Migration of Depozones within the Northern Part of the Priverkhoyansk Foreland Basin – Possible Analog to McMurray Formation

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Summary

The Tithonian to Aptian sedimentary succession filling in the Priverkhoyansk foreland basin was studied in detail. The obtained field and analytical data including sedimentary stuructures, petrological and zircon dating studies made it possible (i) to define precisely the timing of onset of the foreland basin subsidence, (ii) to recognize source area and clarify type of rocks there, and (iii) to establish weathering rates and reworking patterns. Our interpretation indicate that changes in sedimentary succession through Tithonian to Aptian directly correlate with change from distal foredeep to proximal foredeep sedimentation, resulting in migration of depozones in westward direction (direction of thrust belt propagation). This integrated basin analysis geoscience approach may serve as an analog to other foreland basins worldwide.

Introduction

The study area is located on the eastern margin of the Siberian craton, in the northern part of the Priverkhoyansk foreland basin. It extends for 1100 km separating the Verkhoyansk fold-and-thrust belt (FTB) to the east from the Siberian craton to the west (Fig. 1a). The Verkhoyansk FTB forms a part of the margin of a wide Mesozoic to Cenozoic orogenic belt which extends far to the east to the coast of the Pacific Ocean (Parfenov et. al, 1995). Folding in the Verkhoyansk FTB formed as a result of late Mesozoic collision between the Siberian craton and the Kolyma-Omolon superterrain. Close to the Siberian craton, the Verkhoyansk FTB is composed mainly of Carboniferous and Permian deposits. Triassic and Jurassic deposits are widespread only further to the east from the study area.

Evolution of the Priverkhoyansk foreland basin is closely related to evolution of the Verkhoyansk FTB with westward progradation of thrusts culminated in the formation of frontal thrust at the boundary of the

Siberian craton. The previous study was mainly focused on structural analysis and tectonics of the Priverkhoyansk foreland basin and adjacent FTB (Parfenov et al., 1990, Prokopiev & Deikunenko, 2001). Folding in the Verkhoyansk FTB is believed to begin in late Jurassic time. From Late Jurassic to Early Tertiary time west-vergent thrusting and folding confined primary Upper Paleozoic to Upper Jurassic sedimentary succession.

Detailed facies and stratigraphic analyses are possible because of excellent exposures along the banks of the Lena River, which are located on Chekurovka Cape (key section) and Chucha Cape (fig. 1b). The additional study was done along the banks of the Aekit R.

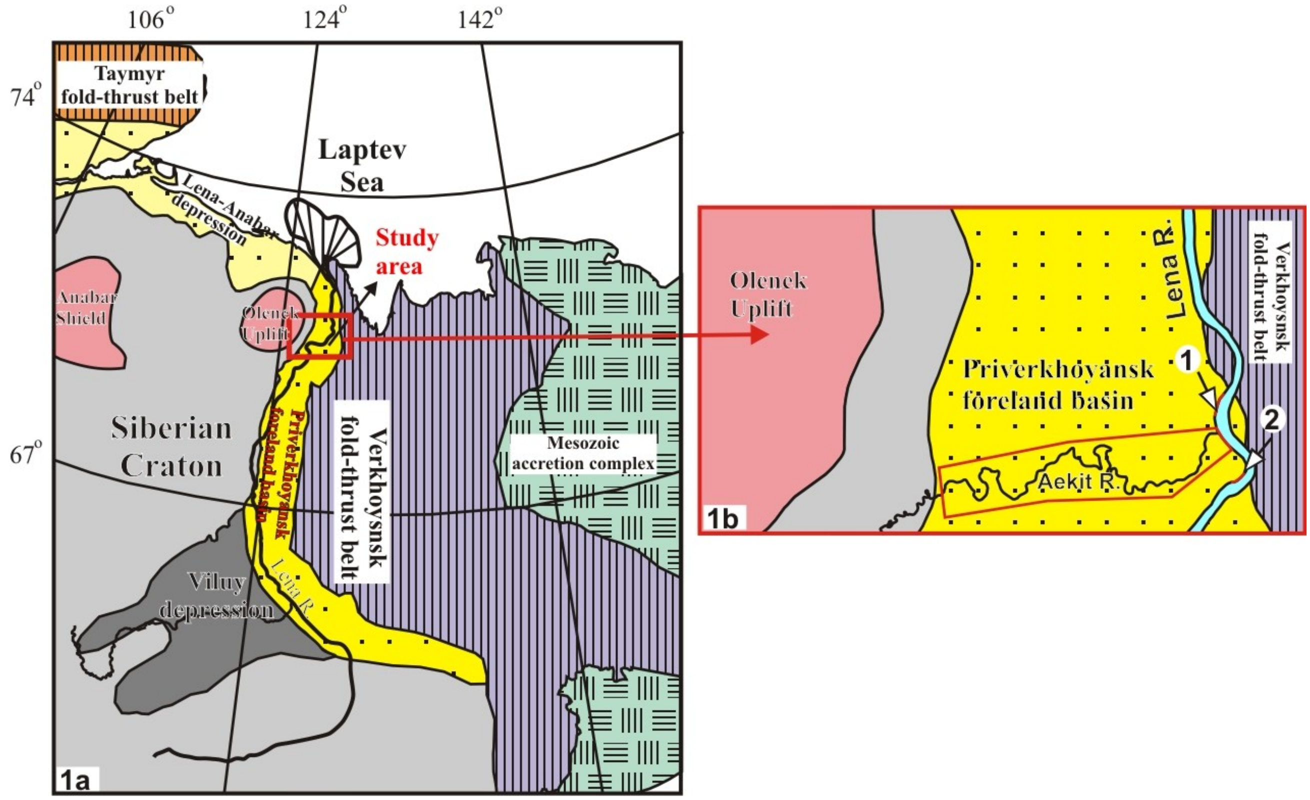

Figure 1: 1 a – Tectonic map of the northeastern margin of the Siberian craton and adjacent fold-thrust belts, simplified after Parfenov et al., 1990; 1 b - detailed map of the study area with location of outcrops: 1- Chekurovka Cape – key section; 2 – Chucha Cape; red rectangle shows the transect through the foreland basin along Aekit R.

Stratigraphy and sedimentary facies analysis

Lower to Upper (Oxfordian) Jurassic strata of the north-eastern margin of the Siberian craton were deposited in a wide epicontinental basin without significant stratigraphic gaps. The youngest section of the Jurassic epeiric basin is represented by the Oxfordian extremely condensed succession mainly composed of glauconitic sandstones (thickness up to 8 m). The Kimmeridgian deposits are absent in the study area. There are some occurrences of reworked Kimmeridgian ammonites in younger formations. Probably, during the Kimmeridgian, the study area also was occupied by a epeiric basin. At the end of the Kimmeridgian, a regression occurred, which resulted in complete erosion of the Kimmeridgian and partly Oxfordian deposits and led to paleosoil formation.

The Tithonian strata with an essential stratigraphic gap lie on different levels of the Oxfordian deposits. They are represented by a thin condensed succession (up to 10 m) of black bituminous shale with rare interbeds of silty sandstones. These are the oldest deposits corresponding to underfilled states of the foreland basin. Their deposition coincided with the formation of the oldest granites known from the eastern part of the Verkhoynask FTB.

The lowermost Berriaisian strata are represented by black-brown siltstones with a thickness range from 5 to 40 meters, which deposited in the environment inherited from the Tithonian stage.
During the Early Berriasian, significant changes in sedimentary environments occurred which led to deposition of a thick succession primarily composed of sandstones with interlayers of coarse-grained siltstones. Sandstones are mostly represented by arkosic arenites with subangular to subrounded grains which indicate a short distance of transportation. According to sedimentary structure analysis these deposits were formed in the frontal part of a large river delta. During the Berriasian - Early Valanginian, a 300 meters thick succession of mostly deltaic sandstones was deposited.
An abrupt shift to fluvial sedimentation occurred in the Late Valanginian. Several thousand meters of sediments accumulated in nonmarine environments from the Valanginian to Aptian (Albian?) during the filling in of the Priverkhoyansk foreland basin. We subdivided this fluvial succession by categorizing rocks into two systems tracts, a low-accommodation systems tract characterized by amalgamated channel belts and a high-accommodation systems tract characterized by channel belts dispersed within fine-grained floodplain deposits. Lower accommodation deposits are usually represented by medium- to coarse grained white to light grey arkosic sandstones which form a succession of stacking channels. Facies architecture of high-accommodation successions is characterized by well preserved fining up abandoned channel fills, crevasses splay delta deposits, swamp deposits, and locally well distinguished lake deposits.
Upper Cretaceous rocks are absent in the study area. According to vitrinite reflectance data, Aptian deposits were covered by at least 2-3 km of sediments. This implies that filling in of the Priverkhoyansk foreland basin continued during Late Cretaceous.

Foreland basin evolution

According to previous mainly structural study, folding in the Verkhoyansk FTB began in the Late Jurassic. The sedimentary facies analysis let us justify that the initiation of the foreland basin started in Tithonian time (fig. 2).

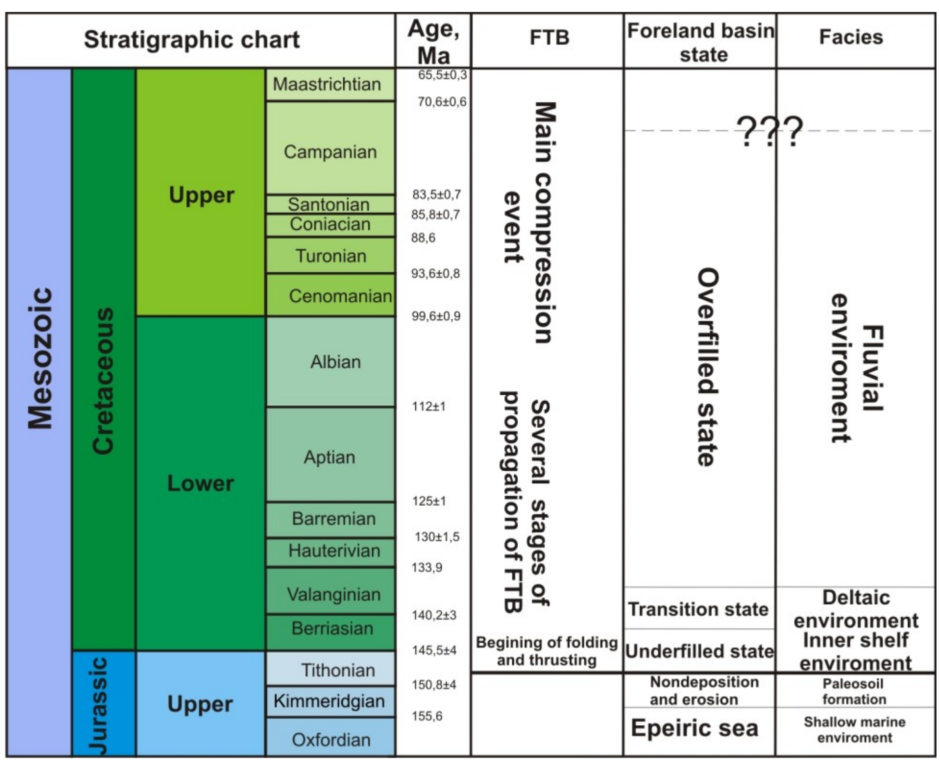

Figure 2: Evolution of the Northern Part of the Priverkhoyansk Foreland Basin and adjacent FTB

The Tithonian black shale represents an underfilled state of the foreland basin evolution. During this state the study area was a distal part of the foreland basin, located far from the FTB which developed much eastward. The Berriassian and Lower Valanginian deposits that accumulated primarily in a deltaic environment are the evidence of propagation of FTB further in a westward direction. The Late Valanginian – Albian mainly fluvial sedimentary succession represents an overfilled state (fig. 2) of the foreland basin and is caused by final propagation of FTB close to its modern boundaries. Recognition of high and low accommodation systems tracts throughout the fluvial succession let us assume that the subsidence was high throughout the deposition of the high-accommodation system tracts, based on the substantial thicknesses of the observed deposits and the lack of obvious scour surfaces and condensed intervals. An abrupt increase in subsidence at this time related to enhanced thrusting is a probable explanation. Lower-accommodation strata are represented by a succession of incised valleys and correspond to a postorogenic phase when erosion of the advancing thrust dominates and the magnitude of the tectonic load decreases.

Conclusions

Changes in sedimentary succession through Tithonian to Aptian directly correlate with a change from distal foredeep to proximal foredeep sedimentation. This migration of depozones in westward direction (direction of thrust belt propagation) recognizes stack depozones vertically in the stratigraphic record.

Sediment accommodation in the Priverkhoyansk foreland basin was controlled primarily by advancing and rising of the FTB. Changes in the fluvial succession of overfilled state of the foreland basin can be explained by flexural subsidence which was caused by loading the adjacent orogenic belt. The main phase of uplift occurred from Valanginian to Late Cretaceous, causing development of the foreland basin with a nonmarine sedimentation. Sandstone petrographic studies as well as available chemical and isotopic data show a mixed source area for the Cretaceous clastic rocks, which includes a component derived from both FTB and the cratonward side of basin.

Acknowledgements

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