

# Vasyugan horizon structure features within junction zone of Ust-Tym depression and Parabel megaswell (Tomsk Oblast)

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**Abstract.** The research area includes Upper Jurassic deposits of Vasyugan horizon. To identify the territorial relationship between Vasyugan and Naunak suites, rugged topography and well profile figure correlation have been made; detailed core lithology analysis (Gurarinskaya, Sobolinaya and Yasnaya areas) has been carried out, conclusions on paleoenvironment have been made. It has been identified that sedimentation occurred in the range of the studied territory where continental facies played a more significant role than it was for Vasyugan suite deposits. Thus, the conjunction zone of Ust-Tym depression and Parabel megaswell are spatially the transition zone of lithologo-facial Vasyugan suite replacement into Naunak one.

## 1. Introduction

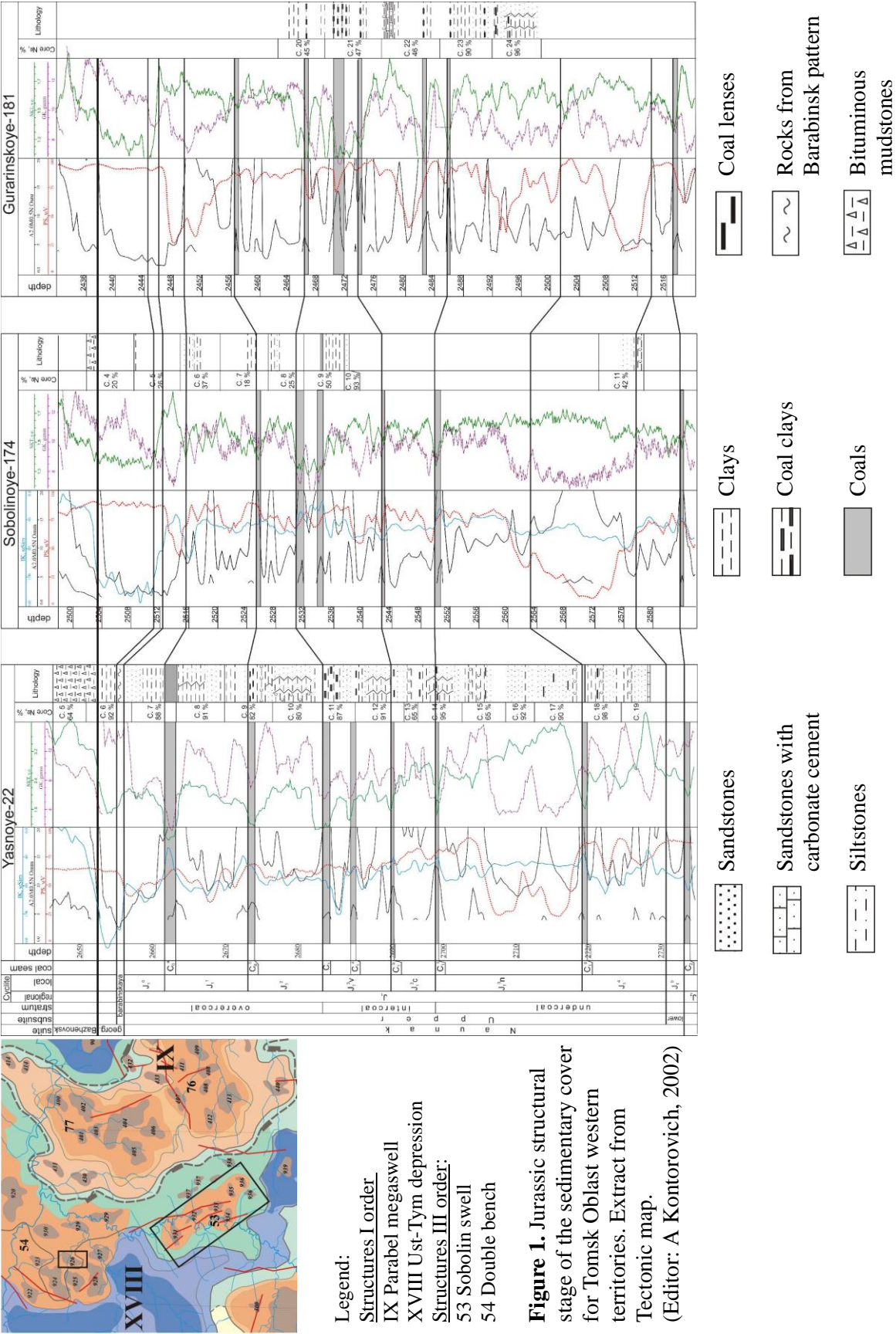
Oil-bearing capacity of Upper Jurassic deposits in the West Siberia territory has been proved by the range of oil field discoveries. A number of contemporary researchers state that “the Mesozoic stratigraphy in the subsurface of the West Siberian Basin contains prolific hydrocarbon accumulations, and thus the depositional environments of marine and marginal marine Jurassic and Cretaceous age sediments are well-established” [1]. Besides, paleogeographic reconstruction of the West Siberian basin during the Jurassic has been proposed by A.E. Kontorovich [2]. However, despite the long history of research and useful know-how material, there are some problems left to be solved. The regional stratigraphic scheme of the Upper Jurassic south-east West Siberia territory shows that Vasyugan horizon includes Vasyugan and Naunak suites. But, so far, the correlation of these territories has been obscure.

The detailed lithologo - stratigraphic separation of Vasyugan suite profile in Tomsk Oblast was made by a number of researchers [3, 4], and, Vasyugan suite, according to widely used concepts is subdivided into 2 subsuites: the lower- mostly clayey with the sandstone strata  $J_1^5$  and  $J_1^6$  locally distributed, and the upper - characterized by sandstone, siltstone, clay and coal interlayers, comprising  $J_1^4$ ,  $J_1^3$ ,  $J_1^2$ ,  $J_1^1$  strata. Upper Vasyugan subsuite has undercoal (regressive), intercoal (continental) and overcoal (transgressive) layers. In the south-east of the territory the intercoal deposits merge with Naunak suite deposits. Naunak suite development area borders on Ust-Tym depression and eastern territories [5].

## 2. Methodology

To identify the structure features of Vasyugan suit transition into Naunak suite, a detailed lithological study of the well profiles was made. The wells were drilled in the junction zone of Ust-Tym depression and Parabel megaswell (Double bench – Yasnoye oil field) and in Ust-Tym depression southern part (Sobolin swell – Sobolin and Gurarinsk oil fields) (figure 1). Well profiles separation and correlation were made with the allowance for system analysis of rock-strata associations [6], on the basis of which the studied deposits of the stratigraphic interval are incorporated into regional cyclite  $J_1$  (figure 2), where local cyclites are identified (from  $J_1^5$  to  $J_1^1$ ).





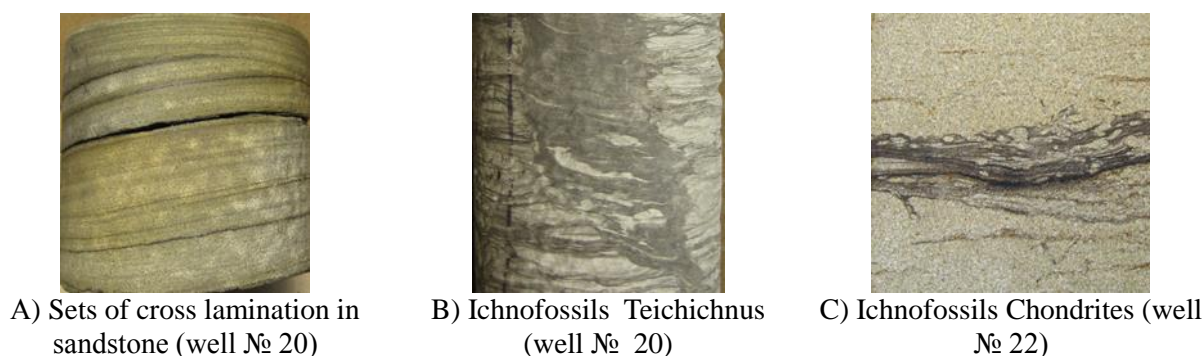
### 3. Results and discussion

On the stratigraphic schemes of Yasnoye, Sobolin, Gurarinsk oil fields the Upper Jurassic profile is characterized by deposits of Naunak, Georgiyev and Bazhenov suites. *Cyclite*  $J_1^5$  in the lower part of the studied profile (according to the core analysis) is characterized by grey and brown-grey homogeneous with thin horizontal lamination sections siderized by clay with benthonic ichnofossils (*Palaeophycus*), which characterize a low dynamic marine environment. Clayey bottom deposits in Sobolin and Gurarinsk areas become arenaceous and form  $J_1^5$  stratum characterized by light-grey fine-grained aleurite sandstones comprised of carbonized and siderized macro-organic inclusions, channels and holes of benthic animals. Sandstone thickness increase is marked sideways from the local uplifts arches to their limbs.

*Cyclite*  $J_1^4$  deposits (undercoal thickness) mostly cover the complex of arenaceous silt rocks interbedded by clays (Gurarinsk, Sobolin areas) or by stratum  $C_1^g$  (Yasnoye area) characterized by coal or coal clays. The cyclite thickness ranges from 8m to 14 m.

In Yasnoye area the cyclite in the lower part has a heterogeneous structure and is characterized by continuous and frequent coal seams, siltstone and fine-grained sandstones interbedding the formation of fine, diversidirectional cross and low-angle lamination, sometimes the laminae cutoff (figure 3 A) and specified by environment hydrodynamic activity. The rocks are intensively subjected to bioturbation and contain various benthonic ichnofossils (*Chondrites*, *Scolithos*, *Teichichnus*) (figure 3 B, C) that attest to good aeration and water area heating.

The upper cyclite part constitutes clayey rocks with interbeds of clay-siderite, clay-coal and coal composition, fine horizontal and wavy stratified structure. The rocks contain plant detritus of various preservation stages, fragments of siderized wood, root systems remains, pyrite. Flood-coast -lagoon environment to the final cyclite formation was likely to present in the studied area.



**Figure 3.** Cyclite  $J_1^4$  rock features (Yasnoye area)

Cyclite  $J_1^{3n}$  with the thickness of 12–20 m is overlaid at the top by the coal seam  $C_1^c$ . Well profiles in the studied areas are different in structure. Yasnoye area profiles contain light-grey sandstones, from fine-grained to coarse-grained. Frequent continuous interbeds with various granulometric composition and graded bedding occur. Rocks have fine low-angle, unidirectional and diversidirectional lamination (figure 4 A) deformed by wash-out and bioturbation, comprising intraformational pebbles and coal inclusions. Sandstones are overlaid by homogeneous horizontal, wave lense-like, stratified clays, partly siderized, while on the top - by coal clays.

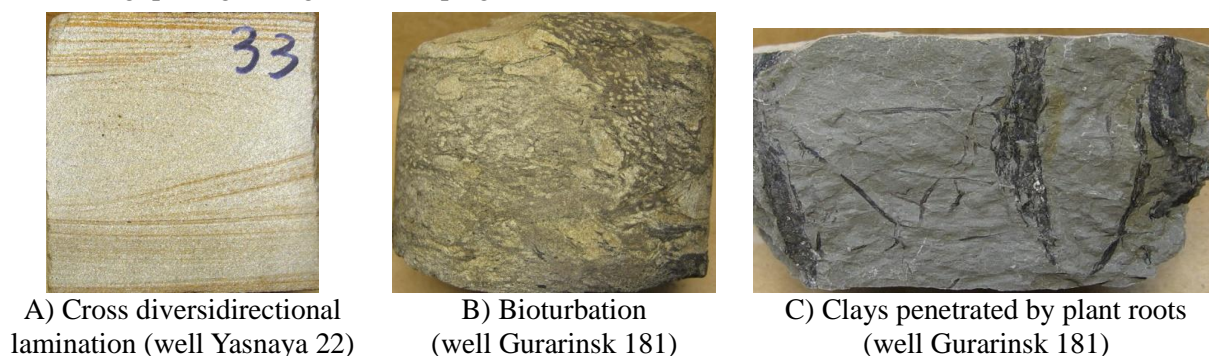
Thus, sediment accumulation in high dynamic environment was preserved during the whole cyclite formation process and is related to coastal bars and barrier islands exposed to the surface and periodically subjected to wash-out.

Gurarinsk area profile (well № 181) is characterized by the frequent interbedding of various lithological composition rocks: sandstones, siltstones, clayey-aleurite and coal clays. Bioturbation structures occur everywhere (figure 4 B), siderite concretions, fragments of wood, root remains (figure 4, C) coal interlayers.

The described features relate to the marginal lagoon sections where sea water continuously penetrated and introduced sand and aleurite material. In the relatively calm periods, fine-grained



sediments accumulated. Presence of coal interbeds and lenses in cyclite  $J_1^{3n}$  profile shows the sea basin shallowing, plant-growing and swamping of the area.



**Figure 4.** Cyclite  $J_1^{3n}$  rock features

In general, cyclites  $J_1^4$  and  $J_1^{3n}$  have a regressive structure and relate to undercoal thickness.

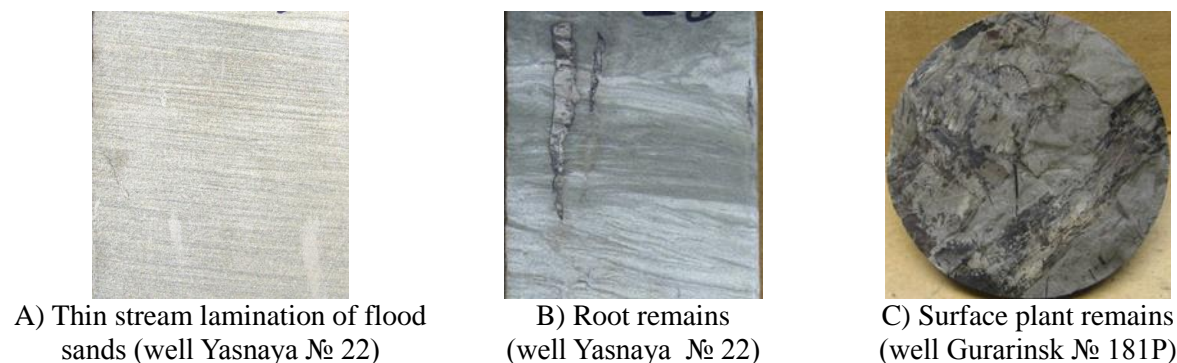
*Cyclite  $J_1^{3c}$  and  $J_1^{3v}$  formation (intercoal thickness)* relate mostly to the continental regime of sedimentation.

According to the identified genetic features, it may be assumed that during the process of  $J_1^{3c}$  deposition the fine-grained sediments of marine origin accumulated at the foot, while in the continental -at the top. The process occurs at the place of bar sandstones distribution (Yasnaya area). Sand material deposition spatially occurs in the areas where under water shoals and lagoons predominated (Gurarinsk area). Rocks are characterized by increased siderization, clays have root system remains. Black coal clays, grey siltstones and black coals interbedding occur in the upper part of the cyclite.

$J_1^{3v}$  sediments accumulation took place during the continental regime within the lacustrine alluvial plain. The coal seam  $C_1^a$  is determined in  $J_1^{3v}$  composition. The continental sedimentation regime was concluded by the coal seam  $C_1$  formation, characterized ,according to the core analysis, by coals and black coal clays with rare thin aleurite bands. The cyclite thickness is 8-20 m.

Based on core samples from well № 20 (Yasnaya area) channel shoal facies were identified. Sandstones filling the channel refer to fine-grained varieties with intraformational clay pebble inclusions. The bedding is rare, capillary, cross and cross wave-like, formed by siderite, clayey material plant detritus inwash. Upwards in the profile, the channel deposits are overlaid by back marsh sediments and characterized by siltstone and clayey interbedding with carbonized root remains, concretions and pyrite pseudomorphs along plant remains, siderite concretions.

Deposits uncovered by wells № 22 (Yasnaya area), № 181 (Gurarinsk area) and № 184 (Sobolin area) were formed in temporarily living flood plain environment conditions. These are characterized by repeated interbeddings of sandstones, siltstones, complex clayey aleurite rock composition, clayey and coal rocks, coal. Rocks are irregularly siderized, they have clay detritus, remains of surface and root plant fragments (figure 5).



**Figure 5.** Facies of temporarily living flood plain areas (cyclite  $J_1^{3v}$ )

Well- isolated cyclites  $J_1^2$ ,  $J_1^1$ ,  $J_1^0$  are marked out in the upper  $J_1$  horizon (overcoal thickness). Alteration and sequence of lithological rock variety stratification illustrate the transgressive-regressive strata character. Coal bands characterize the continuous sea water-level decline and continental sedimentation conditions restoration in the studied area.

*Cyclite*  $J_1^2$  of the studied area is characterized by the clayey-aleurite strata and separated from the overlying deposits by the coal shed indexed  $C_0^6$ . The thickness of the deposits is not more than 16m.

Various multiple ichnofossils, that are found in the cores during drilling, provide basic evidence of the fact that at the beginning of the deposit formation the whole territory was covered by sea. Besides, regular continuous aleurite and clayey material interbedding, wave-like and cross wave-like alternation with thin low-angle and horizontal lamination show regular variability of aqueous environment dynamics.

Follow-up sea regression resulted in the territory proximity to the shore line, bog and vegetation formation that became rock features of continental origin. The upper part of the profile studied by coring includes clayey rocks comprised of plentiful carboniferous plant detritus, large well- preserved plant fragments, root system remains, black coal clays and coals interbeds.

Sediment accumulation of the *cyclite*  $J_1^1$  was made during transgressive-regressive stage. The thickness of these deposits varies from 4 to 11 m.

Well profiles in Gurarinsk area show distinct regressive sedimentation nature with fragment size increase from bottom to top. Ichnofossils (*Chondrites* и *Terebellina*), structural and textural rock features, carbonate sediment formation indicate that the process occurred in desalted marine water area in the places close to the shore line and relatively calm hydrodynamics.

In Yasnaya area wells, the sandstones occupy the midsection of the profile, having cross and cross wave-like lamination and are fine-grained, irregularly calcitized and siderized. Upwards the profile, they are changed by lagoon sediments characterized by siltstone and clayey material interbedding with the pyrite and siderite concretions abundant, worm channels, remains of surface plant fragments and roots. At the top, the deposits are overlaid by the coal seam  $C_0^a$ .

Overlaid deposits are of the *cyclite*  $J_1^0$ , sedimentation of which occurred in conditions of low shallow water mobility. The process resulted in the formation of irregular arenaceous aleurite clayey rocks of deformed bioturbation (figure 6, A). In general, the cyclite thickness varies from 3 to 7 m.



A) Deformed bioturbation rock, *Terebellina* ichnofossils (well № Yasnaya 20)



B) Belemnite onychites in clays (well Gurarinsk № 182)



C) Belemnite rostra in the rocks of Barabinskaya pattern (well Gurarinsk № 182)

**Figure 6.** Features of cyclite  $J_1^0$  rocks and Georgiyevk deposition series

On the log Georgiyevk deposition series are positively marked out according to (showing) specific resistance decrease and natural radioactivity increase. These are characterized by dark-grey clays with rostra remains and belemnite onychites (figure 7, B). Barabinsk pattern rocks are marked out at the base of the series. These occur washed out on the underlying rocks of horizon  $J_1$  and are quite different in appearance and substance composition. These are heterogeneous non-sorted aleurite-clayey rocks with green-bluish tinge, breccia-like with phosphate inclusions, great amount of pyrite and glauconite, numerous belemnite rostra characterized by calcite (figure 7, C).

The total deposition thickness of Georgiyevk series within Yasnaya area is almost 3 m, increasing in the southern part of Ust-Tym depression to 12 m.

#### 4. Conclusion.

1. Upper Jurassic deposits widely spread in the profiles of Gurarinsk, Sobolin and Yasnaya fields represent spatially the transition zone of lithologo-facial Vasyugan suite replacement into Naunak one.

2. The lower part of the studied profile (cyclite  $J_1^5$ ) according to the lithological characteristics and formation conditions are related to Low Vasyugan subsuite.

3. Cyclites  $J_1^4$  and  $J_1^3n$  formed during sea regression under conditions of progressive transition process from coastal marine environment to flood plain coast environment are related to the deposits of the Upper Vasyugan subsuite undercoal stratum.

4. Cyclite  $J_1^3c$  and  $J_1^3v$  sediments accumulating in continental conditions are also related to temporary analogue – the intercoal strata of the Upper Vasyugan subsuite, but are notable for its increased thickness and coal – bearing capacity.

5. The most significant differences are in the overcoal stratum structure where, according to the core analysis, marine and continental features of sedimentation combine; coal seams  $C_0^a$  and  $C_0^b$  are marked out in the profile. Cyclites  $J_1^2$   $J_1^1$  and  $J_1^0$  formation regime are of transgressive-regressive (pulsating) character and continuously changed from marine to continental.

6. In general, the studied profile is comparable to Vasyugan suite profile, but it is different due to the thickness increase, higher content of coal material including either the overcoal stratum. This shows the more significant role of continental deposits.

7. The fact that the territory is related to the transition zone is also due to Georgiyev and Bazhenov suites deposits that overlie the overcoal stratum. These are not Maryanov suite deposits that are thought to be in the profiles of Naunak suites.

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