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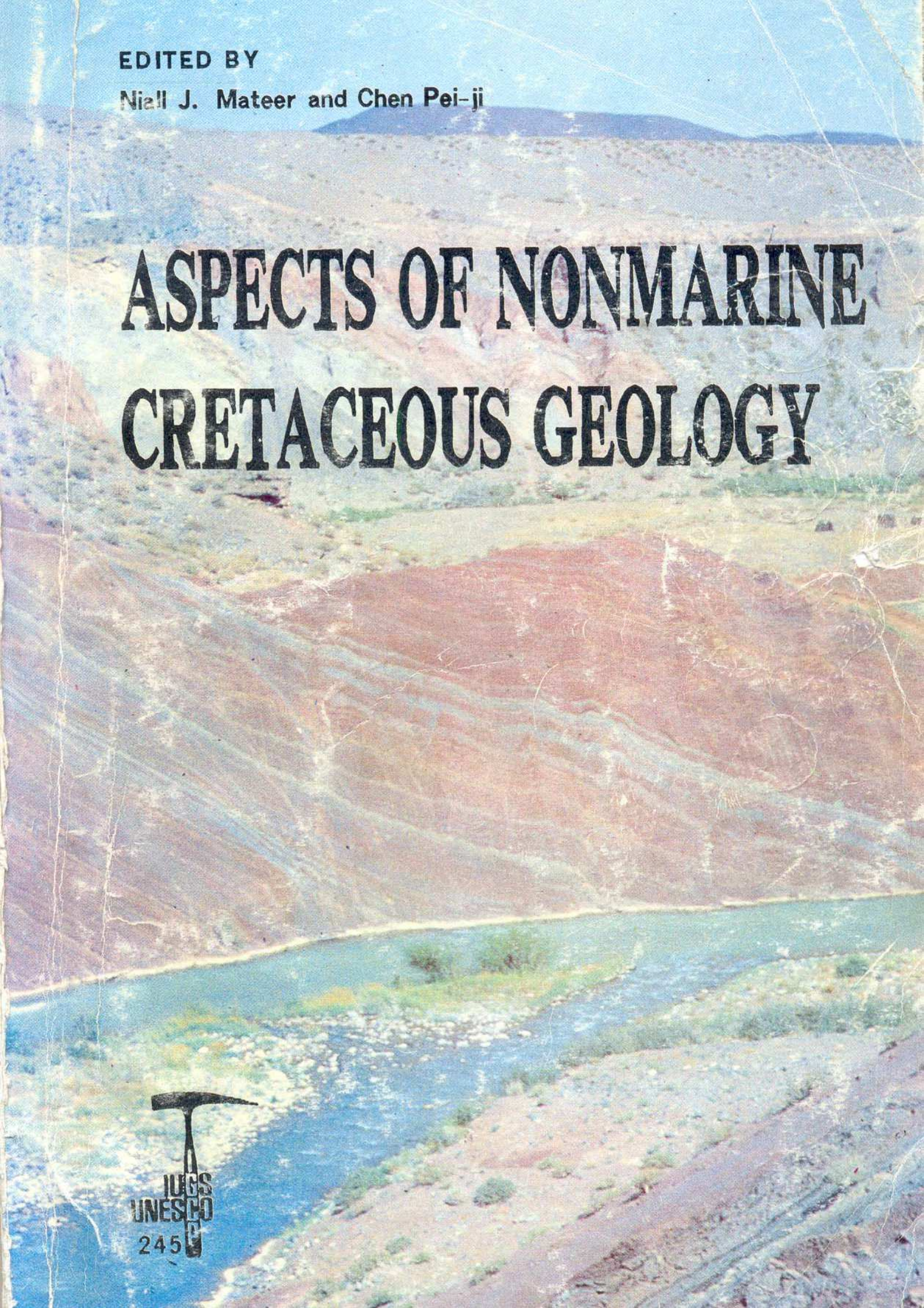
ASPECTS OF NONMARINE CRETACEOUS GEOLOGY



The Early Cretaceous flora of Transbaikalia

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ABSTRACT

The nonmarine Cretaceous deposits of Transbaikalia are divided into the Turginian and Kutinskian suites which contain plant megafossils which indicate late Neocomian to Aptian, and Aptian-Albian ages, respectively. The florisfloristc succession suggests a cooling during Kutinskian time. Evidence for this is also found in the migration of the temperate-subtropical ecotone some 200 km to the south.

INTRODUCTION

Despite almost a century of study on the Transbaikal flora, it has been considered of limited biostratigraphic value for Mesozoic strata in eastern Asia. The opinion that this flora was both endemic and transient in nature was a result of random sampling and preliminary identifications by various workers. For example, Prynada (1962) believed that the Turginian flora consisted of only five species of little biostratigraphic importance: *Czekanowskia* cf. *rigida* Heer, *Baiera* sp., *Pityophyllum* cf. *solmsii* Sew., *Pityospermum turgense* Pryn., and *Pityospermum* sp.

There is no complete section in Transbaikalia in which vegetational change during the Jurassic and Cretaceous can be observed. The upper Mesozoic of local basins is represented by volcanogenic, volcanoclastic, and coal-bearing rock units. Freshwater continental sediments were deposited on a heterogenous basement including well-dated Lower Jurassic marine beds. Isolation of basins, structural contacts between series and formations, and facies variations hinder correlations and lead to acute discrepencies between stratigraphic results utilising different groups of the lake fauna. Such stratigraphic schemes have been outlined by Kolesnikov (1964), Oleinikov (1975), and Zherikhin (1978). Recent K-Ar dating on the volcanic sequences has been done, but results have not yet been forthcoming.

PLANT ASSEMBLAGES AND THEIR CORRELATION

Plant megafossils from 37 localities in the Undino-Dainian, Ust-Karskian, Serebrjanskian, Argunskian, Elizavetinskian, Turgino-Kharanorskian, Chitino-Ingodinskian and Zazinskian basins permitted four Jurassic and Early Cretaceous floral complexes to be distinguished (Fig. 1). These are, according to lithostratigraphical subdivisions proposed by 'Chitageologia' geologists (Sinitsa and others, 1984): Shadoronskian, Undino-Dainian, Turginian and Kutinskian.

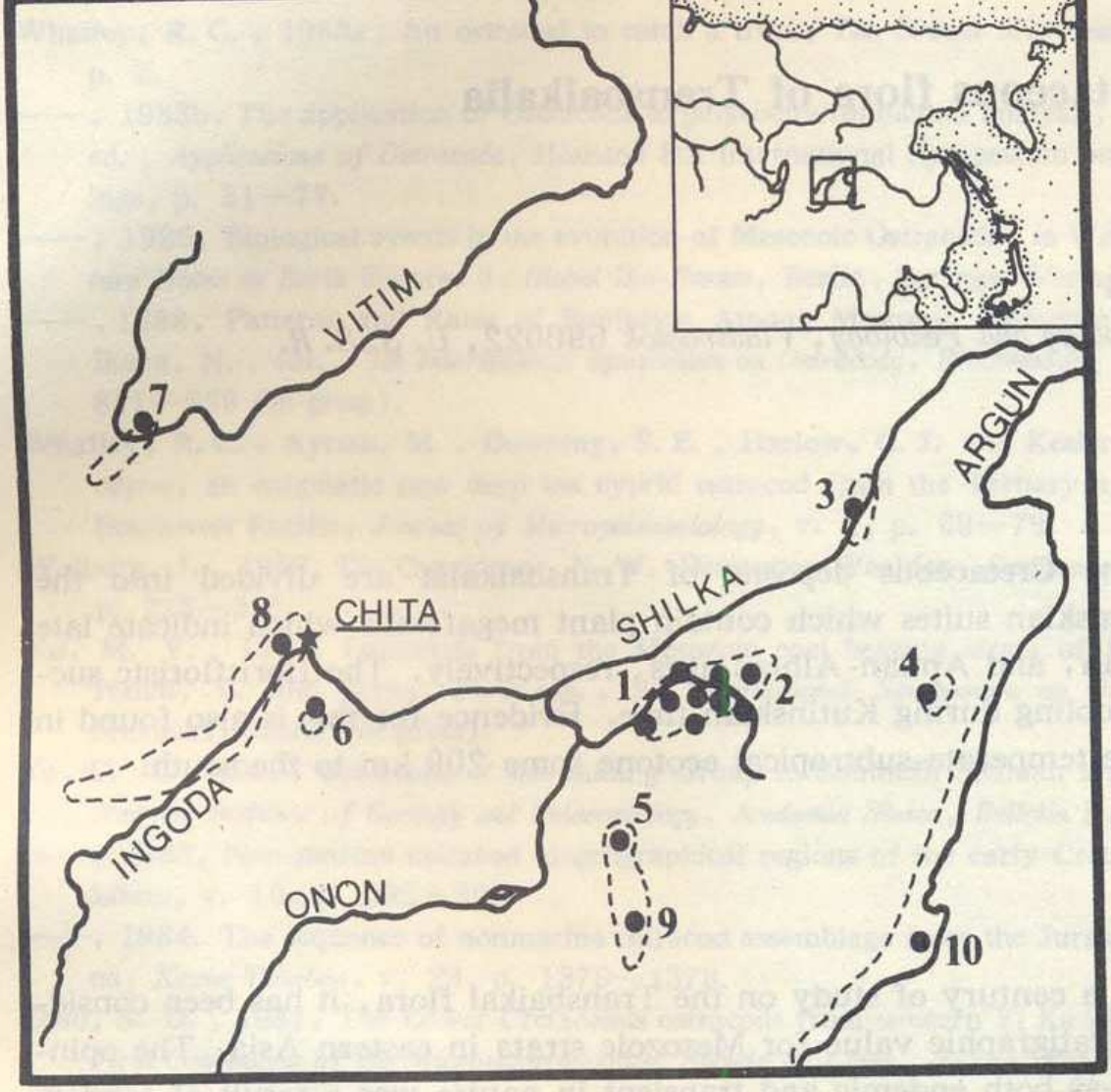

Figure 1. Map showing collection localities. 1——Several localities of the Shadoronskian and Undino-Dainian from the Undino-Dainian depression; 2—— Shivia locality, Undino-Dainian depression; 3—— Ust-Karskian depression; 4—— Serebrjanskian depression; 5—— "Middendorf" locality (stratotype of the Turginian Formation), Turgino-Kharanorskian depression; 6—— Semen locality, Elizavetinskian depression; 7—— Baisa locality, Zazinskian depression; 8—— Chernovskian quarry, Chitino-Kharanorskian depression; 9——Kharanorskian quarry, Turgino-Kharanorskian depression; 10——Kutinskian quarry, Argunskian depression.

Shadoronskian and Dainian Assemblages

The section of the upper Mesozoic in Transbaikalia is mostly represented in the Undino-Dainian basin where the sequence starts with Shadoronskian age sediments. Plants similar to those from the Talynzhanskian comlpex of the Bureja basin, which indicate an uppermost Middle Jurassic age, were identified from the upper part of the Shadoronskian series (Krassilov, 1973).

The overlying Undino-Dainian Series contains a flora characterized by horsetails and conifers, but does not permit a detailed age assignment. Nevertheless, there appears to be a change of dominant forms at the Shadoronskian-Dainian boundary. The lower Shadoronskian is dominated by *Phoenicopsis*, whereas *Czekanowskia* predominates in the upper part. The cycadophyte *Heilungia* and various species of ferns are also commonly found. Conifers dominated the forest vegetation and are primarily represented by samaras and, less commonly, by cones and needles. The coastal vegetation consisted mainly of horsetails, possibly forming a type of horsetail filter retarding the supply of other plant remains.

limnobiota and facies, the latter changing from predominantly andesitic volcanogenic and alluvial deposits to trachyandesitic (latite) and lacustrine deposits. This is a most important boundary in the evolution of terrestrial and freshwater ecosystems of Transbaikalia, and may coincide with the Jurassic-Cretaceous boundary.

Turginian Assemblage

The next stage in the evolution of the Transbaikal flora is represented by the Early Cretaceous Turginian assemblage (Bugdaeva, 1984). Plant fossils from the following localities are included in this assemblage -1) Middendorf locality, Turga river in the Turgino-Kharanorskian basin; 2) Semen locality in the Elizavetinskian basin, near Chita; 3) Shivia in the Undino-Dainian basin; 4) Baisa in the upper reaches of Vitim river. This assemblage is highly diverse, in particular cycadophytes and various conifers. Principal index fossils are *Baisia hirsuta*, *Pseudolarix*, and a bennettite *Otozamites lacustris* (Krassilov and Bugdaeva, 1982). Strata of the upper Selenginskian member in the Gusinoe Lake region (in western Transbaikalia) can be correlated with the Turginian series. These strata contain Turginian forms, such as *Cladophlebidium dahuricum*, *Podozamites eichwaldii*, and *Samaropsis* cf. *rotundata*, the former being from the Semen locality, and the latter two being from Baisa. Srebrodolskaja (1983) considered the age of the Semen flora as Aptian-Albian, whereas Vakhrameev and Kotova (1977) view the Baisa flora as Barremian-Aptian.

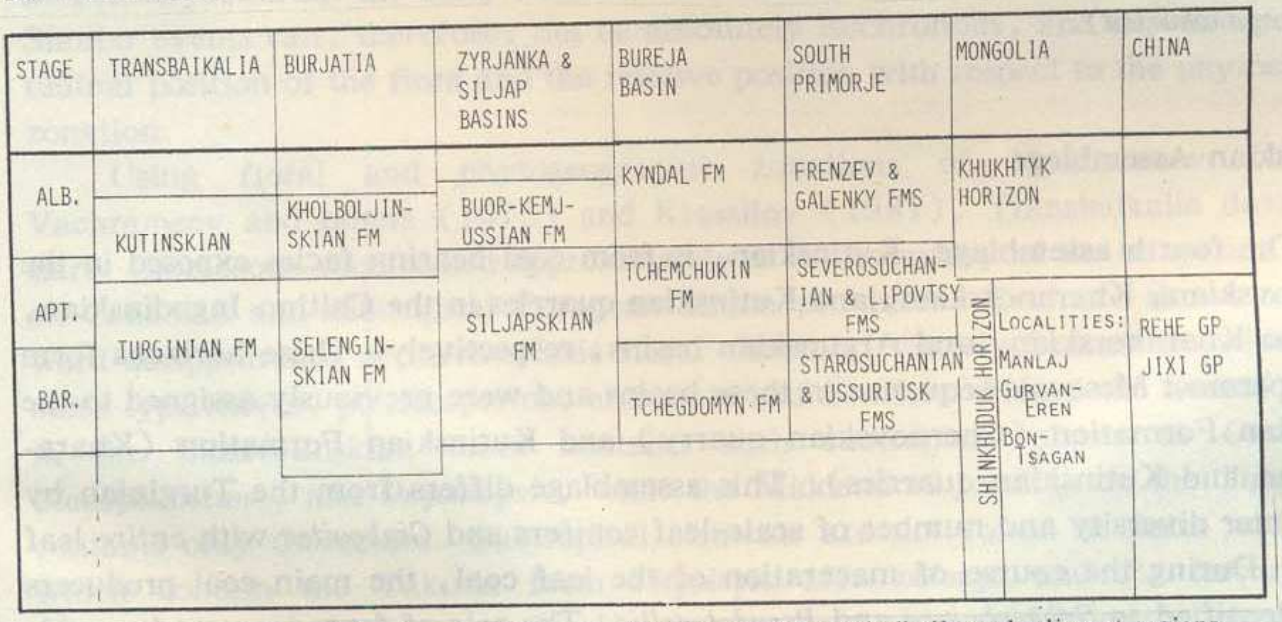

Figure 2. Correlation of the Lower Cretaceous formations of Transbaikalia and adjacent regions.

The significant systematic diversity of the Turginian flora facilitates correlation with adjoining regions (Fig. 2). Related floras, notably *Neozamites* and *Cladophlebidium*, occur in the Tchegdomyn and Tchemchukin formations of the Bureja basin, the age of which is between Barremian and Aptian. The Ussurijsk (Barremian) and Lipovtsy (Aptian) formations of southern Primorye, and the Severosuchanian Formation (Aptian) of Partizansk basin, both contain *Cladophlebidium dahuricum* (Krassilov, 1967).

Four characteristic complexes are recognized in the Early Cretaceous flora of Mongolia: 1) *Baiera manchurica* (Berriasian ?); 2) *Otozamites lacustris-Pseudolarix*

erensis (Barremian-Aptian); 3) *Bairella hastata-Araucaria mongolia* (Aptian); 4) *Limnothetis-Limnoniobe* (Aptian to ? early Albian).

The leaves of *Otozamites* and *Pseudolarix* have been found in at the Middendorf locality (Turga) and Semen localities, and morphological and epidermal studies of show a similarity with *Otozamites lacustris* from Mongolia. These plants permit correlation of the Turginian flora with the Early Cretaceous Mongolian flora from Bon-Tsagan, Manlaj, and Gurvan-Eren (Krassilov, 1982).

In the Jurassic of northern China and, in particular, the Jurassic-Cretaceous boundary, formations such as the Longzhaogou, Jixi, and Rehe (e. g., Li and others, 1982), were compared with approximately equivalent Japanese, Mongolian, and Soviet sequences. Some Chinese workers are of the opinion that the Turginian sequence is Late Jurassic in age, thus coeval with the Tchaganyi and Tsagantsab formations. The Turginian sequence would correlate with the northern China Yunshan and Longjiang formations (Li and others, 1982) in addition to the Khingan and lower Zhidan groups. However, it is apparent that from the floral lists of Li and others (1982) that it is difficult to compare these Chinese formations with the Turginian. For example, the Yunshan Formation contains Jurassic forms such as *Coniopteris vsevolodii*, *Raphaelia diamensis*, and *Ginkgoites sibiricus*. It is here suggested that correlation with the Shadoronskian series would be more appropriate. Many Chinese stratigraphers regard the upper part of the Rehe and Jixi groups as Cretaceous, a view concured with here since they contain common floral components with the Turginian sequence (e. g., *Coniopteris setacea*, *Neozamites verchojanensis*, and *Baiera manchurica*).

Kutinskian Assemblage

The fourth assemblage, Kutinskian, is from coal-bearing facies exposed in the Chernovskian, Kharanorskian, and Kutinskian quarries in the Chitino-Ingodinskian, Turgino-Kharanorskian, and Argunskian basins, respectively. These horizons form the uppermost Mesozoic sequence in these basins and were previously assigned to the Tigninian Formation (Chernovskian quarry) and Kutinskian Formation (Kharanorskian and Kutinskian quarries). This assemblage differs from the Turginian by the greater diversity and number of scale-leaf conifers and *Ginkgoites* with entire leaf blades. During the course of maceration of the leaf coal, the main coal producers were identified as *Sphenobaiera* and *Pseudotorellia*. The role of ferns increased considerably. *Czekanowskia*, common in underlying beds, is absent in the Kutinskian Formation. Overlying the main productive coal bed at the Kharanorskian locality, there is a leaf bed containing the bennettite *Nilssoniopteris* aff. *prynadae* known also from the Buor-Kemussian Formation of the Zyryanka basin (Samylina, 1964). Although no fossil angiosperms were found, the pollen *Asteropollis asteroides* was found in this bed by Sirotenko (oral commun.).

Inasmuch as differences in floras are mostly quantitative and largely agree with the general scheme of phytoclimatic evolution, a significant hiatus between the Turginian and Kutinskian formations is not expected. The absence of common species in the Early Cretaceous of Mongolia and the coeval coal-bearing strata of

time. However, it should be noted that many conifers with scaled leaves, such as *Brachyphyllum* and *Pagiophyllum*, which are characterisitc of the upper part of the Bon-Tsagan and Shin-Khuduk formations in Mongolia, have been found in the Turgino-Kharanorskian basin.

The analogous succession of Lower Cretaceous floral assemblages of Transbaikalia and Mongolia, with the appearence of such characteristic plants as *Otozamites* in the middle part, and the increase in scale-leaf conifers in the upper part, gives grounds for the correlation of the Turginian assemblage with the Bon-Tsagan 23, Manlay, and Gurvan-Eren assemblages. Furthermore, the Kutinskian can also be correlated with the Bon-Tsagan 45 and Shin-Khuduk 60 assemblages dated as Neocomian and Aptian, respectively.

PALAEOCLIMATIC INTERPRETATION

In addition to comparing the systematic composition of these assemblages, there is another promising method of correlation; this is the use of cliseria, or climatically controlled succession of plant assemblages. Analysis of relatively well-studied floras from the Primorye and Bureja basins indicate a climatic optimum in the Berriasian and Aptian (high cycadophyte index values). A sharp increase in occurrence of *Ginkgoites* indicates a migration from uplands to lowlands, thus a cooling took place in Primorye during the early Albian, and during the Aptian in the Bureja basin. Similar events can, therefore, not be absolutely isochronous, and depend upon latitudinal position of the flora and the relative position with respect to the phytoclimatic zonation.

Using floral and phytogeographic zonations of Vachrameev (1964) Vachrameev and others (1975) and Krassilov (1981), Transbaikalia during the Early Cretaceous was located approximately at the boundary of the temperate Siberian-Canadian and subtropical European-Sinian provinces. Evidence shows a northward disappearence of thermophilic floral elements, namely bennettites with *Otozamites*-type leaves, pteridosperms, and scale-leaf conifers. Hence the Semen locality in the Elizavetinskian basin contains such subtropical plants as *Otozamites*, *Cladophlebidium*, and *Onychiopsis*, while the Middendorf locality on the Turga river contains only *Otozamites*. Subtropical elements are not found in Baisa and Shivia which contain the Yakutia form *Pityolepis* aff. *oblonga* and *P. tsugaeformis*. *Cladophlebidium dahuricum* and *Onychiopsis* have been recovered from the upper Selenginskian member in the Gusinoe Lake series. The boundary dividing localities of frequent and infrequent occurrences of thermophilic plants is just north of 50°N, between Baisa and Shivia in the north, and Semen, Turga, and Gusinoe Lake in the south.

Despite the small number of localities, the change in the Kutinskian flora vegetation from south to north is apparent. The inverse ratio of *Ginkgoites* and conifers is evident in northern and southern quarries; namely the predominance of *Ginkgoites* in Chernovskian deposits, lesser abundance in Kharanorskian, and scarcity in the southernmost Kutinskian quarry (*Ginkgo* ex. gr. *huttonii* being reported from the latter by Pistsov, 1966). In addition to *Desmiophyllum*, the conifers *Pseudolarix*, *Taxo-*

norskian and Kutinskian).

Judging from the cycadophyte and pteridosperms diversity, the climatic optimum during the Late Cretaceous occurs within Turginian time. During Kutinskian time predominance of *Ginkgoites*, reduction of the cycadophyte index, and shift of thermophilic forms approximately 200 km to the south, indicate initiation of cooling. This shift may be presumed to have taken place between the late Aptian and early Albian. The Transbaikalia flora occupies an intermediate position between Bureja basin and southern Primorye.

On the strength of the above evidence, it is here suggested that a Barremian-Aptian age for the Turginia flora seems probable, whereas the main coal accumulation occured in late Aptian to Albian time.

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