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# Cretaceous Ecosystems and Their Responses to Paleoenvironmental Changes in Asia and the Western Pacific

## Short Papers



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# **Cretaceous Ecosystems and Their Responses to Paleoenvironmental Changes in Asia and the Western Pacific**

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Edited by O.S. Dzyuba, E.B. Pestchevitskaya and B.N. Shurygin

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The book contains materials of the reports submitted to the Fourth International Symposium of International Geoscience Programme (IGCP) Project 608. Theoretical, methodical and practical questions of Cretaceous paleogeography, paleontological characteristics and stratigraphy of different regions of Asia and the Western Pacific are discussed. The significant attention is given to the Cretaceous climate and environmental changes, biogeography, biodiversity of terrestrial and marine ecosystems, and vertebrates of Asia and Western Pacific.

This book will be of interest to a wide range of geoscientists who study the Cretaceous Period.

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Cover illustration: *Psittacosaurus sibiricus*. Painting by Andrey A. Atuchin

## First flowering plants in Primorye region (Russia)

E.B. Volynets<sup>1</sup>, E.V. Bugdaeva<sup>1</sup>, V.S. Markevich<sup>1</sup> and T.A. Kovaleva<sup>1,2,3</sup>

<sup>1</sup>Institute of Biology and Soil Science, Far Eastern Branch of RAS, pr. 100-letiya 159, Vladivostok 690022, Russia; e-mail: volynets61@mail.ru

<sup>2</sup>Research Center of Paleontology & Stratigraphy, Jilin University, Changchun 130026, China

<sup>3</sup>Key Lab of Past Life & Environment in NE Asia, MOE, Changchun 130026, China

The interaction between biotic and abiotic processes during the Cretaceous was best pronounced in Primorye region located at the boundary of temperate and subtropical zones. The mid-Cretaceous deposits here are widely distributed in the Alchan River, Partizansk and Razdolnaya River basins. Their sedimentary sequences were formed under different conditions. In the eastern part of this area, since the Aptian time the largest sea transgression began. Marine biota was of the Tethyan type. In North-West Pacific region, the first Ocean Anoxic Event (OAE1), which was recorded both in the ocean and epicontinental basins, occurred in the Aptian–Albian time. The beginning of the Albian was marked by maximum transgression. The predominant biota of epicontinental basins was represented by bivalves (*Aucella* and *Inoceramus*) and ammonites typical of North-Pacific Province. The sediments of Alchan River, Partizansk and southern part of Razdolnaya River basins accumulated under influence of sea; the northern part of the latter was developed as intracontinental basin.

Any variation in deposition and climatic conditions resulted in abrupt changes in the taxonomic composition of fossil floras. The Aptian fossil flora of the Primorye region was characterized by high diversity, considerable share of thermophilic elements, and maximum values of cycadophyte index suggesting obvious trend to increase in temperature. Since the Early Albian a volcanic activity within this region gradually increased, being maximum in the mid-early Late Albian. At this time, the sea regression and expansion of continental environments were recorded. The vegetation typical of humid climate deteriorated. The diversity of terrestrial floras decreased; the number of thermophilic elements dropped, and values of cycadophyte index reduced. Intensification in a volcanic activity caused the formation of specific floras. The Late

Albian flora was taxonomically most diverse including subtropical elements. At the Early–Late Cretaceous boundary, the significant geological events (a lull in volcanic activity of the Sikhotealin volcanic belt, a change in nature of sedimentation) and climatic changes (climate became warmer and more humid) occurred.

The events that occurred in both marine and continental ecosystems are believed to be synchronous and are considered as reflecting climatic evolution and tectogenesis.

Flowering plants in the geological record of Primorye region first appeared in the Aptian of the Razdolnaya River Basin. The angiosperm remains are almost entirely restricted to sandstone or sandy beds with cross-bedding or cross-lamination, or light-gray mudstone beds representing weathered volcanic ash. In contrast, only conifer, cycadophyte and fern remains are found in equivalent finer-grained, parallel-bedded units. It is possible to recover their remains from tuffaceous mudstone, because that ash fall covered all area of basin. The environmental interpretation of these deposits can evidence about the early angiosperm ecology. These plants apparently colonized disturbed surfaces of the land such as riparian settings or place of accumulations of fallen volcanic ash.

Most recently, we have found new remains of the flowering plants in the Late Aptian (probably, Late Aptian–Early Albian) deposits in the Razdolnaya River Basin, belonging to the Lipovtsy Formation (Bugdaeva et al., 2014; Kovaleva et al., 2016). The earliest angiosperms of Primorye region are represented by leaves of *Dicotylophyllum* sp. (Podgorodnenka coal field – Sokol Bay, nearly Vladivostok City) and by dispersed cuticle of indeterminable platanoids (Porechye coal mine and nearly Dongning City, China). The extremely rare Aptian angiosperm leaves are generally small, have disorganized venation, and are largely restricted to sandy and coaly stream margin lithofacies.

Throughout the Aptian and probably Lower Albian corresponding to the Lipovtsy Formation, palynoflora consists almost entirely of pteridophyte spores and gymnosperm pollen. In other localities of the Lipovtsy Formation, such as Porechye mine and outcrop nearby Dongning City, the Dongning Formation, the Chinese part of the Razdolnaya River Basin, the upper part of the Staryi Sutschan Formation of the Partizansk Coal Basin, tricolpate, tricolporoidate, and monosulcate pollen grains of recognizably angiospermous affinities occur. The earliest angiosperm pollen is represented by *Clavatipollenites hughesii* Coup., *Tricolpites micromunus* (Groot. et Penny) Singh, *T. vulgaris* (Pierce) Sriv., *T. variabilis* Burg., *Tricolpites* spp., *Quercites sparsus* (Mart.) Samoil., *Retitricolpites vulgaris* Pierce, *R. georgiensis* Brenn., and *Fraxiniopollenites variabilis* Stanl. in Razdolnaya River Basin. *Asteropollis asteroides* Hedl et Norris and *Cyclusphaera psilata* Volkh. et Sepul. were found in Partizansk Coal Basin.

It may be noted that there is co-occurrence of the above-mentioned morphotypes, although in the Potomac Group of North America monosulcates appear earlier and were described as older pollen types (Hickey and Doyle, 1977). They include small, finely columellar grains with granular sulcus membranes (*Clavatipollenites hughesii*).

We did not reveal megafossils of flowering plants in the Aptian of the Alchan River and Partizansk basins. The sediments of this age accumulated in environments of seaside plains under marine influence.

During the Albian, the thermophilic bennettitaleans lose their importance and vacate ecological niches in the brushwood and under a canopy of coniferous forests; these niches were actively colonized by angiosperms. The Albian palynofloras in the Alchan and Partizansk River basins contain rapidly diversifying tricolpate pollen and several new assemblages of locally abundant angiosperm leaves.

In the Cenomanian the flowering plants dominate in the plant communities of Razdolnaya River, Alchan River, and Partizansk River basins. Aquatic plants *Potamogeton*, *Quereuxia*, and *Cobbania* appeared in the Alchan River Basin.

The first morphotypes of dicot leaves were Laurifolia and Rosifolia. Ranunculifolia and

Platanifolia were added to them in the Albian. Morphotype *Nymphaefolia* appears in the Cenomanian, the importance of *Platanifolia* increases (Volynets, 2005).

There is an opinion that the early flowering plants were “weeds”. This fact was supported by findings of angiosperms in the Partizansk (Krassilov and Volynets, 2008) and Alchan River (Bugdaeva et al., 2006; Volynets, 2005) basins. V.A. Krassilov and E.B. Volynets (2008) described a new plants *Achaenocarpites capitellatus* and *Ternaricarpites floribundus* (morphotype *Ranunculifolia*) from the Late Albian of Primorye. These plants composed the pioneer communities colonizing a surface of volcanic ash.

An important aspect of our study has been an attempt to draw inferences on the paleoecology of early angiosperms from the types of sediment in which their remains are preserved. Depositional settings for sedimentary sequences containing the first flowering plants included river valleys and area after volcanic ash falls. The appearance, invasion and wide spread of these plants in the plant communities took place during the deterioration of climatic and environmental conditions.

Morphological, stratigraphic, and sedimentological analyses of the Early Cretaceous pollen and leaf sequences from Alchan River, Partizansk and Razdolnaya River basins of Primorye region show an approximate scheme of the adaptive radiation of the early angiosperms and suggest the ways of their initial ecological and systematic diversification.

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