *Juvenites* and prionitid ammonoids which closely resemble the Early Olenekian *Gurleyites* of the Tethys and *Arctoprionites* of the Boreal realm.

The ammonoid fauna of Khentey Province, consisting mainly of Tethyan type, allows us to draw a supposed Tethys–Boreal realm boundary during Early Triassic time between the Uda River (Khabarovsk region) in the north and Khentey (Mongolia) and Bolshiye Churki Range (Amur area) in the south. The presence of relatively rare typical Boreal elements in association with Tethyan ammonoids in the Olenekian ammonoid faunas of Khentey, Bolshiye Churki Range and South Primorye seems to be one of peculiarities of Olenekian sequences of peripheral parts of the Tethys. During Anisian time the Tethyan and Boreal realms seemed to be more isolated than in the Olenekian.

The existence of the ammonoid-bearing marine Triassic in Mongolia supports the idea that the Mongolia–Okhotsk Ocean between the Siberia and Mongolia–North China continents still existed during the Triassic.

Introduction

The Mongolia–Okhotsk Belt is a collision zone between the Siberia and Mongolia–North China continents, which had been separated by the Mongolia–Okhotsk Ocean (Zonenshain et al., 1990). Opinion is divided as the time of the final collision of these two continents, i.e. the closure of the Mongolia–Okhotsk Ocean : the end of the Permian (e.g., Wang, 1986 ; Wang and Liu, 1991), Triassic (Şengör and Natal'in, 1996), Triassic–Late Jurassic (Zonenshain et al., 1990), Early–Middle Jurassic (Zhao et al., 1990 ; Enkin et al., 1992) and Middle Jurassic (Zorin et al., 1995, 1998 ; Zorin, 1999). Wang and Liu (1991) stressed that the sediments changed from marine to terrestrial in Late Permian and Mesozoic marine sediments are lacking in the Mongolia–Okhotsk Belt. On the other hand, the Mesozoic collision concepts are supported by the paleomagnetic data and widely distributed subduction-related Mesozoic volcano-plutonic rocks along the belt. Triassic–Jurassic shallow marine sediments of the Onon and Aga–Borzya Zone (Zonenshain et al., 1990 ; Zorin et al., 1995, 1998 ; Zorin, 1999), distributed in the Russia–China–Mongolia border area, are circumstantial evidences for the surviving of the ocean between these two continents, although no Mesozoic ophiolite has been known from the Mongolia–Okhotsk Belt in Mongolia. Shallow marine ammonoid-bearing Triassic strata have also been known in the Khentey Province of northeast Mongolia (Zonenshain et al., 1971 ; Badarch et al., 2002). This ammonoid-bearing Triassic is important for considering the closure time and the extent of the Mongolia–Okhotsk Ocean as well as for discussing details of Triassic ammonoid paleobiogeography of northeast Asia. Particulars about the Triassic ammonoid fauna, however, have not yet been described.

This paper contains a description of the Triassic ammonoid fauna recovered from the southern ridge of Mt. Saikhan Undur Ovoo of Khentey Province, Mongolia, and discussion on the biostratigraphic, paleobiogeographic and paleogeographic significances of the fauna.

Geological setting

In Mongolia marine Triassic strata with ammonoids have been known from two areas in the Khentey mountain region : the Mt. Saikhan Undur Ovoo area of Khentey Province and Chonyn Khudag area of Dornod Province. The Mt. Saikhan Undur Ovoo area is located in the Jargarant River basin, which is the upstream area of the Onon River (Fig. 1A). The Triassic of the area was first studied by Zonenshain et al. (1971) and later examined minutely by Akjigitov and Batmun-

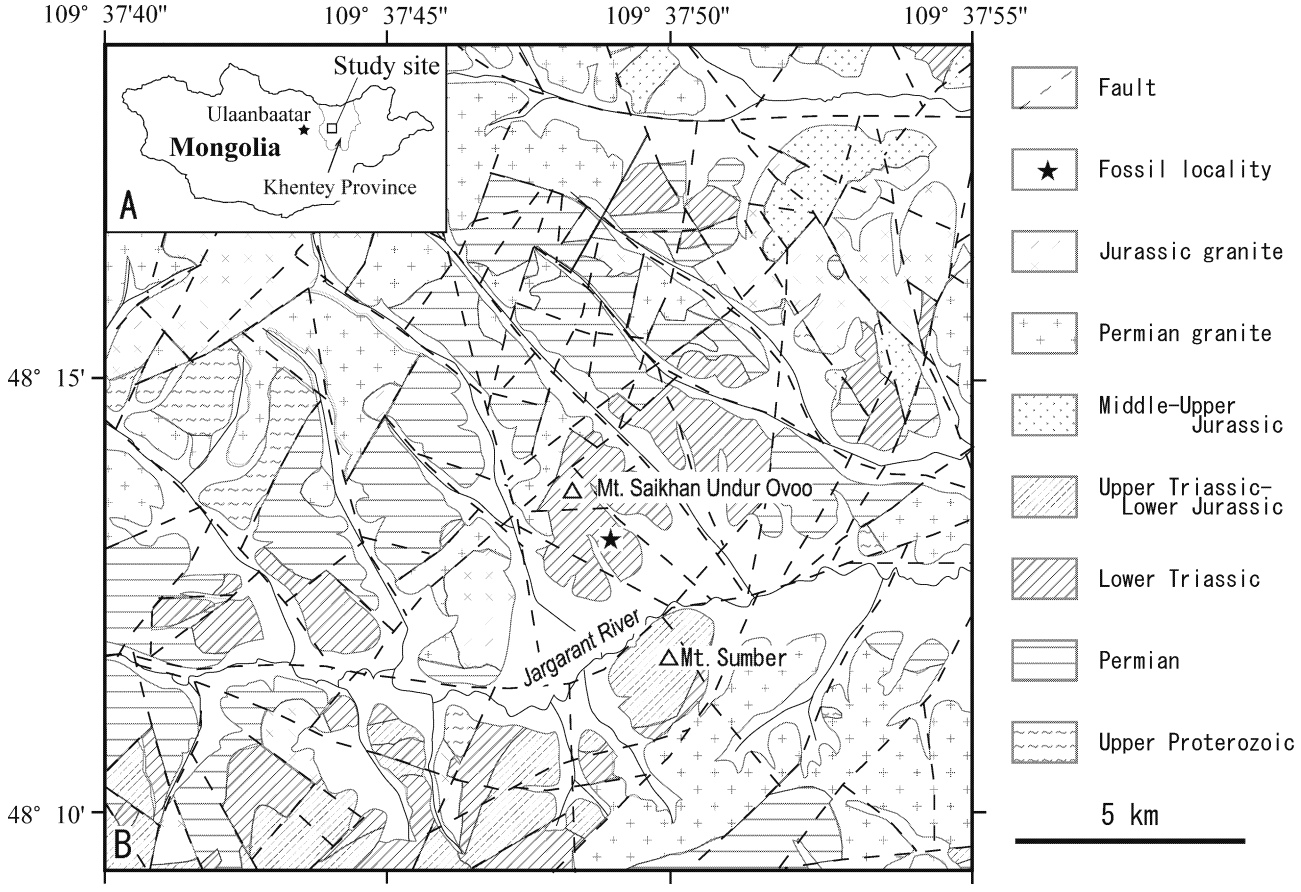

Figure 1. Index map (A) and geological map of the area around Mt. Saikhan Undur Ovoo, Umnudelger, Khentey Province, Mongolia (B) (from Akjigitov and Batmunkh, 1985).

kh (1985). Near Mt. Saikhan Undur Ovoo, north of Khentey village, Umnudelger, Khentey Province the Triassic covers unconformably the Permian sandstone and mudstone and Permian granite (Fig. 1B). It attains more than 1,000 m in thickness and consists of basal sandstone, thick sandstone, thick mudstone and their alternating beds. Full section around Mt. Saikhan Undur Ovoo area (Zonenshain et al., 1971) is as follows :

1. Basal conglomerate ·····20 m
2. Gray and pink gray, cross-bedded sandstone ·····30 m
3. Black siltstone, with intercalated sandstone 20 m
4. Gray sandstone, with beds of black siltstone ·····300 m
5. Black to dark gray mudstone and sandstone40 m
6. Gray sandstone ·····20 m
7. Black siltstone, with bivalves ·····30 m
8. Gray, thin-bedded, siliceous sandstone, with beds of black mudstone ·····100 m
9. Dark gray, carbonaceous mudstone, with bivalves and ammonoids ·····5 m
10. Black mudstone and sandstone ·····250 m
11. Alternating beds of dark gray sandstone, mudstone and siltstone ·····10 m
12. Dark gray, fine-grained tuff ·····10 m
13. Alternating beds of black mudstone, siltstone and sandstone ·····250 m
14. Pink gray sandstone and black siltstone ···150 m.

We collected many ammonoid fossils in association with small bivalves from the calcareous sandy mudstone of this unnamed Triassic formation, which is the bed 9 of Zonenshain et al. (1971), distributed on the southern ridge of Mt. Saikhan Undur Ovoo (109°37′49″E, 48°13′16″N).

Age of the fauna

Zonenshain et al. (1971) listed such ammonoid species as *Euflemingites romundari* Tozer, *Anasibirites* cf. *ehimensis* Bando, *A.* ? sp., *Prosphingites* aff. *ovalis* Kiparisova and *Anakashmirites* sp. from bed 9 and concluded that the age of the fauna is Olenekian. The ammonoid specimens, however, have not yet been described.

Investigated mollusc collection by us from the southern ridge of Mt. Saikhan Undur Ovoo, Umnudelger (Khentey Province, Mongolia), is represented by eight ammonoid species of five genera belonging to Kashmiritidae, Melagathiceratidae, Prionitidae, Flemingitidae ? and Palaeophyllitidae ? families, one nautiloid species and some other small

bivalves. These specimens were collected from small outcrops belonging to bed 9 of Zonenshain et al. (1971) and loose blocks nearby. The loose blocks were distributed in a narrow area (several meters square) on the ridge and show same lithology as those of outcrops consisting of calcareous sandy mudstone with thin sandstone beds. In addition some of ammonoids (for instance, Kashmiritidae and Flemingitidae ? ; Palaeophyllidae, Kashmiritidae and Prionitidae) were found in same blocks. Therefore, we have every reason to believe that collected ammonoids of the locality were contemporary.

Kashmiritidae (*Pseudoceltites*) is a predominant element in the ammonoid fauna of Mt. Saikhan Undur Ovoo. It comprises *Pseudoceltites (Saikhanites) khenteyensis* subgen. and sp. nov. and *Pseudoceltites* (*Saikhanites*) sp., so we call the ammonoid bed as the *Pseudoceltites* (*Saikhanites*) *khenteyensis* Bed. All typical kashmiritid ammonoids (*Pseudoceltites*, *Anakashmirites*, *Kashmirites*, *Eukashmirites*, *Hanielites*) are known only from the Olenekian (late Early Triassic) strata (Zakharov, 1978). Shevyrev (1986) concluded that some kashmiritids (*Metophiceras*, *Tompophiceras*, *Hypophiceras*) appeared in Induan (early Early Triassic) time, but we incline to consider *Tompophiceras* to be a constituent of Dzhulfitidae (Zakharov, 2002), and *Metophiceras* and *Hypophiceras* to be of Xenodiscidae (Dagys and Ermakova, 1996 ; Zakharov, 2002). The present study is based on about 21 adult and some juvenile kashmiritid ammonoids (*Pseudoceltites*) described as representatives of the new subgenus *Saikhanites.* Zakharov (1978) expected that the genus *Anakashmirites* is the kashmiritid with most primitive suture. But *Pseudoceltites (Saikhanites*) seems to be the most "primitive" group of Kashmiritidae originated, apparently, at the beginning of the Olenekian (Fig. 2), because *Saikhanites* has a goniatitic suture-line. The subgenus *Pseudoceltites* is known only from the upper Olenekian. The ancestral group for kashmiritid ammonoids is still unknown. In its suture construction the envisioned ancestral group seems to be somewhat more primitive than known xenodiscid, ophiceratid and dzhulfitid ammonoids.

Mt. Saikhan Undur Ovoo species of the family Melagathiceratidae (*Juvenites* sp. and Melagathiceratidae gen. and sp. indet.) closely resemble some Early Olenekian melagathiceratids from the *Euflemingites romunderi* Zone of British Columbia (Tozer, 1994) and *Hedenstroemia bosphorensis* and *Anasibirites nevolini* Zones of South Primorye.

Species of the family Prionitidae are Olenekian, mainly Early Olenekian in age. Prionitids from the area are poorly preserved and, therefore, not determined in generic and specific levels, but most closely resemble some Early Olenekian (Smithian) *Arctoprionites* from the *Anawasatchites tardus* Zone of British Columbia (Tozer, 1994), Early Olenekian *Gurleyites* from the *Owenites egrediens* Beds of Timor (Welter, 1922) and *Anasibirites nevolini* Zone of South Primorye (Zakharov, 1968).

In the Mt. Saikhan Undur Ovoo fauna, six mollusc shells and their fragments with spiral sculpture were recognized ; they seem to be flemingitid ammonoids (*Euflemingites* and *Flemingites*). *Euflemingites* is a common element for the Early Olenekian *Hedenstroemia* and *Anasibirites* Beds of the Tethys and *Euflemingites romunderi Zone of the Boreal realm. Flemingites*, differing from *Euflemingites* by having radial sculpture, is known from the *Hedenstroemia* Beds of the Lower Olenekian.

One ammonoid shell from the area, identified as *Anaxenaspis* ? sp., most resembles *Anaxenaspis kraffti* Tozer (ribbing shells) from the *Euflemingites romunderi* Zone of Arctic Canada (Tozer, 1994).

We incline to the Early Olenekian age for the *Pseudoceltites* (*Saikhanites*) *khenteyensis* Bed of Khentey Province in Mongolia, as with Zonenshain et al. (1971). Because it contains Early Olenekian *Juvenites* and some prionitid ammonoids closely resemble Early Olenekian *Gurleyites* of the Tethys and *Arctoprionites* of the Boreal realm, and yields probable representatives of the Early Olenekian genera *Euflemingites* and *Flemingites.* Therefore, we correlate the *Pseudoceltites* (*Saikhanites*) *khenteyensis* Bed of Mongolia with the *Hedenstroemia bosphorensis* (upper part) and *Anasibirites nevolini* Zones of South Primorye (Zakharov,

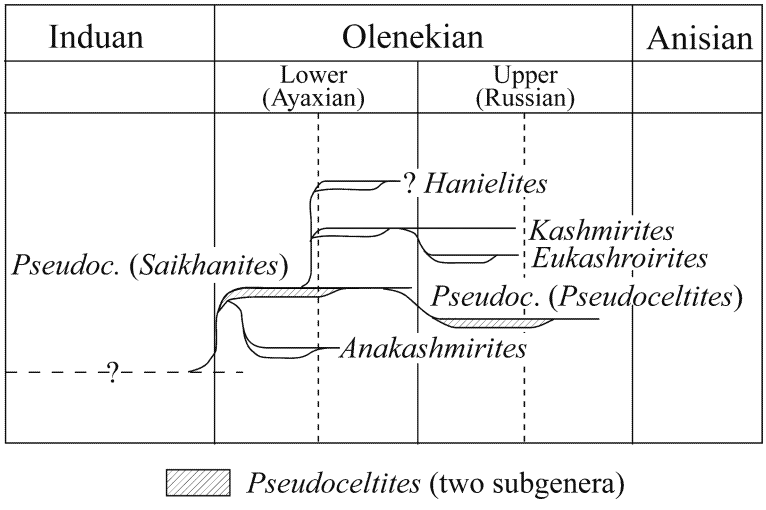

Figure 2. Chart showing the Kashmiritidae phylogeny and range of Olenekian kashmiritid genera and subgenera.

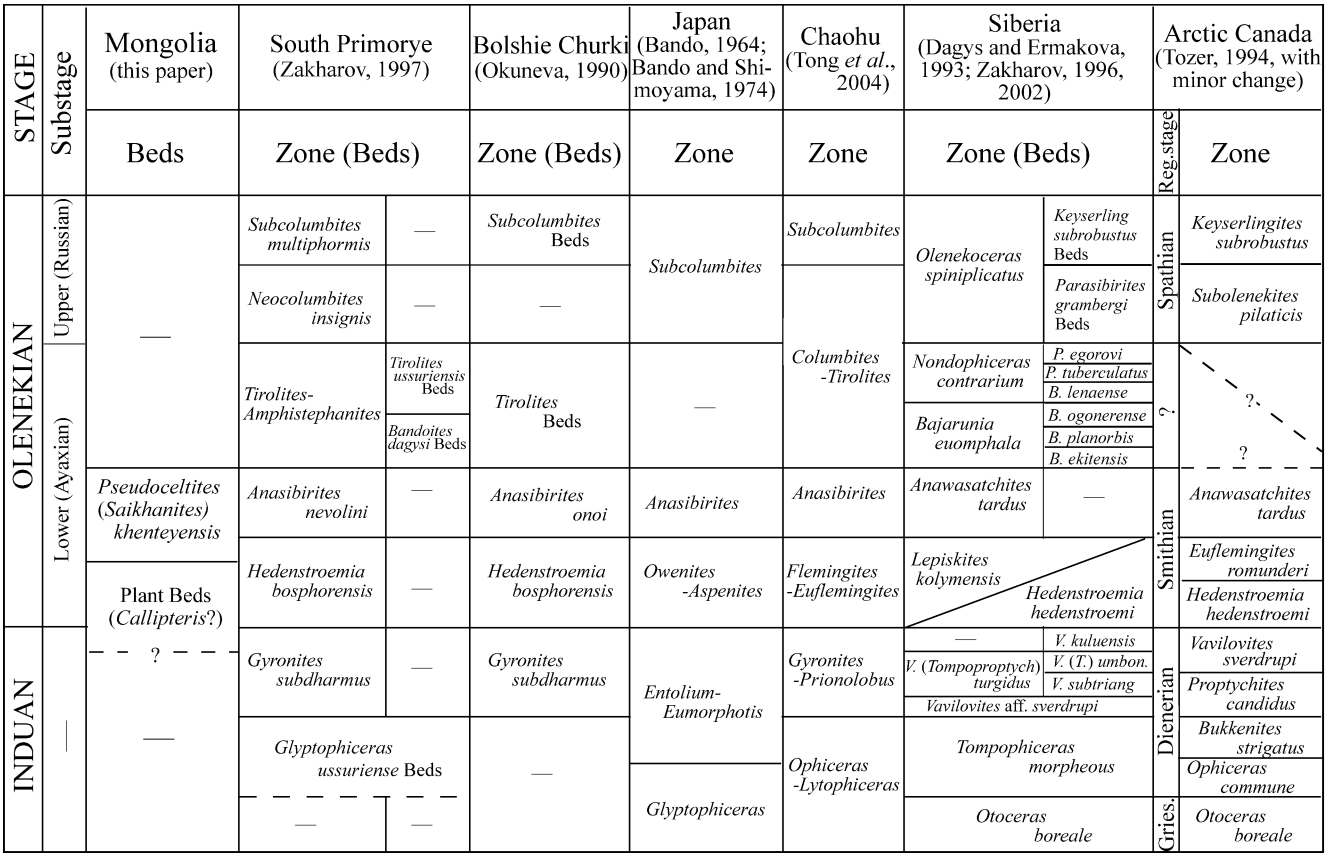

Figure 3. Correlation of the Early Triassic ammonoid zones in the Tethys (Mongolia, Far East, South China) and Boreal realms. Abbreviations : *P. egorovi* – *Praesibirites egorovi*, *P. tuberculatus* – *Praesibirites tuberculatus*, *B. lenaense* – *Boreoceras lenaense*, *B. ogonerense* – *Boreoceras ogonerense*, *B. planorbis* – *Boreoceras planorbis*, *B. ekitensis* – *Boreoceras ekitensis*, *V.* (*Tompoproptych.*) *turgidus* – *Vavilovites* (*Tompoproptychites*) *turgidus*, *V. kuluensis* – *Vavilovites kuluensis*, *V.* (*T.*) *umbon.* – *Vavilovites* (*Tompoproptychites*) *umbonatus*, *V. subtriang.*– *Vavilovites subtriangularis*, Gries.– Griesbachian.

1997) ; *Hedenstroemia bosphorensis* (upper part) and *Anasibirites onoi* Zones of Bolshiye Churki Range in Amur area (Okuneva, 1990) ; *Owenites–Aspenites* Zone (upper part) of the Iwai Formation at Iwai, near Tokyo (Sakagami, 1955 ; Kummel and Sakagami, 1960 ; Bando, 1964), *Anasibirites Zone* of the Taho Formation in Shikoku (Yehara, 1926 ; Spath, 1934 ; Shimizu, 1932 ; Shimizu and Jimbo, 1933), Japan ; *Flemingites–Euflemingites* (upper part) and *Anasibirites* Zones of the Anhui Province in South China (Tong et al., 2004) ; *Hedenstroemia hedenstroemi* (upper part) and *Anawasatchites tardus* Zones of the Verkoyansk and Kolyma areas in Siberia (Popow, 1961 ; Zakharov, 1978, 1996 ; Dagys and Ermakova, 1993) ; and the *Euflemingites romunderi* and *Anawasatchites tardus* Zones of Arctic Canada (Tozer, 1994) (Fig. 3).

Paleobiogeography of the fauna

Kashmiritid genera, except for *Kashmirites*, are typical Tethyan faunistic elements of Olenekian age. Species of the genus *Kashmirites* were also widely distributed in the Tethys, but some of them have been found in the Lower Olenekian (Smithian) *Euflemingites romunderi* and *Wasatchites tardus* Zones of the Boreal realm (Tozer, 1994). Most of species of the Olenekian family Melagathiceratidae were distributed in both the Tethys and Boreal realms, but only species of the genus *Proharpoceras* are exclusively Tethyan ones. A part of prionitid genera (*Hemiprionites*, *Gurleyites*, ? *Albanites* and ? *Proavites*) has been found only within the Tethys, the rest (*Prionites*, *Anasibirites* and *Wasatchites*) in both the Tethys and the Boreal realms, but only two genera (*Arctoprionites* and *Anawasatchites*) (Tozer, 1994) were discovered in the Boreal realm. Prionitids from Mongolia are poorly preserved, but, as already stated previously, closely resemble *Arctoprionites* and *Gurleyites*. *Euflemingites* is a common element for both the Tethys and Boreal realms. On the other hand, *Flemingites* is restricted in the Tethys. Five genera (*Burijites*, *Paleophyllites*, *Eophyllites*, *Ussuriphyllites* and *Schizophyllites*) belonging to the Palaeophyllitidae have been discovered from the Tethys, but the rest (*Anaxenaspis* and *Leiophyllites*) from both the Tethys and Boreal realms. *Anaxenaspis* ? sp. from the Mt. Saikhan Undur Ovoo area most resembles *Anaxenaspis kraffti* Tozer (ribbing shells) from Arctic Canada, as mentioned earlier.

Thus the Olenekian ammonoid fauna from Mt. Saikhan Undur Ovoo, Khentey Province is fundamentally a Tethyan

type and the northeast Mongolia is considered to have belonged to the Tethyan faunal province during the Early Triassic. The ammonoid fauna, however, contains rare elements of the Boreal realm. The meaning of existence of the Arctic elements will be discussed in the next chapter.

Supposed position of the northern edge of the Tethys in Early Triassic time

Early Triassic ammonoid faunas of the Boreal type within the Northeast Russia area have been known from Taimir, Olenek Gulf area, Olenek River basin, Buur River basin, Lena River (lower reaches), West Verkhoyansk area, East Verkhoyansk area, Indigirka River (upper reaches), the origins of Kolyma River (Kenyelichi), Okhotsk (Taigonos) area, Zeya River (upper reaches) basin (Keyserling, 1845 ; Mojsisovics, 1886, 1888 ; Kiparisova and Popow, 1956 ; Popow, 1956, 1957, 1958, 1961 ; Domokhotov, 1960 ; Lazurkin and Korchinskaya, 1963 ; Vozin and Tikhomirova, 1964 ; Vavilov, 1964, 1965, 1967, 1969 ; Zakharov, 1969, 1970a, 1970b, 1971, 1974, 1978, 2002 ; Zakharov and Khudolozhkin, 1969 ; Vavilov and Lazovsky, 1970 ; Korostelev, 1972 ; Arkhipov, 1974 ; Zakharov et al., 1975 ; Vavilov and Zakharov, 1976 ; Bytchkov et al., 1976 ; Dagys et al., 1979 ; Ermakova, 1981 ; Dagys and Ermakova, 1988, 1990, 1996). The southern boundary of the Boreal realm is indicated to be situated not more northerly than the upper reaches of Uda River (Amur River basin) (Fig. 4), where *Olenikites* sp. (identified by one of the authors, Y.D. Zakharov), typical element of the Boreal Late Olenekian ammonoid fauna, was collected by E.P. Brudnitskaya. The occurrence of Boreal *Olenikites* in Bolshiye Churki Range, Low Khingan, another, more southern, area of the Amur River basin (Okuneva, 1990) has not been confirmed.

In eastern Asia only three regions with northern Tethyan Early Triassic ammonoid fauna had been known till now : Japan (Kitakami, Shikoku, Iwai, Nakano-tani) (Bando, 1964), South Primorye (Diener, 1895 ; Kiparisova, 1961 ; Zakharov, 1968, 1978, 1996, 1997 ; Zakharov et al., 2002, 2003, 2004 ; Markevich and Zakharov, 2004 ; Burij and Zharnikova, 1981) and Bolshiye Churki Range (Khabarovsk region, Lower Khingan terrane of the southern part of the Bureya Massif) (Bobylev and Okuneva, 1967 ; Okuneva, 1976, 1990 ; Zakharov, 1978). South Primorye and Bolshiye Churki Range seem to belong to a single faunistic province during the Early Triassic, because their Lower Triassic sequences are characterized by the same ammonoid species, such as *Gyronites subdharmus* Kiparisova, *Dieneroceras chaoi* Kiparisova, *Arctoceras septentrionale* (Diener), *Meekoceras boreale* Diener, *Prosphingitoides ovalis* (Kiparisova), *Parahedenstroemia nevolini* (Burij and Zharnikova) and *Euflemingites prinadai* (Kiparisova) (Okuneva, 1990), and by very similar species of such genera as *Churkites*, *Wasatchites*, *Tirolites*, *Arnautoceltites* and *Subcolumbites* (Okuneva, 1990 ; Zakharov, 1978 ; Markevich and Zakharov, 2004).

In the northern edge of the Tethys the Early Triassic ammonoid fauna consists mainly of the following genera, which have not been recovered for certain in the Boreal realm : *Ussuria*, *Parussuria*, *Metussuria*, *Parahedenstroemia*, *Epihedenstroemia*, *Churkites*, *Khvalinites*, *Dieneroceras*, *Prosphingitoides*, *Pseudoprosphingites*, *Zhitkovites*, *Arnautoceltites*, *Owenites*, *Gyronites*, *Gurleyites*, *Inyoites*, *Gurleyites*, *Palaeokasachstanites*, *Proharpoceras*, *Hellenites*, *Neocolumbites*, *Columbites*, *Subcolumbites*, *Procolumbites*, *Prenkites*, *Preflorianites*, *Pseudoceltites*, *Amphistephanites*, *Tirolites*, *Bandoites*, *Tchernyschevites* and *Flemingites* ("*F.*" *reticulatus* Tozer from British Columbia seems to be a representative of different genus). This is a strong argument in favor of significant isolation of the Boreal realm in the Early Triassic. At the same time the upper sequences of the Lower Triassic in both South Primorye (Zakharov, 1968 ; Zakharov et al., 2005) and Kitakami (Ehiro, 1993 : described as *Keyserlingites*) contain ammonoids *Olenekoceras*, which is absent in other areas of the Tethys, but very typical for the *Olenikites spiniplicatus* Zone of Arctic Siberia. Some Keyserlingitids, closely resemble *Olenekoceras*, but with strong bituberculate sculpture, seem to be representatives of a new genus. We consider that "*Keyserlingites*" *miroshnikovi* Burij and Zornikova from South Primorye (Zakharov, 1968) and "*K.*" *stephensoni* from Idaho (Kummel, 1969) are representatives of a new genus of the family Keyserlingitidae. Besides, basal beds of the Olenekian in South Primorye yield very rare representatives of the genus *Hedenstroemia*, which is common for the Lower Olenekian in the Boreal realm and Himalayas, but absent in the tropical part of the Tethys (we do not agree with Shevyrev (1986) that *Meshedenstroemia* Zhao is a synonym of the *Hedenstroemia* Waagen). In the *Tirolites* Beds of South Primorye the ammonoid *Bajarunia* was discovered (Zakharov, 1978), which usually common for the Lower Triassic of Arctic Siberia (Dagys, 1984). These facts show that the Boreal and Tethys realms had nevertheless more or less short-term connections during Olenekian time. The presence of *Hedenstroemia*, *Olenekoceras* and, apparently, *Bajarunia* in association with typical Tethyan ammonoids seems to be one of peculiarities of Lower Triassic sequences of peripheral parts of the Tethys.

The newly described Early Triassic ammonoid fauna from Mt. Saikhan Undur Ovoo, Khentey Province in Mongolia allows us to expect the Tethys-Boreal realm boundary was located just north of the Khentey area and Bolshiye Churki Range. Because, the Mt. Saikhan Undur Ovoo ammonoid fauna is fundamentally a Tethyan type, but contains rare elements of the Boreal realm, same as those from Bolshiye Churki Range and South Primorye.

During Anisian time the Tethyan and Boreal realms seemed to be more isolated than in the Olenekian. Because, Boreal elements are more rare in the Anisian ammonoid assemblages in the Tethys. For example, the earliest Anisian ammonoid fauna of South Primorye is composed mainly of Tethyan genera, and contains only a single typical Boreal-type element, *Arctohungarites* (Zakharov, 1968 ; Zakharov and Rybalka, 1987). Outside of the Boreal realm representatives of *Arctohungarites* are also known in the Lower Anisian of Central Qinghai, China (He et al., 1986 ; Shevyrev, 1995). The genus *Arctohungarites* originated, apparently, at the beginning of the Anisian in the Tethys and migrated later (mainly in middle Early Anisian) to high latitudes.

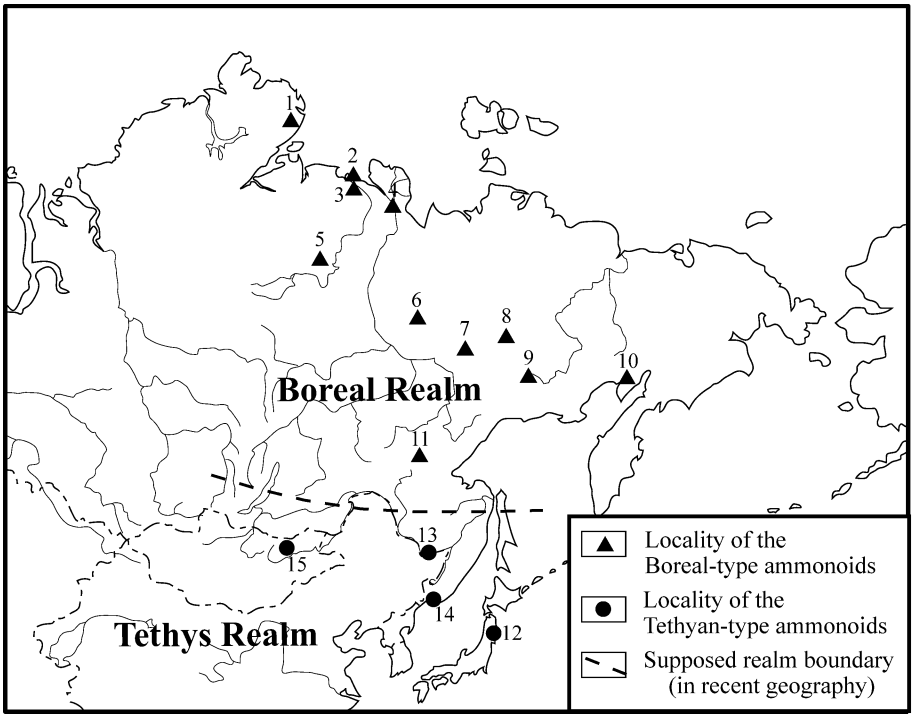

Figure 4. Main ammonoid localities and supposed position of the Tethys–Boreal realm boundary in northeast Asia during Early Triassic time. 1 – Taimir, 2 – Olenek Gulf, 3 – Olenek River (lower reaches), 4 – Buur River basin, 5 – Lena River (lower reaches), 6 – Western Verkhoyansk area, 7 – Eastern Verkhoyansk area, 8 – Indigirka River (upper reaches), 9 – Kolyma River basin (Kenjelichi), 10 – Okhotsk (Taigonos) area, 11 – Uda River basin, 12 – Japan (Kitakami), 13 –Bolshiye Churki Range, 14 – South Primorye, 15 – Khentey (Mongolia).

Paleogeographic significance of the fauna

The *Pseudoceltites* (*Saikhanites*) *khenteyensis* Bed in the Mt. Saikhan Undur Ovoo area, Khentey Province is intercalated in the thick terrigenous clastic sequence of unnamed Triassic formation, which is widely distributed in the area. The widely distributed marine Olenekian strata offer us a circumstantial evidence for the existence of the Mongolia–Okhotsk Ocean in the Mongolia–Okhotsk Belt of Khentey Province at least during the Early Triassic time.

The Olenekian strata of the Mt. Saikhan Undur Ovoo area and of the Bolshiye Churki Range, to the east of Khentey Province, are considered, probably, to be deposited on the northern continental shelf of the Mongolia–North China continent of Zonenshain et al. (1990), because these localities belonged to the northern peripheral zone of the Tethyan ammonoid faunal realm as discussed above. Since the southern part of Mongolia and Inner Mongolia already changed to the continental environment in Late Permian time (Wang and Liu, 1991), the warm water current from the low latitudinal part of Tethys or Panthalassa must have flowed into the Mt. Saikhan Undur Ovoo area through the South Primorye and Bolshiye Churki Range area. Accordingly the northern continental margin of the Mongolia–North China Continent is considered to had extended east to west or east–southeast to west–northwest, not northeast to southwest. This reconstruction of continental arrangement is the same as those of Zorin et al. (1998) and Zorin (1999), mainly based on the paleomagnetic data (Zhao et al., 1990 ; Pruner, 1992).

Systematic Description

By Y.D. Zakharov and M. Ehiro

All specimens described here were collected from the Lower Olenekian *Pseudoceltites* (*Saikhanites*) *khenteyensis* Beds at the southern ridge of Mt. Saikhan Undur Ovoo, Umnudelger area, Khentey Province, Mongolia, and are stored in the Tohoku University Museum, Sendai, Japan.

Order Ceratitida Hyatt, 1884
Superfamily Dinaritoidea Mojsisovics, 1882
[nom. transl. Shevyrev, 1968 (ex Dinaritidae Mojsisovics, 1882)]
Family Kashmiritidae Spath, 1930
Genus ***Pseudoceltites*** Hyatt, 1900

Pseudoceltites : Hyatt, 1900, p. 558 ; Spath, 1934, p. 239 ; Arkell et al., 1957, p. L142 ; Kiparisova and Popow, 1958, p. 31 ; Kummel, 1969, p. 437, Shevyrev, 1986, p. 88 (pars).

Type species.—*Celtites multiplicatus* Waagen, 1895 ; Upper Ceratite Limestone of the Salt Range.

Composition.—1. Subgenus *Pseudoceltites* Hyatt, 1900; 2. Subgenus *Saikhanites* Zakharov and Ehiro, subgen. nov.

Subgenus ***Saikhanites*** Zakharov and Ehiro, subgen. nov.

Type species.—*Pseudoceltites* (*Saikhanites*) *khenteyensis* sp. nov.; Lower Olenekian of Mongolia.

Diagnosis.—Shell discoidal, evolute, sculptured like *Pseudoceltites*. Distinguished from subgenus *Pseudoceltites* by having goniatitic suture-line (or ceratitic one with very small denticulations).

Species assigned.—Two species: *Pseudoceltites* (*Saikhanites*) *khenteyensis* sp. nov. and *Pseudoceltites* (*Saikhanites*) sp. from Lower Olenekian of Mongolia.

Etymology.—Name from Mt. Saikhan Undur Ovoo (Mongolia).

Pseudoceltites* (*Saikhanites*) *khenteyensis Zakharov and Ehiro, sp. nov.

Pl. I, Figs. 1–20

Materials.—IGPS coll. cat. no. 109651 (holotype) and paratypes: IGPS coll. cat. no. 109652–109670.

Description.—Shell discoidal, evolute, venter broadly rounded (Pl. I, Figs. 13c, 14c, 17c, 18c, 20c), flattened at inner whorls (Pl. I, Fig. 6b), with rounded ventral shoulders; umbilicus very wide with rounded umbilical edge. Broad folds extending across the venter from the prominent parts of ribs located at the ventro-lateral area. The flattened lateral areas bear strong radial ribs that begin on umbilical shoulder and become significantly thicker at ventral shoulder.

Sutures shown in Figure 5. Three lateral saddles at the external part of the suture. The large first lateral saddle lies near the ventral shoulder, the smaller second lateral saddle lies near umbilical shoulder and smallest one on the umbilical wall. Suture goniatitic, no denticulations at the base of U-shaped lobe, the smaller next lobe locates on the umbilical shoulder.

Comparison.—The present species most resembles *Pseudoceltites* (*Pseudoceltites*) *cheneyi* Kummel (1969, p. 438, pl. 44, figs. 4–11) from the Upper Olenekian Thaynes Formation, the *Columbites* Zone, of southeastern Idaho, but differing in its somewhat more evolute shell and simpler (goniatitic) suture-line.

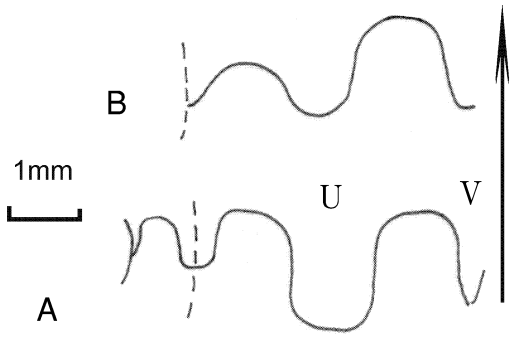

Figure 5. Suture lines of *Pseudoceltites* (*Saikhanites*) *khenteyensis* sp. nov. A, IGPS coll. cat. no. 109651 (holotype), at H=6.9 mm; B, IGPS coll. cat. no. 109657, at H=5.8 mm; *Pseudoceltites* (*Saikhanites*) *khenteyensis* Bed on the southern ridge of Mt. Saikhan Undur Ovoo, Umnudelger, Khentey Province.

Distribution.—Mongolia, Lower Olenekian.

Etymology.—The name from Khentey Province (Mongolia).

***Pseudoceltites* (*Saikhanites*)** sp.

Pl. II, Figs. 1–9

Materials.—Nine poorly preserved specimens and some juvenile shells and shell fragments, IGPS coll. cat. no. 109671–109679.

Description.—Shell discoidal, from semi-evolute to evolute, laterally compressed; venter rounded, with rounded ventral shoulders; umbilicus wide with abruptly rounded umbilical edge. Very weak folds across the venter extending from the prominent parts of ribs located at the ventro-lateral area. Flanks covered with strong radial ribs that begin on umbilical shoulder and become significantly thicker at ventral shoulder.

Measurements (mm)

Specimen number (IGPS coll. cat. no.)	D	H	W	U	H/D	W/D	U/D
109651 (holotype)	34.8	11.0	–	16.1	0.31	–	0.46
109652	59.4?	12.2?	–	34.9	0.21?	–	0.59?
Same specimen	48.2	12.0?	–	23.6	0.25?	–	0.49
109653	51.7	13.7	–	24.5	0.26	–	0.47
109654	ca. 47	18.0	–	ca. 28	0.38	–	0.60±
109655	39.0	11.0	–	19.0	0.28	–	0.49
109656	33.3	9.6	–	14.5	0.29	–	0.44
109657	27.8	8.7?	–	14.7	0.31	–	0.53
109658	26.1	8.8	–	12.7	0.34	–	0.49
109659	–	6.2	5.6?	–	–	0.28?	–
109660	19.2	5.2?	–	8.8	0.27	–	0.46
109661	17.9	6.0	–	8.1	0.34	–	0.45
109662	17.4	4.3	3.2?	9.7	0.25	0.18?	0.56
109663	14.9	5.0	–	6.6	0.34	–	0.44

Measurements (mm)

Specimen number (IGPS coll. cat. no.)	D	H	W	U	H/D	W/D	U/D
109671	42.5	14.9	–	18.4	0.35	–	0.43
109672	42.0	13.6	11.0?	17.2	0.32	0.26?	0.41
109673	26.7	8.0	–	11.1	0.30	–	0.42
109674	24.2	9.3	–	9.0	0.38	–	0.37
109675	24.1	9.4	–	10.3	0.39	–	0.43
109676	9.9	3.2	2.2?	3.7	0.32	0.22?	0.37

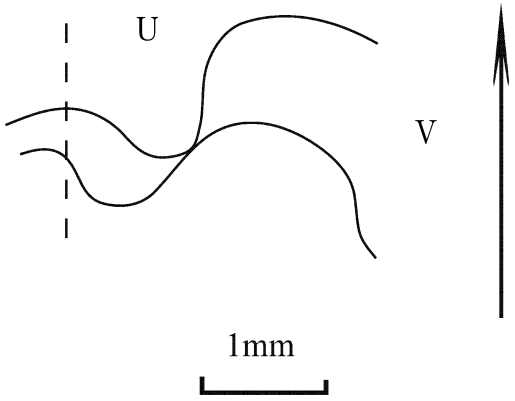

Figure 6. Suture lines of *Pseudoceltites* (*Saikhanites*) sp., IGPS coll. cat. no. 109676, at H=3.9 mm; *Pseudoceltites (Saikhanites) khenteyensis* Bed on the southern ridge of Mt. Saikhan Undur Ovoo, Umnudelger, Khentey Province.

Suture lines shown in Figure 6. Suture goniatitic. Two lateral saddles at external part of the suture. Lower and broad first lateral saddle lies near the ventral shoulder and the smaller second lateral saddle on the umbilical shoulder. U-shaped lobe between them; the smaller next lobe locates, apparently, on the umbilical edge.

Comparison.—This species is very similar to *Pseudoceltites* (*Saikhanites*) *khenteyensis* sp. nov. described above, but differs by having more involute shell and broader lateral saddles of the suture.

Distribution.—Mongolia, Lower Olenekian.

Family Melagathiceratidae Tozer, 1971
Genus ***Juvenites*** Smith, 1927

Type species.—*Juvenites kraffti* Smith, 1927

Juvenites sp.

Pl. II, Fig. 21

Measurements (mm)

Specimen number (IGPS coll. cat. no.)	D	H	W	U	H/D	W/D	U/D
109680	19.1?	8.8	–	–	0.46?	–	–

Measurements (mm)

Specimen number (IGPS coll. cat. no.)	D	H	W	U	H/D	W/D	U/D
109681	5.8?	2.5?	5.1	2.0	0.43?	0.88	0.34?

Material.—One poorly preserved specimen, IGPS coll. cat. no. 109680.

Description.—Small semi-evolute shell with arched venter and flattened flanks. Ventral shoulders rounded; umbilicus rather narrow with abruptly rounded umbilical edge. Venter and flanks ornamented with numerous radial constrictions and ribs.

Suture-line unknown.

Comparison.—The most closely comparable species is *Juvenites needhami* Tozer (1994, p. 54, pl. 22, figs. 5, 6) from the Lower Olenekian (Smithian). The main difference is that the Mongolian specimen has more involute shell. But further comparison is impossible because of lacking data of suture-line of the described species.

Distribution.—Mongolia, Lower Olenekian.

Melagathiceratidae gen. and sp. indet.

Pl. II, Figs. 22a, b

Material.—One poorly preserved specimen, IGPS coll. cat. no. 109681.

Description.—Small semi-evolute shell with broadly arched venter; venter joining with short flanks without ventral shoulders; umbilicus rather narrow with abruptly rounded umbilical edge. Venter and flanks ornamented with numerous radial constrictions and ribs, having small tubercles on the umbilical edge.

Suture-line unknown.

Comparison.—Similar fossils were recently collected by Y.D. Zakharov in Lower Olenekian sequences of the *Hedenstroemia bosphorensis* and *Anasibirites nevolini* Zones of the Abrek and Artyom sections of South Primorye. They seem to belong to a new genus and new species of the family Melagathiceratidae, which have not been described yet.

Distribution.—Mongolia, Lower Olenekian.

Superfamily Meekoceratoidea Waagen, 1895
[nom. transl. Spath, 1934 (ex Meekoceratidae Waagen, 1895)]
Family Prionitidae Hyatt, 1900

Prionitidae gen. and sp. indet.

Pl. II, Figs. 10–13

Materials.—Six poorly preserved specimens, IGPS coll. cat. no. 109682–109685.

Description.—Shell discoidal, from semi-involute, laterally compressed; venter apparently tabulate with abruptly rounded ventral shoulders; umbilicus rather narrow with rounded umbilical edge. Umbilical and central parts of the flanks covered with strong radial ribs, slightly curved in the middle parts of the flank.

Sutures shown in Figure 7. First lateral saddle somewhat lower then the second one; U-lobe with seven denticles at its base and in the lower part of a wall; middle and umbilical parts of the suture-line not preserved.

Comparison.—This species resembles some Olenekian representatives of the family Prionitidae (*Gurleyites* and *Arctoprionites*). From *Gurleyites armatus* (Welter) from the Lower Olenekian *Owenites egrediens* Beds (Block "P") in Timor (Welter, 1922, p. 135, pl. 166) and *Anasibirites nevolini* Zone of South Primorye (Zakharov, 1968, p. 127, pl. 23, fig. 9) it differs in having somewhat more evolute shell and more denticulated U-lobe; from *Arctoprionites williamsi* Tozer from the Lower Olenekian (Smithian) *Anawasatchites tardus* Zone of British Columbia (Tozer, 1994, p. 83, pl. 34, Fig. 1–4) it is distinguishable by lacking the bullae near the umbilical margin; from *Arctoprionites prontchischevi* Zakharov from the Upper Olenekian *Olenikites spiniplicatus* Zone of Arctic Siberia (Zakharov, 1978, p. 183, pl. 11, Fig. 3, 4) differs by different proportions of the lateral saddles: the first lateral saddle of Mongolian species is somewhat lower than its second lateral saddle.

Distribution.—Mongolia, Lower Olenekian.

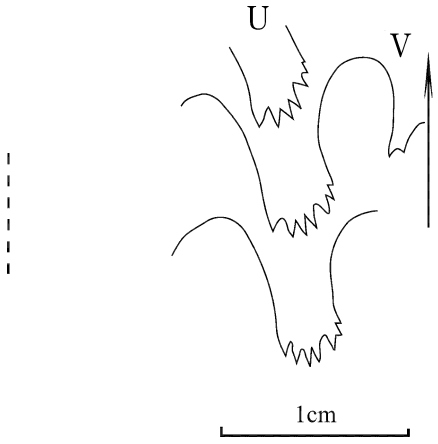

Figure 7. Suture lines of Prionitidae gen. and sp. indet., IGPS coll. cat. no. 109682, at H=28.6 mm; *Pseudoceltites* (*Saikhanites*) *khenteyensis* Bed on the southern ridge of Mt. Saikhan Undur Ovoo, Umnudelger, Khentey Province.

Superfamily Ussuritoidea Hyatt, 1900
[nom. transl. Zakharov, 1979 (ex Ussuritidae Hyatt, 1900)]
Family Flemingitidae Hyatt, 1900
Genus ***Flemingites*** Waagen, 1892

Type species.—*Ceratites flemingianus* de Konick, 1863

Flemingites ? sp. indet.

Pl. II, Figs. 14, 15

Materials.—Two poorly preserved specimens, IGPS coll. cat. no. 109686, 109687.

Description.—Shell discoidal, evolute, with rounded ventral shoulders; flanks laterally compressed; umbilicus wide, with rounded umbilical edge; surface ornamented with regular spiral ridges and radial ribs, folds and rare constrictions.

Suture-line unknown.

Comparison.—This species resembles some flemingitid ammonoids from the Lower Olenekian *Hedenstroemia bosphorensis* Zone of South Primorye described as *Flemingites radiatus* Waagen (Zakharov, 1968, p. 86, pl. 15, Fig. 2), but differs in having more evolute shell.

Distribution.—Mongolia, Lower Olenekian.

Genus ***Euflemingites*** Spath, 1934

Type species.—*Flemingites guyerdetiformis* Welter, 1922

Euflemingites ? sp. indet.

Pl. II, Figs. 16–19

Materials.—Four fragmental shells, IGPS coll. cat. no. 109688–109691.

Description.—Shell discoidal, with diameter less than 40

Measurements (mm)

Specimen number (IGPS coll. cat. no.)	D	H	W	U	H/D	W/D	U/D
109682	80?	37?	10?	18.8?	0.46?	0.13?	0.24?
109683	77?	39.2?	–	12.8?	0.51?	–	0.17?
109684	58.3	28.8?	–	12.9	0.49?	–	0.22
109685	48.5	22.1	–	14.0	0.46	–	0.29

Measurements (mm)

Specimen number (IGPS coll. cat. no.)	D	H	W	U	H/D	W/D	U/D
109686	13.2	4.8	2.5?	6.2	0.36	0.19?	0.47

Measurements (mm)							
Specimen number (IGPS coll. cat. no.)	D	H	W	U	H/D	W/D	U/D
109688	30.5?	12.6	–	10.4	0.41	–	0.34

mm, semi-evolute, with rounded venter and ventral shoulders ; flanks laterally compressed ; umbilical edge rounded ; surface with strong, regular spiral ridges, but no radial ornamentation.

Suture-line unknown.

Comparison.—In view of its shell form and sculpture ornamentation this species resembles *Euflemingites prynadai* (Kiparisova) from the Lower Olenekian *Hedenstroemia bosphorensis* Zone of South Primorye (Kiparisova, 1961, p. 76, pl. 15, Fig. 1) and *Euflemingites romundari* Tozer from the Lower Olenekian (Smithian) Blind Fiord Formation of Arctic Canada (Tozer, 1994, p. 72, pl. 25, Fig. 4 and 5). From *Euflemingites* cf. *tsotengensis* Chao from the *Flemingites-Euflemingites* Zone of the Yinkeng Formation (Tong et al., 2004, p. 200, pl. 2, figs. 13-15) it differs by more involute shell and stronger spiral ridges.

Distribution.—Mongolia, Lower Olenekian.

Family Palaeophyllitidae Popow, 1958
Genus ***Anaxenaspis*** Kiparisova, 1956

Type species.—*Xenaspis orientalis* Diener, 1895

Anaxenaspis ? sp.

Pl. II, Fig. 20

Material.—One poorly preserved specimen, IGPS coll. cat. no. 109692.

Description.—Shell discoidal, semi-evolute ; flanks gently convex ; umbilicus moderately wide with rounded umbilical edge ; flanks covered with numerous strong radial ribs.

Suture-line unknown.

Comparison.—This species is similar to *Anaxenaspis kraffti* Tozer (1994, p. 74, pl. 23, Fig. 2, 3) from the Lower Olenekian (Smithian) *Euflemingites romundari* Zone of Ellesmere Island, Arctic Canada in forms of strong and very frequent radial ribs. A comparison is impossible because of lacking information of suture-line of the Mongolian species. From *Anaxenaspis orientalis* Kiparisova (Diener, 1895, p. 41, 44, pl. 3, Fig. 3 ; Kiparisova, 1961, p. 53, Fig. 10, Fig. 1 ; Zakharov, 1968, p. 51, pl. 2, figs. 1-3, pl. 3, figs. 1, 2) it differs by its involute shell and stronger ribs.

Distribution.—Mongolia, Lower Olenekian.

Acknowledgments

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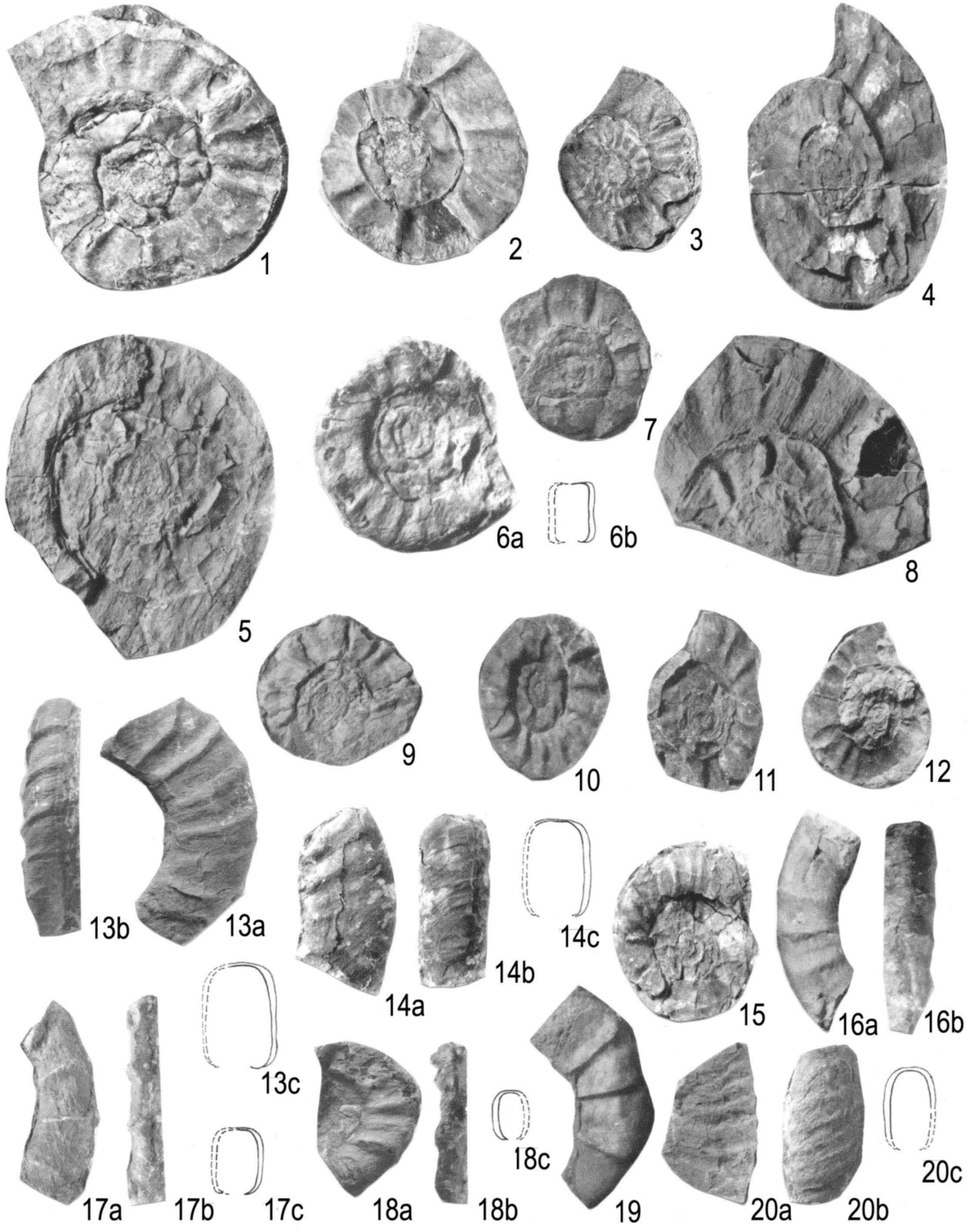
Measurements (mm)							
Specimen number (IGPS coll. cat. no.)	D	H	W	U	H/D	W/D	U/D
109692	ca. 31	9.5	–	9.2	0.31±	–	0.30±

PLATE I

Figure 1-20. *Pseudoceltites* (*Saikhanites*) *khenteyensis* sp. nov. collected from the *Pseudoceltites* (*Saikhanites*) *khenteyensis* Bed at the southern ridge of Mt. Saikhan Undur Ovoo, Umnudelger, Khentey Province, Mongolia. All figures are lateral views and approximately natural size unless otherwise stated.

1. IGPS coll. cat. no. 109651 (holotype), ×1.5 ; 2. IGPS coll. cat. no. 109655 ; 3. IGPS coll. cat. no. 109661, ×1.5 ; 4. IGPS coll. cat. no. 109653 ; 5. IGPS coll. cat. no. 109652 ; 6a-b. IGPS coll. cat. no. 109662, lateral view (a) and cross section (b), ×2.0 ; 7. IGPS coll. cat. no. 109657 ; 8. IGPS coll. cat. no. 109654 ; 9. IGPS coll. cat. no. 109658 ; 10. IGPS coll. cat. no. 109663, ×1.5 ; 11. IGPS coll. cat. no. 109665 ; 12. IGPS coll. cat. no. 109660, ×1.5 ; 13a-c. IGPS coll. cat. no. 109668, lateral (a) and ventral (part) (b) views, and cross section (c) ; 14a-c. IGPS coll. cat. no. 109664, lateral (a) and ventral (b) views, and cross section (c), ×2.0 ; 15. IGPS coll. cat. no. 109656 ; 16. IGPS coll. cat. no. 109659, lateral (a) and ventral (part) (b) views ; 17a-c. IGPS coll. cat. no. 109667, lateral (a) and ventral (part) (b) views, and cross section (c) ; 18a-c. IGPS coll. cat. no. 109670, lateral view (a) and ventral (part) (b) views, and cross section (c), ×1.5 ; 19. IGPS coll. cat. no. 109666 ; 20a-c. IGPS coll. cat. no. 109669, lateral (a) and ventral (b) views, and cross section (c), ×1.5.

Thin lines of cross sections are across the rib and broken lines denote estimated part.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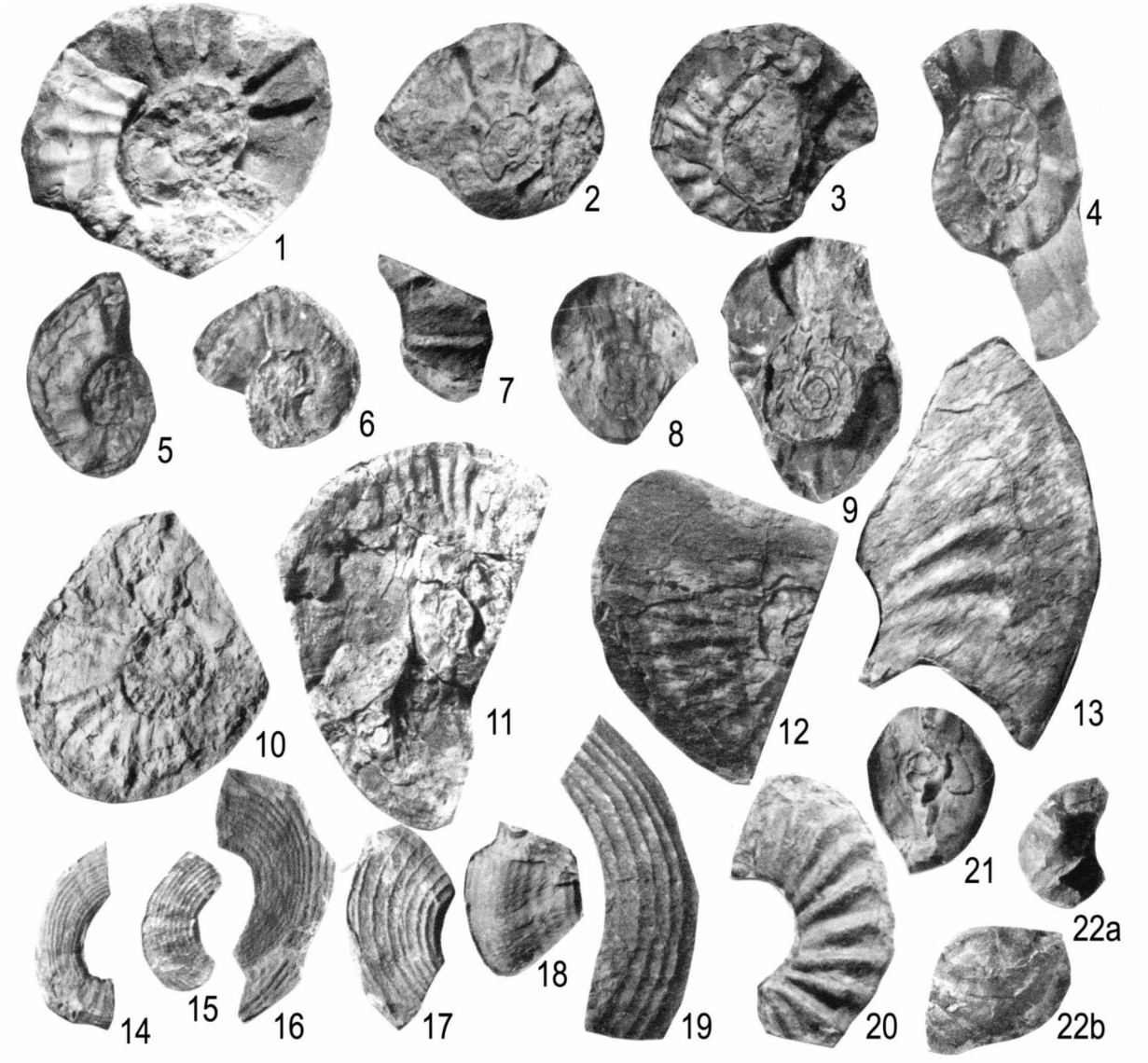

PLATE II

Ammonoids collected from the *Pseudoceltites* (*Saikhanites*) *khenteyensis* Bed at the southern ridge of Mt. Saikhan Undur Ovoo, Umnudelger, Khentey Province, Mongolia. All figures are lateral views and approximately natural size unless otherwise stated.

Figure 1–9. *Pseudoceltites* (*Saikhanites*) sp.: 1. IGPS coll. cat. no. 109672; 2. IGPS coll. cat. no. 109677; 3. IGPS coll. cat. no. 109678; 4. IGPS coll. cat. no. 109671; 5. IGPS coll. cat. no. 109674; 6. IGPS coll. cat. no. 109676, ×1.5; 7. IGPS coll. cat. no. 109679; 8. IGPS coll. cat. no. 109675; 9. IGPS coll. cat. no. 109673, ×1.5.

Figure 10–13. Prionitidae gen. and sp. indet.: 10. IGPS coll. cat. no. 109685; 11. IGPS coll. cat. no. 109682; 12. IGPS coll. cat. no. 109684; 13. IGPS coll. cat. no. 109683.

Figure 14–15. *Flemingites*? sp.: 14. IGPS coll. cat. no. 109686, ×2.0; 15. IGPS coll. cat. no. 109687, ×2.0.

Figure 16–19. *Euflemingites*? sp.: 16. IGPS coll. cat. no. 109688; 17. IGPS coll. cat. no. 109689; 18. IGPS coll. cat. no. 109690; 19. IGPS coll. cat. no. 109691;

Figure 20. *Anaxenaspis*? sp.: IGPS coll. cat. no. 109692.

Figure 21. *Juvenites* sp.: IGPS coll. cat. no. 109680, ×1.5.

Figure 22a–b. Megalaticeratidae gen. and sp. indet.: IGPS coll. cat. no. 109681, lateral (a) and ventral (b) views, ×3.0.

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