Regional stratigraphy and its dependency on tectonic movements (case study: Upper Cretaceous and Paleogene stages in Western Siberia)

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Abstract. Multiscale and divergent tectonic movements have been identified in Western Siberia of which first-order movements caused transgressions and regressions, as well as the partial formation of sediments. As a result of tectonic movement direction turn, no transgression was observed in the cross-sections of Campanian and Danian central section and in the Priabonian top section. During second-order tectonic movements and undirectional transgression insignificant bed thicknesses and channels were formed. Such movements could have included different tectonic activities within the western and eastern parts of the region limited by the Koltogorsk-Urengoy Rift. Third-order tectonic movement of moderate amplitude promoted either extension, contraction or even depth variations of the marine basin itself.

1. Introduction
The vertical tectonic movements within the West Siberian Plate were both divergent (ascending and descending) and multi-scaled. Wide-range movements resulted in the subsidence or uplift of almost the whole territorial region. These movements (epeirogenic) could be of the first order, i.e. the mostly large-scale and prominent in this region. During the transgression cycles, sedimentary rocks accumulated, which according to the lithological and microfaunal data, differed both vertically and laterally.

2. General characteristics
Ascending tectonic movements generated the uplift of the Western Siberia territory and the destruction of pre-existing out-cropped rocks. Subsequent sediment thicknesses under the influence of further transgression accumulated on the underlying eroded sediments. Moreover, previously accumulated and subsequently destructed stratigraphic units became concealed sequences. Special investigation is vital to determine these free sequences and graded unconformity. These unconformities and concealed stratigraphic units have been observed in the Upper Cretaceous and Paleogene deposits of Western Siberia, which were mainly detected within foraminiferal zones and correlated to adjacent regions. These investigations showed concealed sequences of the Campanian, Danian and Priabonian stages. Accordingly, foraminifer associations were observed in the lowermost or uppermost sequences. In the Late Cretaceous and Paleogene, the amplitude of tectonic movements was gradually increasing as a result of the growing thickness of concealed stratigraphic units. It is well known that Western Siberia became an elevated continent in the Neogene. The accumulation of Neogene continental sediments is mainly observed within the southern latitudinal elongated Omsk depression. Late Cretaceous positive multi-scaled tectonic movements became more apparent in the beginning of the Campanian stage.
Santonian Slavgorodsky suite (lowermost Early Campanian) is widely observed in the marine sediment sequences of Western Siberia [1, 3, 4]. Late Campanian-Maastrichtian (Gankinsk suite) transgression changed its direction – from south to north through the Turgay Straight which, by this time, had widened and significantly deepened. The boreal transgression direction (Santonian – Early Campanian) turned to the south resulting in the outcropping of early Campanian sediments, the bulk of which was destructed by erosion and denudation. This graded stratigraphic unconformity between the Santonian and Maastrichtian sediments, corresponding to the concealed Middle Campanian Stage, can be determined by the correlation of West Siberian foraminiferal zones to those of Central Asia (Kazakhstan) and East-European Platform.

3. Biostratigraphic suite description

The overlying Gankinsk suite (top of Upper Campanian – Maastrichtian) is composed of mainly clays and aleurolites with carbonate impurities, as well as calcareous-secretion foraminifera within three foraminiferal zones: lower *Cibicidoides primus* zone (uppermost Upper Campanian), central *Spiroplectammina variabilis* – *Gaudryina rugosa spinulosa* zone (lower Maastrichtian) and upper *Spiroplectammina kasanzevi* – *Balimina rosenkrantzii* zone (upper Maastrichtian). The analogues of Campanian foraminiferal zones identified in adjacent regions - *Cibicides temirensis*, *Brotzenella monterelensis*, significant part of *Globorotalites emdiensis* have not been revealed within Western Siberia stratigraphic units.

The transgression direction from south to boreal was again observed in Late Maastrichtian (Gankinsk suite), resulting in almost complete concealed Danian Stage, whereas only the lowermost sequences were preserved from erosion and could be traced in the Omsk depression [2, 4, 10]. Simultaneously, Bakchar iron-ore horizon was forming in the east. The overlying Paleocene Talitsk suite is composed of dark-grey opota clays and includes mainly agglutinated quartz-siliceous foraminifer assemblages with *Ammoscalaria friabilis*. However, in all marginal shallow-water suite areas calcareous-secretion foraminifera intertwining with agglutinated ones could also be identified [2, 4]. This is also observed in the Selandian Stage (Middle Paleocene, lowermost part of the Talitsk suite). The investigation of the foraminifer assemblages from the top Talitsk suite (Thanetian Stage, Upper Paleocene) demonstrated no uppermost foraminifel zone analogues in this stratigraphic unit. However, the upper planktonic foraminifer zone analogues have been found in the adjacent regions of south Russia: *Acarinina acarinata*. In Transur Urals the planktonic foraminifer as *Acarinina subsphaerica* with consistent Late Paleocene agglutinated forms have been found in the Talitsk suite (upper horizons) [5]. Therefore, it could be noted that only the upper *Acarinina acarinata* zone (Upper Paleocene) in Western Siberia is concealed. This could be explained by two factors- slight elevation of Western Siberia territory and concealed sequences of upper foraminiferal zone during the Late Paleocene. The Eocene lower subsuite of Lyulinvorsk suite is composed of dark-grey or grey gazes (silicites) and opota clays. The formation of such clays could be associated with the significant hydrological regime changes within the basin itself, which, previously had favourable conditions for both foraminifera and radiolarians in the Early Paleocene. However, deformed sugar-white benthic foraminifera are rare, and this fact makes it impossible to determine their stratigraphic value. The boreal transgression direction turn was not observed here, but stratigraphic unconformity was detected between the Upper Paleocene and Lower Eocene sediments due to the concealed Paleocene upper sequences (planktonic foraminifer zone with *Acarinina acarinata*) (table 1). The following Eocene transgression, partial erosion of previous Thanetian sediments (top Talitsk suite) resulted in graded stratigraphic unconformity [6, 8].

Increasing amplitude of positive tectonic movements has been observed towards the end of Eocene. By this time, Lyulinvorsk suite formation had been completed, which, in its turn, included greenish-grey clay silicate with varying degrees of opoka clays not only in the lower subsuite but also in the middle and upper subsuites. In SW mid-Lyulinvorsk subsuite, Middle Eocene calcareous foraminifera assemblages were detected [4], while in the central and southern areas, Middle Eocene agglutinated quartz-siliceous foraminifera assemblages with *Gaudryinopsis subbotinae* were widely
distributed. By the end of Eocene (Upper Lyulinvorsk subsuite) the transgression decrease was observed, and the sediments were mainly coarse-grained agglutinated foraminifera. The foraminiferal zone with *Labrospira honesta* was defined. In the uppermost horizons, rare fragments of ferruginized reophacida and haplophragmiida could be found, i.e. layers with *Reophax dentaliniformis – R. subfusiformis* assemblages. The sharp boreal Eocene transgression turn to the southern Tavdinian one (Lower Oligocene) resulted in the uplifting, outcropping and destruction of the Upper Eocene horizon (uppermost layer of upper Lyulinvorsk subsuite). In this case, there is a graded stratigraphic unconformity (between Lyulinvorsk and Tavdin suites), which could be correlated in time to eroded Eocene uppermost foraminiferal zones (most of the Priabonian Stage) [6]. In the overlying Tavdin suite, Lower Oligocene foraminiferal zone with *Cibicoides pseudoungerianus – Evolutonion decoratum* were defined [2, 4]. Tavdin suite is composed of greenish-grey, sometimes, ferruginated book clays with powered sandy material. This suite encloses benthic calcareous secretion and planktonic foraminifer assemblages according to which the suite age was determined as Early Oligocene. Tavdin southern transgression comparably to previous boreal Lyulinvorsk one was moderate as it extended practically to the latitudinal Ob river currents. Tavdin suite benthic and planktonic foraminifera are diverse and abundant in the south of the region (near Petukhovo) in comparison with the central and western regions. In the eastern area the Tavdin suite is lithologically altered due to the sandy material increase. There is a lack of foraminifera here. Range of foraminifera in above-mentioned assemblage is similar to Early Oligocene species in West Europe and USA [2]. Integrally, Early Oligocene basin (Tavdin suite) was shallow and moderately lateral within the southwestern part of the area. The eastern part of West Siberia, in comparison with the western part, was tectonically more active. Their borderline coincides with the location of the Koltogorsk-Urengoy rift. In the eastern area, the developing 2nd-order tectonic movements are subordinate to 1st-order vertical movements, which, in its turn, are associated with the uplifting and subsidence within the West Siberia territory.

| Series | Subsuite | Stages | Zones of planktonic foraminifera | Zones and beds with benthic foraminifera of Western Siberia (Podobina, 2009 [4]) |
|--------|----------|--------|---------------------------------|---------------------------------------------------------------------------------|
| Paleocene | Middle | Seland | M. velascoensis | Acarinina acarinata | Foraminifer zones |
| | | | Ac. soldadoensis – Gl. pseudomenardii | | unrevealed |
| | | | Acarinina subsphaerica | Acarinina subsphaerica | Beds with foraminifera |
| | | | | Igorina djanensis | Glomospira gordialiformis, Cibicoides favorabilis |
| | | | | | Glomospira gordialiformis, Cyclammina coksuvorovae |
| | Upper | Thanetian | Gl. pseudomenardii – P. variolata | Morozovella conicotruncata | Ammoscalaria friabilis |
| | | | Igorina albeari | Morozovella | Cibicoides proprius |
| | | | Igorina pusila | | Cyclammina coksuvorovae |
From the end of Early Oligocene (Latdorfian Age), Middle Oligocene (Rupelian Age) to Late Oligocene ( Chattian Age) a depression zone formed in West Siberia due to 1<sup>st</sup>-order ascending tectonic movements where continental sediments accumulated (Abrosimovka, Novomikhailovka and Zhuravka suites). At the beginning of Neogene the West-Siberian continent was formed under the influence of tectonic movements, within the territory of which, there was practically no sedimentary environment. Besides high-amplitude 1<sup>st</sup>-order tectonic movements resulting in the transgression direction turn and the continental uplifting (West Siberia), subordinate 2<sup>nd</sup> – order tectonic movements existed, which affected both the reduction and expansion of transgression in separate regions of West Siberia. According to lithological evidence these tectonic movements became apparent in the west and east areas and revealed foraminifera in different stratigraphic horizons. From the viewpoint of these factors, the following example should be examined - Ipatovsky horizon. Its western area embraces Sedelnikov suite of compact grey gaze clays (40-60 m in thickness), including single coarse-grained, poorly-preserved agglutinated quartz-siliceous foraminifera (probably, Coniacian Age). Its eastern area embraces similar Ipatovsky suite (Pudino – Napas) with a thickness of  60-270 m. This suite is primarily composed of loose rocks - grey sands and aleurolites. Within the uppermost layer of this suite the Narym iron-ore horizon could be traced, including Late Coniacian assemblage of single brown calcareous-secretion foraminifera with Dentalina basiplanata – D. tineaformis [1, 3, 4]. In the west (borehole 23 in Beryozovo) these assemblage layers correlate with sediments containing more abundant species composition of Dentalina tineaformis – Cibicides sandidgei assemblages [3].

Rather active 2<sup>nd</sup> tectonic movements in the eastern area resulted in the significant erosion of previously accumulated rocks. In this case, not only the Danian Stage but also the upper Maastrichtian zone with Spiroplectammina kasanzevi – Bulimina rosenkrantzi are concealed. Relatively primitive foraminifera with agglutinated walls, often sugary-white colour, prevailed in the shallowed Early Campanian, Selandian and Thanetian basins of east West Siberia. Within this eastern area Tym iron-ore horizon was detected on the Lyulivorsk and Tavdin suite boundaries. The rocks of this area include interbedded glauconitic aleurolites and sandstones enclosing fragments of Reophacida and Haplophragmiida.

According to lithological and microfauna characteristics there are a number of examples that confirm the possible 2<sup>nd</sup> -order tectonic activity within east West Siberia.

### 4. Conclusion

The channels connecting the West-Siberian basin with adjacent seas opened and disappeared as a result of 2<sup>nd</sup> -order tectonic activity movements at various times. The most stable and changing was the Late Cretaceous and Paleogene Turgay Channel expanding and deepening during the Turonian, Santonian, Maastrichtian, Eocene (Lyulivorian) and Early Oligocene transgressions. According to foraminifera data, their similarity with adjoining basins, is supposed to have temporarily existed in the
Urals and other West Siberia areas. However, of particular interest is Pre-Yenisey channel formed in the Late Cenomanian when West Siberia was a continent. Thus, Late Cenomanian foraminifera with *Gaudryinopsis nanushukensis elongatus* (*Trochammina wetteri tumida* – *Verneuilinoides kansasensis* zone) appeared in the south-east of this region (borehole E-150, on the outskirts of Seversk). During Santonian, the Mariinsk channel formed in the south-eastern part through which the characteristic Santonian calcareous-secretion foraminifera migrated from Kazakhstan basin to the West-Siberian basin. These findings in correlation with agglutinated quartz-siliceous foraminifera from central West Siberia showed that the bulk of the Slavgorodsk suite is of the Santonian age. Previously, the Slavgorodsk suite had been assigned to the Campanian Stage excluding such factors as tectonic movements, channel formation, comparison of foraminifer assemblages from different regions, including those foraminifera from northern Kazakhstan and East-European platform [7].

Constant oscillating 3rd-order tectonic movements throughout the Phanerozoic and, in this case, Late Cretaceous and Paleogene resulted in the alternation of relatively deep-water and shallow facies within the sequence, which, in its turn, also influenced the biota composition (foraminifera) in these basins.

**References**

[1] Podobina V 1989 Foraminifery i zonalnaya stratigrafiya verhnego mela Zapadnoy Sibiri Tomsk University Press 232 p
[2] Podobina V 1998 Foraminifery i biostratigrafiya paleogena Zapadnoy Sibiri Tomsk "NTL" Press 338 p
[3] Podobina V 2000 Upper Cretaceous Foraminifera and Biostratigraphy of Western Siberia Tomsk (NTL Press) 388 p
[4] Podobina V 2009 Foraminifera, Biostratigraphy of the Upper Cretaceous and Paleogene of Western Siberia Tomsk State University Press 432 p
[5] Podobina V and Amon E 1992 Microfauna and biostratigraphy of Paleogene deposits in the Sarbay section of North-West of Turgay In: *Materials on Paleontology and Stratigraphy of Western Siberia* Tomsk (Tomsk University Press) 88-97
[6] Sokolov B (ed.) 2005 Practical guidebook on microfauna 8 Cenozoic Foraminifera S.-Petersburg (VSEGEI Press) 324 p
[7] Regional stratigraphic schemes of the Mesozoic deposits of the West-Siberian Plain Tyumen 1991
[8] Unified regional stratigraphic scheme of Paleogene and Neogene deposits of the West-Siberian plain 2001 Novosibirsk
[9] Berggren W A and Pearson P N 2005 A revised tropical to subtropical Paleogene planktonic foraminiferal zonation. *Journal of Foraminiferal Research* 35 279-298
[10] Podobina V 2011 The Danian and Selandian calcareous benthic foraminiferal assemblages and biostratigraphy of Western Siberia. *Geologos* 17 97-110