[PS]Structure and Mesozoic Tectonics of the Southeastern Taimyr Fold and Thrust Belt*

D. A. Zastrozhnov[1], A. K. Khudoley[2], and V. E. Verzhbitsky[3]

Search and Discovery Article #30304 (2013)**
Posted December 16, 2013

*Adapted from poster presentation given at AAPG 3P Arctic Polar Petroleum Potential Conference & Exhibition, Stavanger, Norway, October 15-18, 2013

[1]Russian Geological Research Institute (VSEGEI), Saint-Petersburg, Russian Federation (zastrozhe@gmail.com)
[2]Faculty of Geology, Saint-Petersburg State University, Saint-Petersburg, Russian Federation
[3]Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russian Federation

Abstract

The Taimyr fold and thrust belt (FTB) consists of several zones that show evidence for Precambrian, late Paleozoic (Hercynian), and Mesozoic tectonic events. Most scientists point to Precambrian and late Paleozoic compression as the most intense compression events, although Zonenshain et al. (1990) argued for a strong Mesozoic tectonic event. Our studies of the Central and Southern Taimyr done in 2005-2012 in the frame of projects supported by the State geological mapping program and by TGS-NOPEC Company also points to important role of the Mesozoic tectonics. The main results are summarized in the following points: 1. The only clear angular unconformity in the sedimentary succession of the Central and Southern Taimyr is between Vendian and underlying rocks. Vendian – Triassic succession does not contain unconformities, although some hiatuses may occur. 2. Pre-Rhaetian unconformity (previously interpreted as pre-Jurassic) may be related to extension event as well as to compression event. 3. Folds in Cambrian up to Upper Permian rock units have very similar geometry. 4. In the eastern part of Southern Taimyr (Tsvetkova Cape area) Permian to Jurassic rocks show similar structural style. 5. Stress axes orientation estimated from the fracture study in Riphean rocks in the Central Taimyr and Permian up to Upper Jurassic sediments in the eastern part of Southern Taimyr (Tsvetkova Cape area) is very similar. 6. Apatite fission track study of samples from the Tsvetkova Cape area point to ca. 150-125 Ma and 75-60 Ma uplift/erosion events 7. In the eastern part of Southern Taimyr, all compression-related structures were affected by a younger extension. In summary, our observations do not show evidence for a strong late Paleozoic compression in the Central and Southern Taimyr. Granite intrusions, previously interpreted as Carboniferous, are ca. 250 Ma and may be presumably linked to the Norilsk trap LIP magmatic event. Also worth noting is that there are no Paleozoic ophiolite complexes within Taimyr FTB. Similarity in fold geometry and stress axes orientation shows that Vendian and younger rocks up to Permian in the Central Taimyr as well as Permian and Mesozoic rocks of the Southern Taimyr were mainly deformed during Mesozoic (Early and/or Late Cretaceous) compressional event, also recognized by brittle fractures in the Riphean rock units. These events are approximately synchronous to major collisional processes occurred in latest Jurassic – Cretaceous time in the northeast Asia and may reflect a connection between Southern Taimyr and Mesozoic fold belts of the northeast Asia. The final extension best documented in the Tsvetkova Cape area likely reflects tectonic relaxation processes right after the compressional event and opening of the Laptev Sea rifted sedimentary basin in Late Cretaceous-Cenozoic.

Structure and Mesozoic tectonics of the southeastern Taimyr fold and thrust belt

D.A. Zastrozhnov[1,2], A.K. Khudoley[3], V.E. Verzhbitsky[4]

[1] *A.P.Karpinsky Russian Geological Research Institute (VSEGEI), Saint-Petersburg, Russia,*
[2] *University of Oslo, Department of Geosciences, Norway*
[3] *Saint-Petersburg State University, Russia*
[4] *P.P. Shirsov Institute of Oceanology, Moscow, Russia*

The Taimyr fold and thrust belt (FTB) consists of several zones that show evidence for Precambrian, late Paleozoic (Hercynian), and Mesozoic tectonic events. Most scientists point to Precamrian and late Paleozoic compression as the most intense compression events with minor Late Mesozoic tectonic activity within southeastern part of Taimyr Peninsula (Vernikovsky, 1996; Pogrebitsky, 1998), although Zonenshain et al. (1990) argued for a strong Mesozoic tectonic event. Our structural studies of the Central and Southern Taimyr done in 2005-2012 also point to important role of the Mesozoic tectonics.

1.Regional Setting

Fig.1. Remote sensing image of Taimyr Peninsula and the locations of the study areas. 1 - The Zhdanova River, 2 - The Verkhneleningradskaya Area, 3 - The Podkhrebetnaya River, 4 - The Chernokhrebetnaya fold zone.

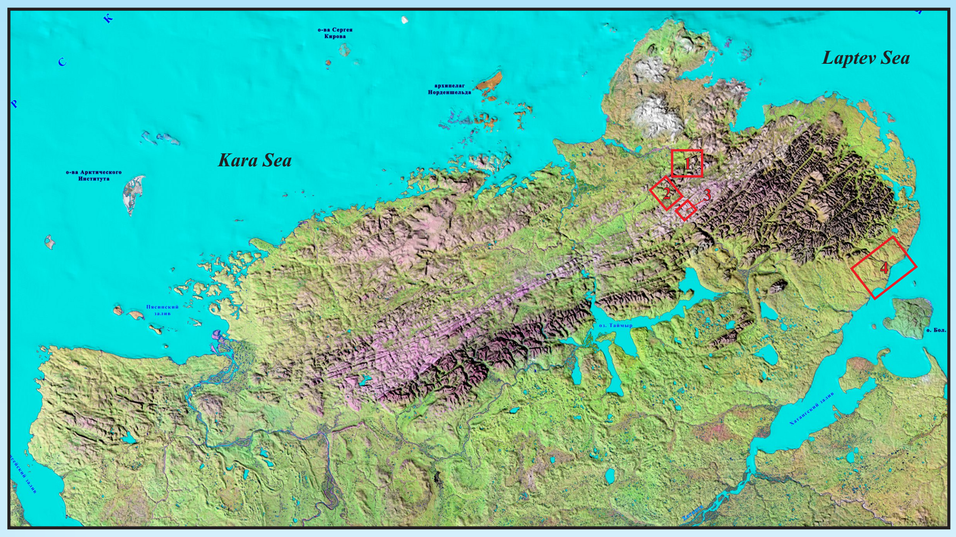


Fig.2. The Taimyr fold-thrust belt. Simplified scheme of tectonic zonation on the geological map (zone boundaries after Vernikovsky, 1996)

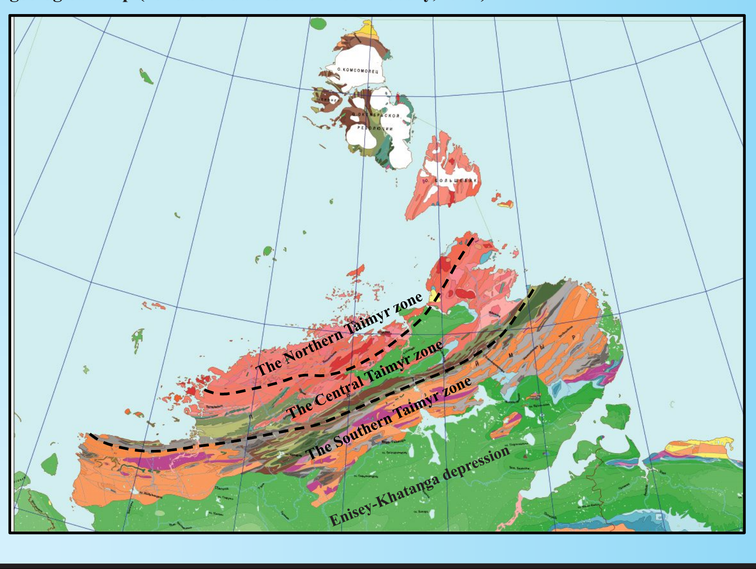
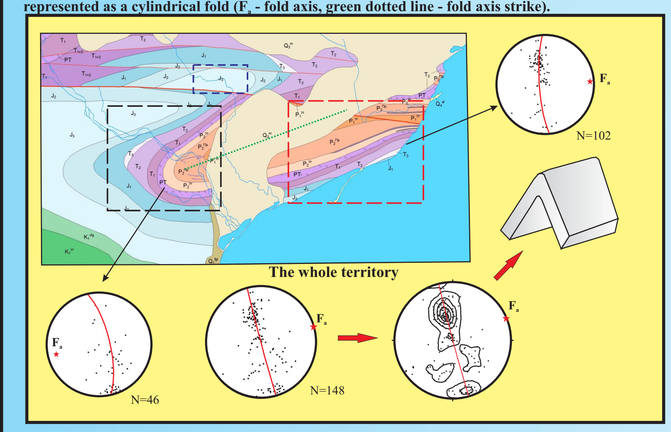


Fig 3. The Chernokhrebetnaya fold zone. Geological map (Migay, 1950, modified) and character of distribution of beddings on the stereograms for different researching areas. Red dashed rectangle - The Tsvetkova Cape Area, black dashed rectangle - The Chernokhrebetnaya River, dark blue rectangle - The Korotkaya River. The whole fold zone belongs to common structural domain represented as a cylindrical fold (F_a - fold axis, green dotted line - fold axis strike).



2.The Chernokhrebetnaya fold zone

The Chernokrebetnaya fold zone is located in the north-eastern part of Enisey-Khatanga depression, near its contact with the Taimyr thrust-fold belt. The study area belongs to the larger Olenek fold zone which strikes along the coast of Laptev's Sea, from Lena Delta to Khatanga Bay.

Regional-scale structural style of the study area is dominated by two major folds, anticline and syncline. Within the anticline fold almost whole section of Permian and Triassic rocks is exposed. The syncline is composed of Jurassic rocks. Both fold axes have ENE trend, similar to those in the Taimyr fold-thrust belt.

Field observations show that there are a lot of structures correspond to different tectonic regimes at the study area. Type of interrelations and orientations of structures allows determining deformational stages and the orientation of principal palaeostress axes. Totally, three deformational stages were identified: 1) main folding, 2) post-orogenic gravitational event (tectonic relaxation), 3) extensional stage.

Fig 4. Pre-Rhaetian unconformity: data (photos) and possible interpretation (cross-section after Migay, 1950, modified). Does it correspond to significant tectonic reorganisation?

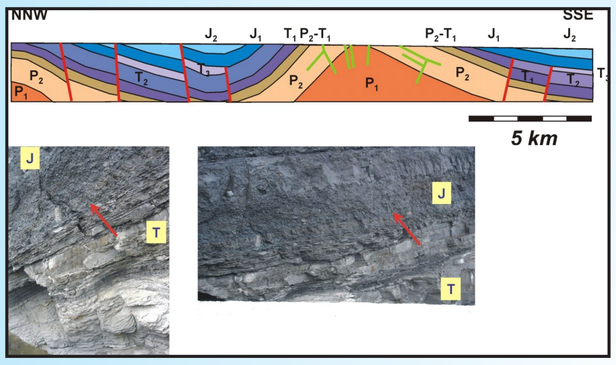
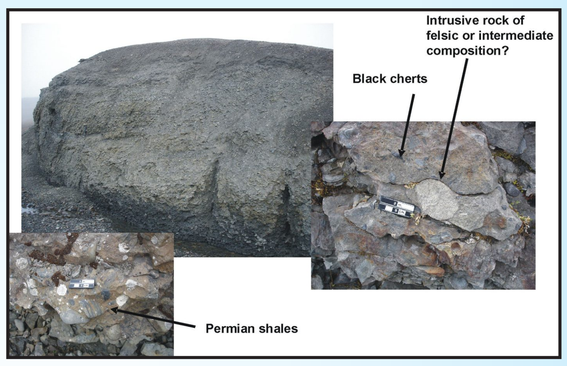


Fig. 5. Upper Jurassic conglomerate unit, Korotkaya River. Can it be related to early compressional event?



The orientation of *the compressional deformations (stages I_{1-3})* is typical for Taimyr tectonic movements, but similarity of structural-kinematic characteristics of Permian to Triassic and also Jurassic rocks refers to Late Jurassic or younger compressional deformational phase (stage) (Fig. 6). This stage can be regarded as a of an Early Cretaceous collision among the Arctic palaeocontinent (Arctida) and the Siberian craton in the Yuzhno-Anyuskaya zone of Verkhoyansk-Chukotkskaya fold system.

At the same time along the Korotkaya River (see location in Fig. 3) we documented 150-m thick unit consisted of interbedded conglomerates, shales and sandstones. Pebbles contain locally derived shales and mafic magmatic rocks as well as black cherts, limestones, quartz, rare felsic magmatic and metamorphic rocks (Fig. 5). Basically, the pebbles composition corresponds to composition of the Neoproterozoic – lower Paleozoic rocks of the southern part of the Taimyr fold-thrust belt, pointing to a prominent Late Jurassic erosion in the latter. It can be interpreted as an evidence for the early pulses of compressional deformations in the Taimyr fold-thrust belt located to the north of the study area.

Subsequent tectonic relaxation and inversion of stress axis (*stage II*) (Fig.6) may be related to post-orogenic gravitational collapse which occurred at the Laptev Sea after forming of the Verkhoyansk-Chukotskaya fold system in Early Cretaceous.

Later deformational structures formed in sublatitudinal extensional regime (*stage III*) (Fig.6) may reflect different rift phases of the Laptev Sea region evolution. Structures that were formed in a similar stress field are present on the eastern border of the Laptev Sea, near the Belkovsky Island, Novosibirsk archipelago.

Fig. 6. The Chernokhrebetnaya fold zone. Deformational stages and related structures.

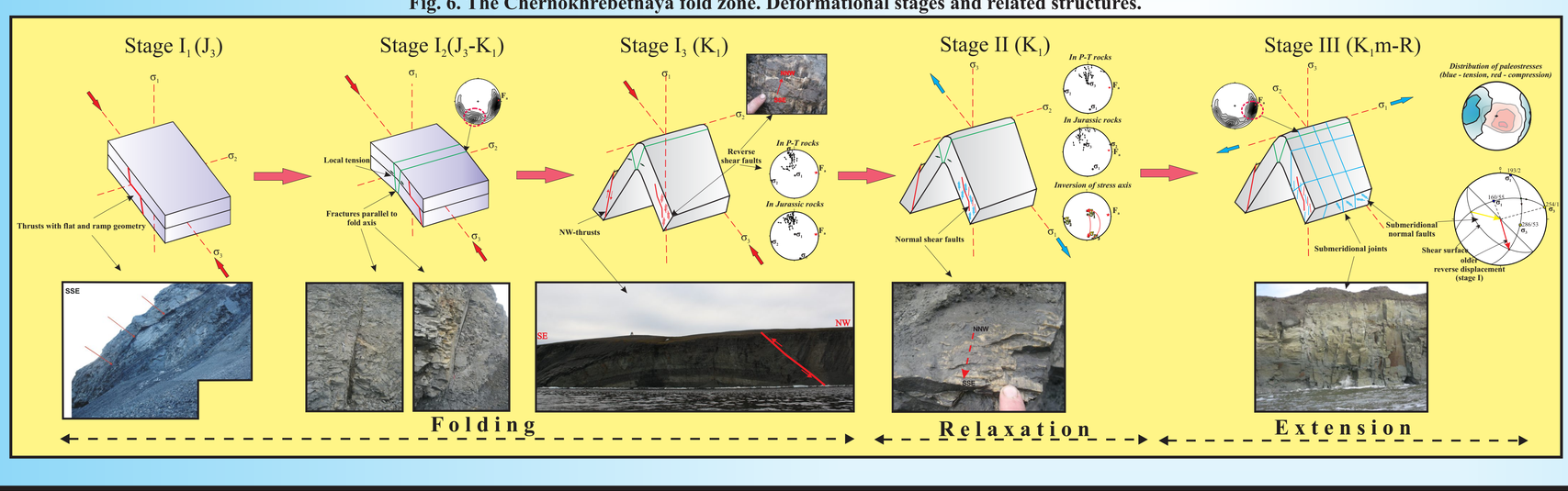
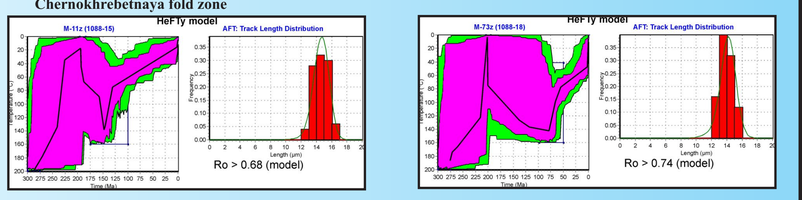


Fig.7. Apatite fission track data from two representative samples Triassic sandstones (M-11z and M-73z) within the Chernokhrebetnaya fold zone



Main Results

1. No evidences for the pre-Late Jurassic–Early Cretaceous deformations were identified in the study area:

-pre-Rhaetian unconformity (previously interpreted as pre-Jurassic) does not show evidences for orogeny event and may be related to extension event. The late Mesozoic compressional event overprinted, rotated and, locally, reactivated extensional faults and created presently observed structural style;

-Permian to Jurassic rocks show similar structural style;

-apatite fission track study of samples from the Tsvetkova Cape area point to ca. 150-125 Ma and 75-60 Ma uplift/erosion events.

2. Although extension related to the opening of the Laptev Sea offshore rift basin was discussed in many papers (e.g., Drachev, 2000, and reference therein), nobody documented extensional structures in onshore natural outcrops on the Laptev Sea west shore.

3. The Central and Southern Taimyr zone (eastern parts)

The Central Taimyr zone consists of three main complexes: 1) Proterozoic, pre-Riphean, metamorphic complex; 2) Lower-Middle Riphean volcanogenic complex, and 3) an Upper Riphean - Vendian-Paleozoic terrigenous-carbonate complex.

Pre-Cambrian complexes show evidences for at least two tectonic events that mark by thrusting, metamorphism (up to amphibolite facies), high rates of minor folding etc (Fig.10, 11). The end of pre-Cambrian deformations is marked by clear regional angular Vendian unconformity with thick quartz conglomerates (Fig.12, 13).

The Southern Taimyr zone coincides with a band of Ordovician to Jurassic deposits. The sediments suffered rather strong deformations decreasing southwards from the boundary of the Central zone. It is very similar to Verkhoyansk complex and shows a gradual transition to platfrom sections south of the Enisey-Khatanga depression (Zonenshain, Natapov, 1990).

Fig. 8. The Verkhneleningradskaya Area. Geological map with cross-sections, and stereograms showing structural style and orientations of kinematic axes

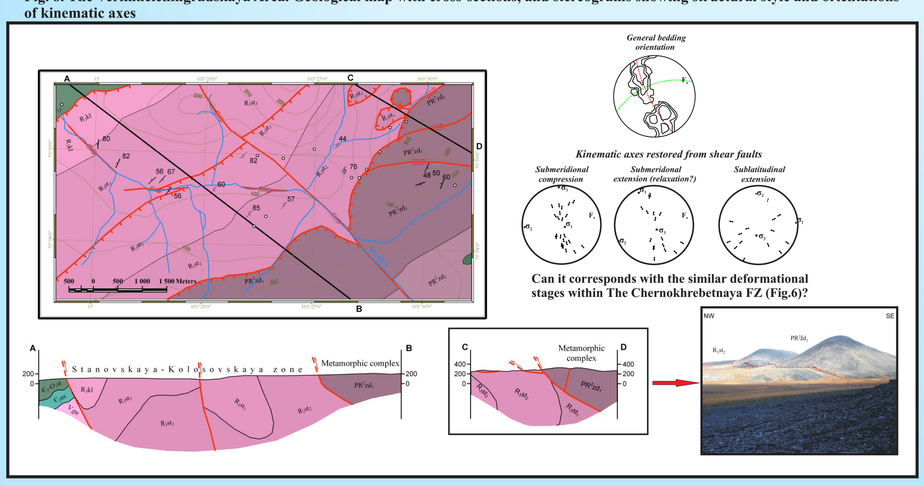


Fig.15. The Podkhrebetnaya River. Geological map with cross-sections, and stereograms showing structural style and orientations of kinematic axes

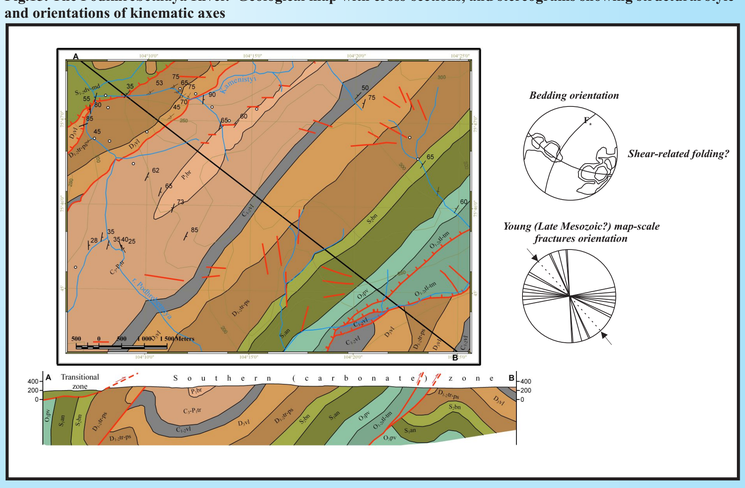


Fig.16. The Podkhrebetnaya River. a) Overturned bedding of D_3 limestones on C_3-P_1 siltstones. Arrow points to contact zone; b) Highly-cleavaged C_3-P_1 siltstones

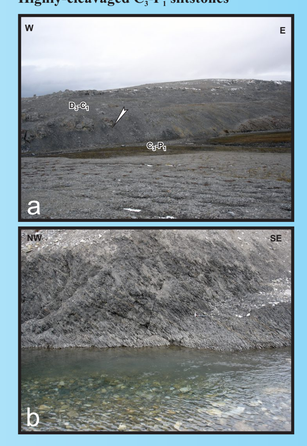


Fig.10. The Zhdanova River. Complex picture of deformational style of PR-rocks with folds with vertical axis showing several strong folding events.

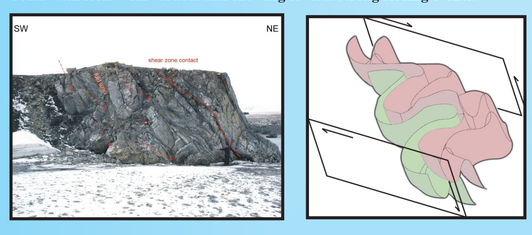
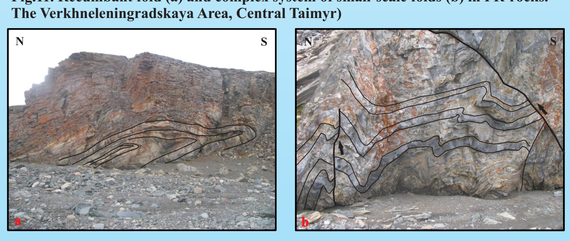


Fig.11. Recumbant fold (a) and complex system of small-scale folds (b) in PR-rocks. The Verkhneleningradskaya Area, Central Taimyr)



Main Results

1) The only clear angular unconformity in the sedimentary succession of the Central and Southern Taimyr is between Vendian and underlying rocks. Vendian – Triassic succession does not contain unconformities, although some hiatuses may occur;

2) Folds in Cambrian up to Upper Permian rock units have very similar geometry (Fig 16-19);

3)Stress axes orientation estimated from the fracture study in Riphean rocks in the Central Taimyr and Permian up to Upper Jurassic sediments in the eastern part of Southern Taimyr (Tsvetkova Cape area) is very similar (Fig.6, 8, 16).

Fig.17. Flexure fold in Lower Paleozoic limestones and black shales. The Ostantsovaya River, Central Taimyr.

Fig18.. Typical folding in Lower Paleozoic siltstones, The Korallovaya River, Central Taimyr.

Fig.19. Minor thrusts in Lower Paleozoic limestones. The Korallovaya River, Central Taimyr.

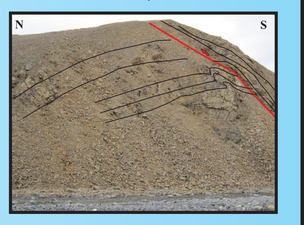


Fig.12. The tectonic contact between Paleozoic and Riphean rocks (a) and Vendian basal quartz conglomerates (b). The Korallovaya River, Central Taimyr.

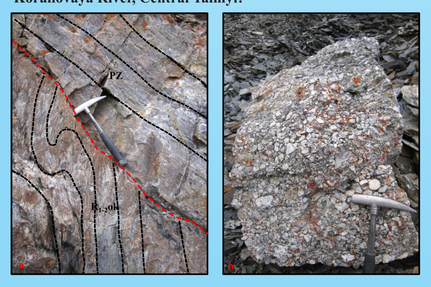
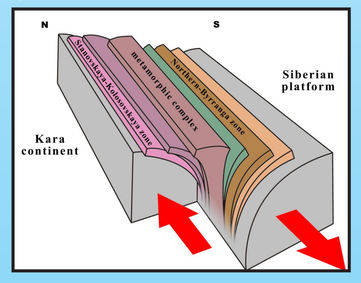


Fig.13. Vendian angular unconformity. The Korallovaya River, Central Taimyr)

Fig.14. The schematic picture showing forming of the Taimyr FTB under transpressional tectonical regime (flower, or palm- tree structure).



References

Migay I.M., 1950. *Geological structure of Tsvetkov Cape Area, East Taimyr*. Leningrad-Moscow, Open file report, NIIGA press, 60 p. In Russian

Pogrebitskiy Y.E. ed., 1998. *Geological State map of the Russian Federation. 1 : 1 000 000 scale, S-47-49 sheet (Taimyr Lake)*. Explanation text. Saint-Petersburg, VSEGEI press, 231 p. In Russian

Vernikovskiy V.A., 1996. *Geodynamic evolution of Taimyr fold-thrust belt*. Novosibirsk, SB RAS press, 202 p. In Russian.

Zonenshain, L., Kuzmin, M., Natapov, L. *Geology of the USSR: A Plate-Tectonic Synthesis* (American Geophysical Union, Geodynamic Series), 21; American Geophysical Union: Washington, DC, USA, 1990.

4. Conclusions

Our observations do not show evidence for a strong late Paleozoic compression in the Central and Southern Taimyr. Similarity in fold geometry and stress axes orientation shows that Vendian and younger rocks up to Permian in the Central Taimyr as well as Permian and Mesozoic rocks of the Southern Taimyr were mainly deformed during Mesozoic (Early and/or Late Cretaceous) compressional event, also recognized by brittle fractures in the Riphean rock units. These events are approximately synchronous to major collisional processes occurred in latest Jurassic – Cretaceous time in the northeast Asia and may reflect a connection between Southern Taimyr and Mesozoic fold belts of the northeast Asia. The final extension best documented in the Chernokhrebetnaya fold zone likely reflects tectonic relaxation processes right after the compressional event and opening of the Laptev Sea rifted sedimentary basin in Late Cretaceous-Cenozoic.

Acknowledgements

This study was done in the frame o different projects: "Southern Coast of Laptev Sea between Khatanga Bay and Lena Delta: Regional Study" (Leader A. Khudoley) supported by TGS-NOPEC Geophysical Company, and Russian State geological mapping program within Central and Eastern Taimyr organised by VSEGEI (Leader V. Proskurnin)