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Middle-Late Jurassic and Early Cretaceous marine fauna evolution in Eastern Russia

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Abstract
Evolution of the Middle-Late Jurassic and Early Cretaceous marine fauna in Eastern Russia and its mixed character were determined by changes in migration pattern with the Boreal, Tethyan and Pacific realms. In the Middle Jurassic it was closely linked with the Eastern Pacific which is especially characteristic for the Russian Far East. Two ambi-Pacific provinces were formed: Beringian Province in the Aalenian-Early Bajocian and North-Pacific in the Late Bajocian-Bathonian. Since the Late Bajocian the North-East of Russia was part of the Arctic Province or Subrealm. In the Late Jurassic and Early Cretaceous the Far East was an ecotone area at the boundary between Boreal and Tethyan realms. Benthic fauna belonged to the Boreal type throughout the interval considered.

Key words
Jurassic, Cretaceous, Ammonites, Bivalves, Paleobiogeography, Eastern Russia

INTRODUCTION

Middle-Late Jurassic and Early Cretaceous marine faunal associations in Eastern Russia were formed under the influence of Boreal, Tethyan and Pacific faunas, which determined the paleobiogeographic specificity of the territory. This is especially characteristic for the Far East, situated at the boundary between Tethyan and Boreal realms which determines a mixed (ecotone) type of many faunal assemblages.

Several phases are outlined in the faunal evolution of Eastern Russia, associated both with evolutionary processes and major abiotic events. The Early/Middle Jurassic boundary was crucial time in the marine paleobiota evolution of this vast region. At that time the diverse mostly pandemic Early Jurassic communities were replaced, by the markedly depauperate and monotonous Middle Jurassic fauna. This event was associated with a late Toarcian regression in Eastern and Northern Russia, closure or narrowing of the Scandinavian-Greenland interspace which resulted in disruption of links with the West European basins. Temperature lowering that started in the Late Toarcian and went on during the Middle Jurassic appears to have created a thermal barrier at the boundary with the Tethyan Realm. At the same time the connections with the Eastern Pacific became enhanced.

AALENIAN-EARLY BAJOCIAN

The basins formed by the Early Aalenian transgression became a part of the extensive Beringian Province of the Boreal Realm in the Aalenian-Early Bajocian (TAYLOR *et al.*, 1984; HILLEBRANDT *et al.*, 1992). It comprised the Far East up to the Eastern Transbaikalia, North-East and Northern Siberia within the Western Pacific as well as Northern and Southern Alaska, Canadian Arctic and British Columbia along the eastern margin of the Pacific (Fig. 1A).

The closed character of this major paleoecosystem resulted in generation of a monotonous endemic biota particularly in Eastern Russia. The European hildoceratid *Pseudolioceras* BUCKMAN, 1889, which penetrated this territory as early as the Toarcian served as an ancestral form for the specific subgenus Tugurites (SEY *et al.*, 1986). In the Aalenian-Early Bajocian the following succession has been recorded: *Pseudolioceras (P.) beyrichi* (SCHLOENBACH, 1865) (Lower Aalenian) - *P. (Tugurites) maclintocki* (HAUGHTON, 1858) (Lower Aalenian) - *P. (T.) tugurense* (KALACHEVA & SEY, 1970) and *P. (T.) whiteavesi* (WHITE, 1889) (Upper Aalenian) - *P. (T.) fastigatum* (WESTERMANN, 1969) and *P. (T.) costistriatum* (WESTERMANN, 1969) (Lower Bajocian). Judging by the abundance of the group the Far East is the dispersal centre of *Tugurites*. Among the specific Beringian taxa are also Late

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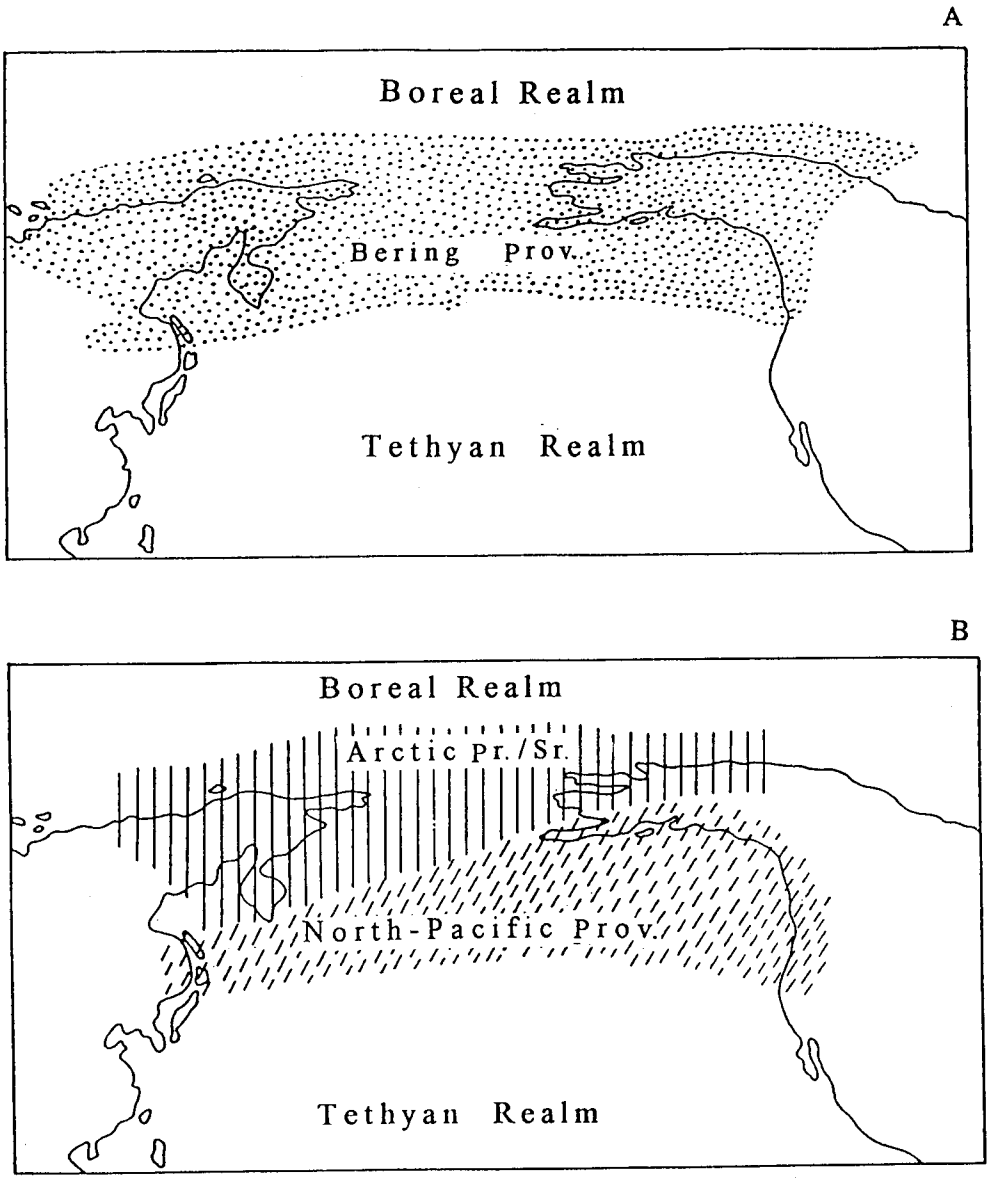
Fig. 1: Middle Jurassic ammonite biogeography of the northern Circum-Pacific: A, Aalenian-Early Bajocian; B, Late Bajocian-Bathonian.



Aalenian *Erycitoides* WESTERMANN, 1964, that are most abundant in Southern Alaska (WESTERMANN, 1964) and Early Bajocian *Arkelloceras* FREBOLD, 1957. These assemblages are less abundant in North-East Russia and particularly in Northern Siberia. They also include scarce Tethyan and pandemic elements such as *Bradfordia* BUCKMAN, 1910, *Chondroceras* MASCKE, 1907, and ? *Normannites* MUNIER-CHALMAS, 1892.

Benthonic communities were dominated by inoceramids starting with the end of the Early Aalenian. They occupied vast areas and mostly replaced all other groups of bivalves.

Along the Eastern Pacific the Beringian Aalenian and especially Early Bajocian faunas of the craton and terrains were much more diverse. Along with the typically Beringian taxa were many Tethyan and pandemic ammonites that might have penetrated there from Western Tethys via the forming Caribbean corridor (HILLEBRANDT *et al.*, 1992).

Late Bajocian-Callovian

The new crisis in biota evolution in Eastern Russia and Eastern Pacific fell on the middle of the Bajocian and was accompanied by segregation of faunas and disintegration of the Beringian Province. This event was to a

large extent determined by tectonic movements, paleogeographic rearrangements and emergence of land barriers. Uplifting of the Chukotka-Alaska block was most likely to isolate basins from most of the Pacific at the northern margin of Asia and North America. At the same time in Eastern Russia the Omolon, Okhotsk and other microcontinents and blocks were approaching each other and the Siberia craton. Uplifting of the Uda-Murgal island arc system was quite possible. Taking into account the lack of connections with the West European seas the Arctic basin appeared to be isolated from the influx of warm waters. Under conditions of a general climatic cooling the Arctic type of the fauna was formed there.

The Far East in the Late Bajocian retained close links with the East Pacific. As a result of the Beringian Province disintegration its southern part was set apart as an extensive North-Pacific Province (Athabascan Province according to TAYLOR *et al.*, 1984) with endemic eurycephalitines, peculiar stephanoceratines, perisphinctids and oppeliids (Fig. 1B). In the authors opinion it is unclear to which real realm it belongs. In the northern Far East (Bureya Basin) the Late Bajocian assemblage comprises abundant eurycephalitines – *Umaltites* KALACHEVA, 1979, (non *Megasphaeroceras* IMLAY, 1961), rarer *Epizigzagiceras* FREBOLD, 1973, *Lyroxyites* IMLAY, 1961, *Macrophylloceras* SPATH, 1927. To the south in Southern Primorye *Cobbanites* IMLAY, 1962, and *Spiroceras* QUENSTEDT, 1858, occur (SEY *et al.*, 1992).

Bathonian and Callovian in the Far East are marked by uplifts, marine regressions and appearance of semiclosed brackish basins. The few known ammonites *Loucheuxia* POULTON, 1987, are also of Eastern Pacific origin.

In the Late Bajocian-Bathonian benthos the inoceramids (often giant in size) became less abundant. Other groups of boreal bivalves, *Maclearnia* CRICKMAY, 1930, *Camptonectes* MEEK, 1864, *Modiolus* LAMARCK, 1799, etc., prevailed.

In the Arctic Province or Subrealm high-latitude faunas of cardioceratids (arctocephalitines and cadoceratines) formed in the Late Bajocian-Bathonian. These faunas were taxonomically scarce but highly abundant, for instance in Eastern Greenland and Northern Siberia. However the coeval fauna of the North-East was depauperated, only a few specimens of arctocephalitines and cadoceratines are known (REPIN & POLUBOTKO, 1996).

Callovian is noted for an extensive southward expansion of high-latitude fauna. In the Eastern Pacific it reached the latitude of Oregon. At the same time connections with European basins were restored and an enrichment of Callovian faunas in the Arctic Province got under way. Nevertheless in North-East Russia the Callovian fauna remained extremely depauperated, including rare *Cadoceras* FISCHER, 1882 and *Longaeviceras* BUCKMAN, 1918. Critical state of the ammonite fauna might have been associated with the paleopole position near the northeastern extremity of Asia, as it is presumed by many scientists.

Under the circumstance the so-called Koiverelen Callovian fauna, including the Tethyan *Lunuloceras* BONARELLY, 1893, *Putealiceras* BUCKMAN, 1922, *Choffatia* SIEMIRADZKI, 1898, is uncommon and doubtless associated with one of the Koryak terranes as it is confirmed by its tectonic position (SEY & KALCHEVA, 1983). The fauna occurs in the tectonic plate composed of tectonic slices of diverse age. One of the slices encloses ammonites. Age of other slices has been determined from radiolarian assemblages of North Tethyan or near-equatorial origin (VISHNEVSKAYA *et al.*, 1991). Coral remains in one of the slices are Kimmedgian-Tithonian. These corals could exist only in low latitudes.

Late Bajocian-Callovian Arctic artocephalitines and cadoceratines are unknown in the Far East. Rare boreal *Longaeviceras* occur in the north of the region (Western Okhotsk area).

LATE JURASSIC-VALANGINIAN

In the Late Jurassic the zoogeographic situation in the North-East did not practically change. Ammonite fauna was composed of rare *Cardioceras* NEUMAYR & UHLIG, 1881, *Amoeboceras* HYATT, 1900, and *Dorsoplanites* SEMENOV, 1898. At the same time in nearby Northern Siberia there were diverse ammonite communities. Nonetheless, ammonite migration into the North-Eastern basins was very limited. It might be explained by existence of a thermal barrier. Unlike the ammonites the Late Jurassic bivalve associations in the North-East were more diverse, buchias being dominant.

A different situation was recorded in the Late Jurassic of the Far East. At the time the ecotone character of the fauna in the region lying at the boundary between Boreal and Tethyan realms was particularly pronounced. In sections in the northern part of the region (Western Okhotsk area) a recurrent change of northern and southern ammonite faunas has been recorded: in the Early Oxfordian – *Cardioceras*, in the Middle-Late Oxfordian – *Dichotomosphinctes* BUCKMAN, 1926, in the Early Kimmeridgian – *Amoeboceras*, Late Kimmeridgian – *Ochetoceras* HAUG, 1885, Middle Volgian (Late Tithonian) – *Durangites* BURCKHARDT, 1912, (Fig. 2).

Such an alternation of migratory directions is most likely to be associated with climatic fluctuation. More tolerant benthonic communities dominated by Boreal buchias did not respond to frequent temperature fluctuations and retained a boreal aspect through the Late Jurassic.

Another type of fauna is recorded in the southern Far East – in Southern Primorye. Only sediments of the ter-

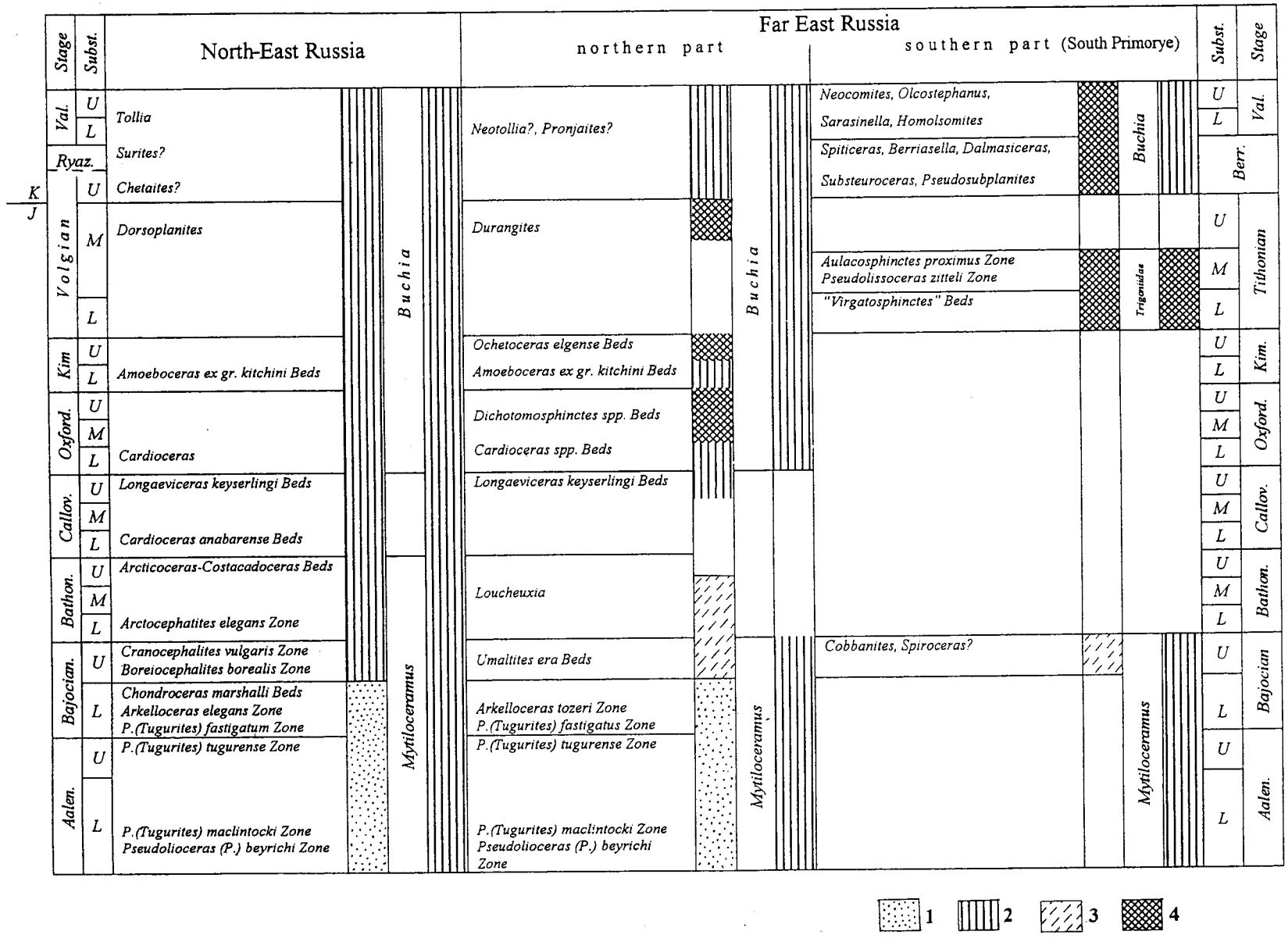

Stage
Subst.
North-Eastern Russia
Far East Russia
northern part
southern part (South Primorye)
Val.
Ryaz.
Volgian
Kim.
Oxford.
Callov.
Bathon.
Bajocian
Aalen.
Berr.
Tithonian
Kim.
Oxford.
Callov.
Bathon.
Bajocian
Aalen.
K
J
Tollia
Surites?
Chetaites?
Dorsoplanites
Amoeboceras ex gr. kitchini Beds
Cardioceras
Longaeviceras keyserlingi Beds
Cardioceras anabarense Beds
Arcticoceras-Costacadoceras Beds
Arctocephatites elegans Zone
Cranocephalites vulgaris Zone
Boreiocephalites borealis Zone
Chondroceras marshalli Beds
Arkelloceras elegans Zone
P.(Tugurites) fastigatum Zone
P.(Tugurites) tugurense Zone
P.(Tugurites) maclintocki Zone
Pseudolioceras (P.) beyrichi Zone
Buchia
Mytiloceramus
Neotollia?, Pronjaites?
Durangites
Ochetoceras elgense Beds
Amoeboceras ex gr. kitchini Beds
Dichotomosphinctes spp. Beds
Cardioceras spp. Beds
Longaeviceras keyserlingi Beds
Loucheuxia
Umaltites era Beds
Arkelloceras tozeri Zone
P.(Tugurites) fastigatus Zone
P.(Tugurites) tugurense Zone
P.(Tugurites) maclintocki Zone
Pseudolioceras (P.) beyrichi Zone
Neocomites, Olcostephanus,
Sarasinella, Homolsomites
Spiticeras, Berriasella, Dalmasiceras,
Substeuroceras, Pseudosubplanites
Aulacosphinctes proximus Zone
Pseudolissoceras zitteli Zone
"Virgatosphinctes" Beds
Cobbanites, Spiroceras?
Buchia
Trigonidae
Mytiloceramus
1
2
3
4

Fig. 2: Middle-Late Jurassic and Early Cretaceous biostratigraphy and biogeographical evolution of ammonites and main bivalve groups of Eastern Russia. Biogeographical symbols: 1, Beringian Province; 2, North-Pacific Province; 3, Arctic Province or Subrealm; 4, Tethyan Realm.

←

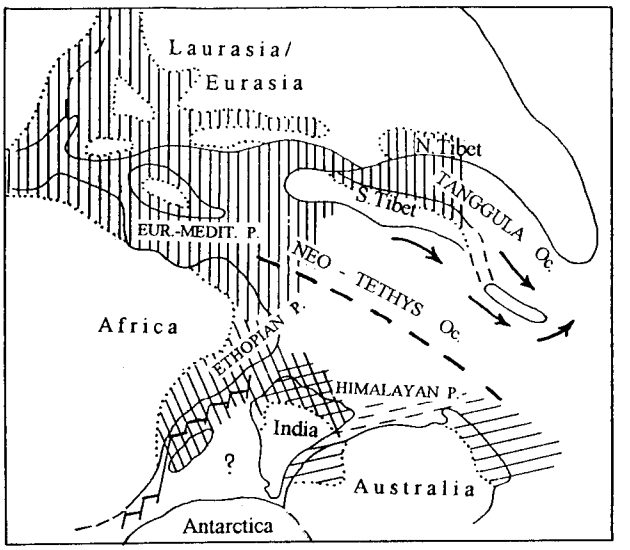
minal Upper Jurassic stage are known there; they contain a diverse assemblage of exclusively Tethyan ammonites and are assigned to the Tithonian. In the north of the region, where Boreal ammonites occur and Boreal buchias prevail, the Volgian has been established. As a consequence the problem of correlating these stages within a single region arose. Equivalency of the Tithonian and Volgian has been traditionally assumed. However there is a long-standing opinion that ranges of these stages are not equal and part of the Volgian belongs to Lower Cretaceous. Later this view has become widespread due to the works of CASEY, ZEISS, HOEDEMAEKER and other researchers. The authors have analysed the mixed Boreal-Tethyan faunas of the Far East, North America, Russian Platform, Northern Caucasus, the data on Western Europe and joined the conclusion that the Upper Volgian belongs to the Lower Cretaceous and corresponds to the lower part of the Berriasian (SEY & KALACHEVA, 1997).

The Tithonian ammonite fauna of Primorye comprises the Lower Tithonian "*Virgatosphinctes*", Middle Tithonian *Haploceras* ZITTEL, 1870, *Pseudolissoceras* SPATH, 1925, *Glochiceras* HYATT, 1900, *Semiformiceras* SPATH, 1925, *Subplanitoides* ZEISS, 1968, *Parapallasiceras* SPATH, 1925, *Lemencia* DOZE & ENAY, 1961, *Aulacosphinctes* UHLIG, 1910, *Sublithacoceras* SPATH, 1925, ? *Himalayites* UHLIG, 1904, and others. In Southern Primorye the Tethyan Lower Berriasian ammonites *Pseudosubplanites* LE HEGERAT, 1971, *Berriasella* UHLIG, 1905, *Dalmasiceras* DJANELIDZE, 1922, have also been recorded (SEY & KALACHEVA, 1996).

Both faunas are highly peculiar since they have no analogues in southeastern Asia and the American continent and are very similar to the ammonite associations of Mediterranean and Submediterranean provinces of Western Tethys. In the neighbouring countries of South-East Asia the East Tethyan taxa prevail and determine the Himalayan or Indo-Malgach Province (HILLEBRANDT *et al.*, 1992).

Recently two more ammonite assemblages, including the typical South European elements, have been recorded in South-East Asia. One of them has been reported from northwestern India (Zanskar area) (OLORIZ & TINTORI, 1990) and includes, along with "*Virgatosphinctes*" and *Aulacosphinctes*, European *Parapallasiceras*; the latter is identical to the Primorye specimens. The other assemblage of Lower Berriasian age has been found in southern China (Southern Tibet) near the Nepal border and is mainly composed of European species of *Berriasella* (LIU GUIFANG & WANG SIEN, 1987).

Fig. 3: Middle-Late Jurassic geodynamic map of southeastern Asia (modified from WESTERMANN & WANG, 1988). Arrows indicate the possible migratory direction of West-Tethyan ammonites into Far East Russia.



European taxa most likely migrated along the northeastern margin of the Tethys as far eastwards as the Far East. The migration can be shown in geodynamic map proposed by SENGÖR, WESTERMANN and other workers (WESTERMANN & WANG, 1988). According to that map, Tethys in the Middle-Late Jurassic comprised the Neo-Tethyan Ocean and Tanggula Ocean, separated by the Southern Tibet terrain. The Mediterranean ammonites could migrate both along the southern and northern margins of the terrain (Fig. 3).

Early Cretaceous marine communities of the Far East occur within the Sikhote-Alin terranes. They retain a clearly ecotone character. Among the ammonites the Pan-Tethyan *Spiticeras* UHLIG, 1903, *Sarasinella* UHLIG, 1905, *Neocomites* UHLIG, 1905, *Olcostephanus* NEUMAYR, 1875, and *Thurmanniceras* COSSMANN, 1901, prevail. Presence of South European *Fauriella* NIKOLOV, 1966, is possible. In the Berriasian they are joined by the Pacific *Substeuroceras* SPATH, 1923, and *Parodontoceras* SPATH, 1923. In Northern Sikhote-Alin rare Boreal *Tollia* PAVLOW, 1913, and *Homolsomites* CRICKMAY, 1930 are known. Benthonic fauna is totally dominated by buchias, in Southern Primorye as well.

Ammonite faunas of the North-East in the Early Cretaceous remain exceptionally pauperate and include

rare finds of typical Boreal taxa ? *Chetaites* SCHULGINA, 1961, ? *Surites* SASONOV, 1951, *Tollia* PAVLOW, 1913 (POKHIALAYNEN, 1994). Buchias retain their predominance among the bivalves.

CONCLUSION

In summary, in the Aalenian and Early Bajocian the ammonite faunas of Eastern Russia were closely associated with coeval faunas of Eastern Pacific, forming the ambi-Pacific Beringian Province. The Far East retained these connections during the Bajocian and Bathonian. Since Late Bajocian the North-East was part of the Arctic Province of the Boreal Realm. In the Late Jurassic and Early Cretaceous the Far East was a transitional zone between the Boreal and Tethyan realms.

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