

Structure and Petroleum Habitat of the Pay Khoy-Novaya Zemlya Foreland Fold Belt, Timan Pechora, Russia*

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Abstract

The study is based on integrated interpretation of geological and geophysical data on the Pay Khoy-Novaya Zemlya foreland fold belt. It strikes for 700 km off the southwestern coast of Novaya Zemlya extending onshore into the north-eastern part of Timan Pechora. It is observed that in the northwestern part of the belt is dominated by transpressional deformations. Typically they involve high-relief flower structures with limited shortening. To the south-east of the fold belt it gradually passes into a typical thin-skinned thrust belt. Structuring there is controlled by multiple delamination of the Paleozoic-Triassic sedimentary section, thrust imbrications, and disharmonic folding. The main detachment level is interpreted to be related to the Upper Ordovician evaporates. Estimated total amount of shortening across the fold belt may well exceed 50 km. Strike-slip deformations in this part of the fold belt have limited development.

Study seismic and geological data permitted the identification of the main episodes of structuring in the Pay Khoy – Novaya Zemlya fold belt. The Middle Devonian-Early Frasnian folding took place in the northern part of the study area. It is marked by the prominent pre-Frasnian unconformity which is getting less important in the southern part of the study area. In the Late Permian the fold belt experienced large-scale sinistral strike-slip along the Tran-Eurasian fault system, which created transpressional structures and led to the drastic bending and curvature of the Urals-Pay Khoy – Novaya Zemlya suture (Sobornov and Yakubchuk, 2004). Shortly afterwards it was followed by an episode of large-scale folding and thrusting in the Triassic. It led to detachment faulting widely developed in the Pay Khoy foreland sealed by the pre-Jurassic unconformity. It is interpreted that it was driven by the south-west lateral escape of the South Kara plate from a collision of the Siberia and North Kara plates, which produced the Taymyr orogen. In the Late Tertiary the fold belt was subjected to a compressional reactivation and general uplift.

The lateral segmentation along the fold belt is likely due to the following control factors. Firstly, they may have resulted from the sinistral displacement on the Trans-Eurasian fault which is oriented obliquely to the fold belt. Secondly, it was preconditioned by the interpreted heterogeneity of the structural grain of the Pechora foreland juxtaposed against the fold belt. Thirdly the structure of the fold belt was controlled by the shape and stress orientation produced by the lateral escape of the Kara plate. The structural appearance of the northwestern segment of the foreland was mainly governed by the sinistral strike-slip transpression. In addition it was to a much greater degree affected by

foreland structure produced by the pre-Frasnian folding. The presence of a structural high in front of the northern segment of the fold belt had likely concealed the detachment folding. The southern segment of the fold belt was mainly shaped by SW-oriented compression during the Triassic escape of the South Kara plate. The development of the Upper Ordovician evaporates facilitated delamination of the sedimentary fill with the wide development thin-skinned thrusting.

The structural segmentation of the fold belt provides diverse types of hydrocarbon traps. Of prime interest are thrust related 4-dip closures, flower structures, carbonate build-ups, pinch-outs, and karstified carbonates subcropping the pre-Frasnian unconformity. The latter are exemplified by the largest known commercial deposits in the area - Titov and Trebs fields. The prominent tectonic thickening and subsequent erosion of the sedimentary section due to thrusting in the inner part of the Pay Khoy segment may account for a greater content of gas.

Selected References

Sobornov, K., and A. Nikishin, 2009, Phanerozoic East Europe – Siberia Interaction and Petroleum Habitat of Northern Eurasia: AAPG Search and Discovery Article #90099. Web accessed 26 November 2013.

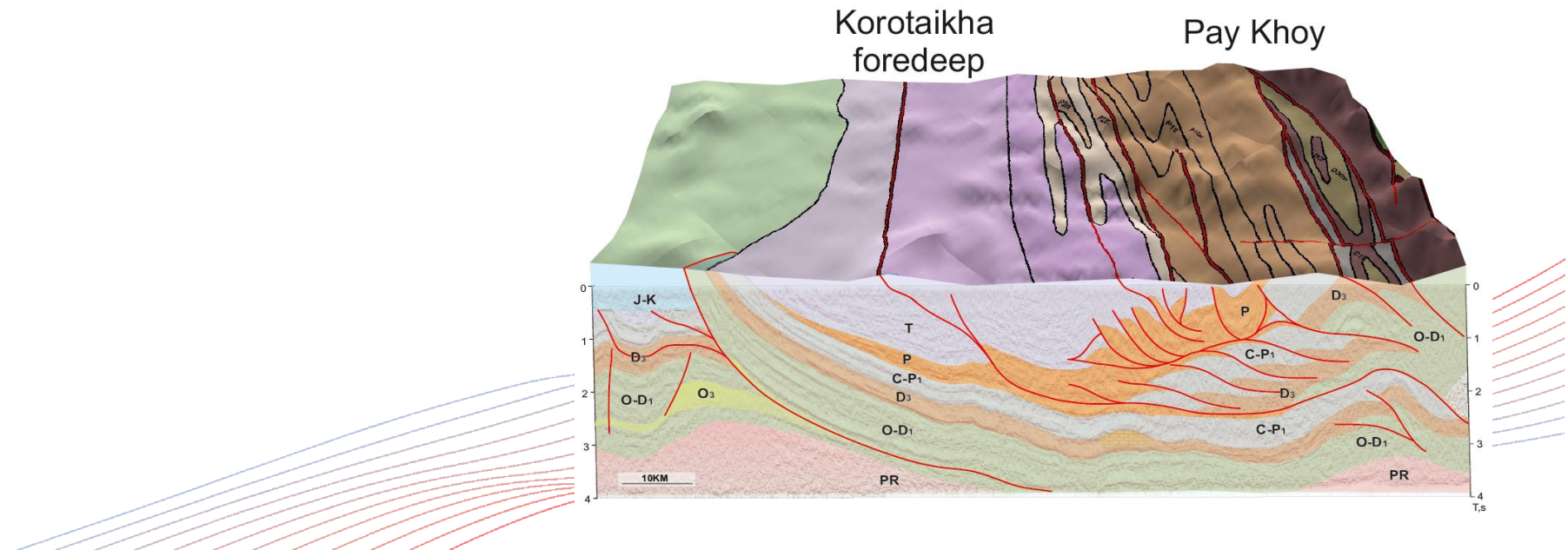
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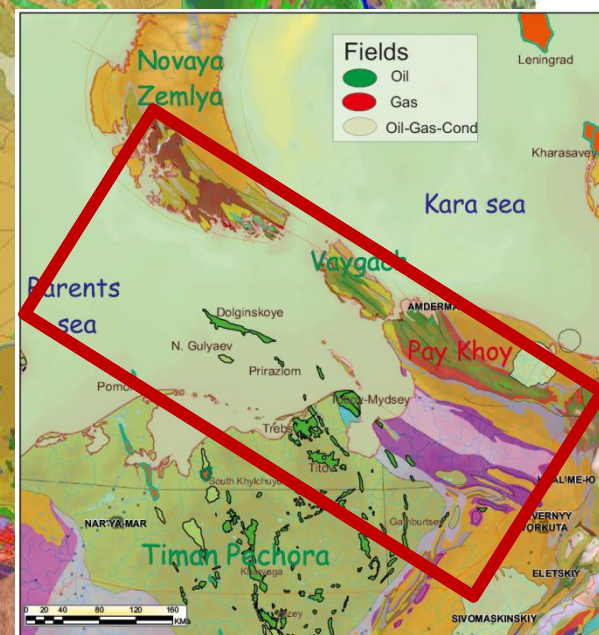
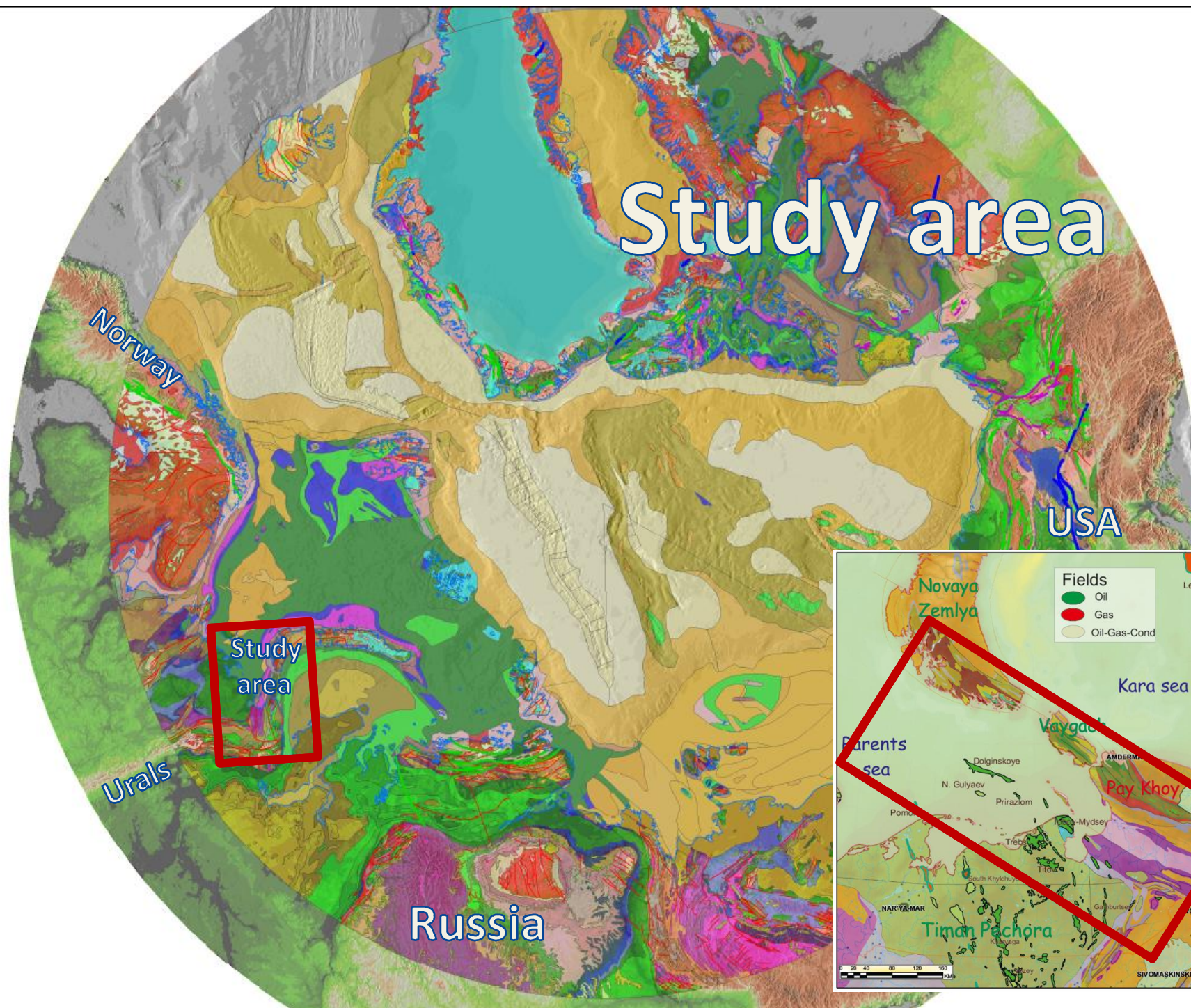
Sobornov, K. and A. Yakubchuk, 2004. Phanerozoic East Europe – Siberia Interaction and Petroleum Habitat of Northern Eurasia: CD-ROM. AAPG/GSA European Region Conference, Prague.

Swirydczuk, K., B.I. Rapoport, V. Lesnichy, and J.A. Quadir, 2003, Yuzhno Khilchuyu Field, Timan-Pechora Basin, Russia, *in* M.T. Halbouty, ed., Giant oil and gas fields of the decade, 1990-1999: AAPG Memoir, v. 78, p. 251-274.

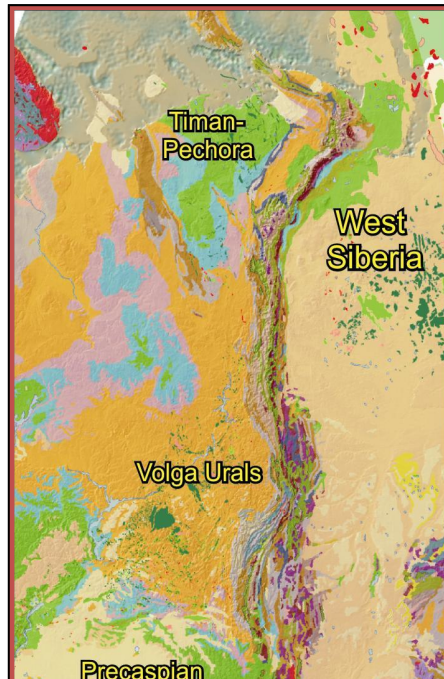
Structure and Petroleum Habitat of the Pay Khoy- Novaya Zemlya Foreland Fold Belt, Timan Pechora, Russia

Konstantin SOBORNOV

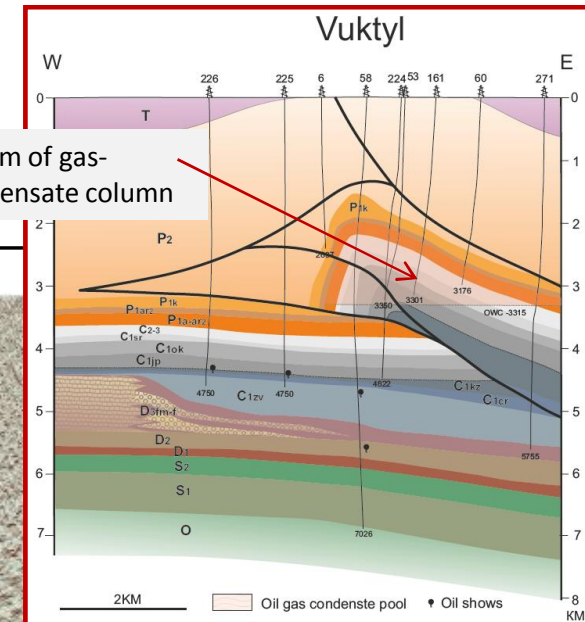
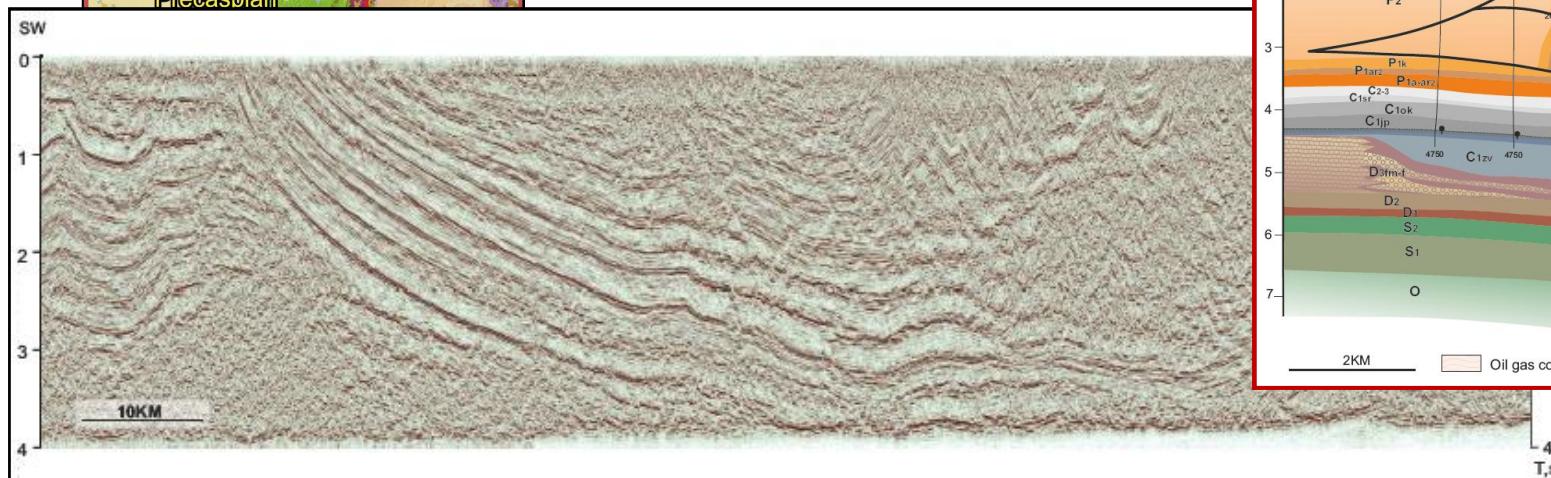




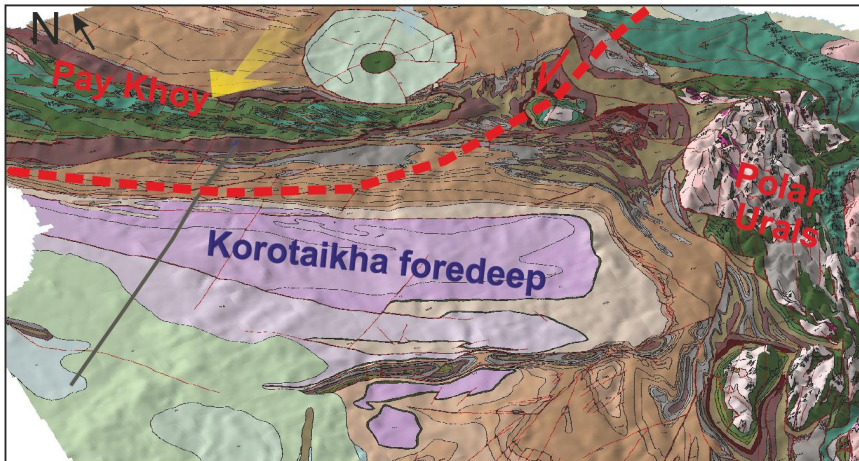
Reasons to study this area



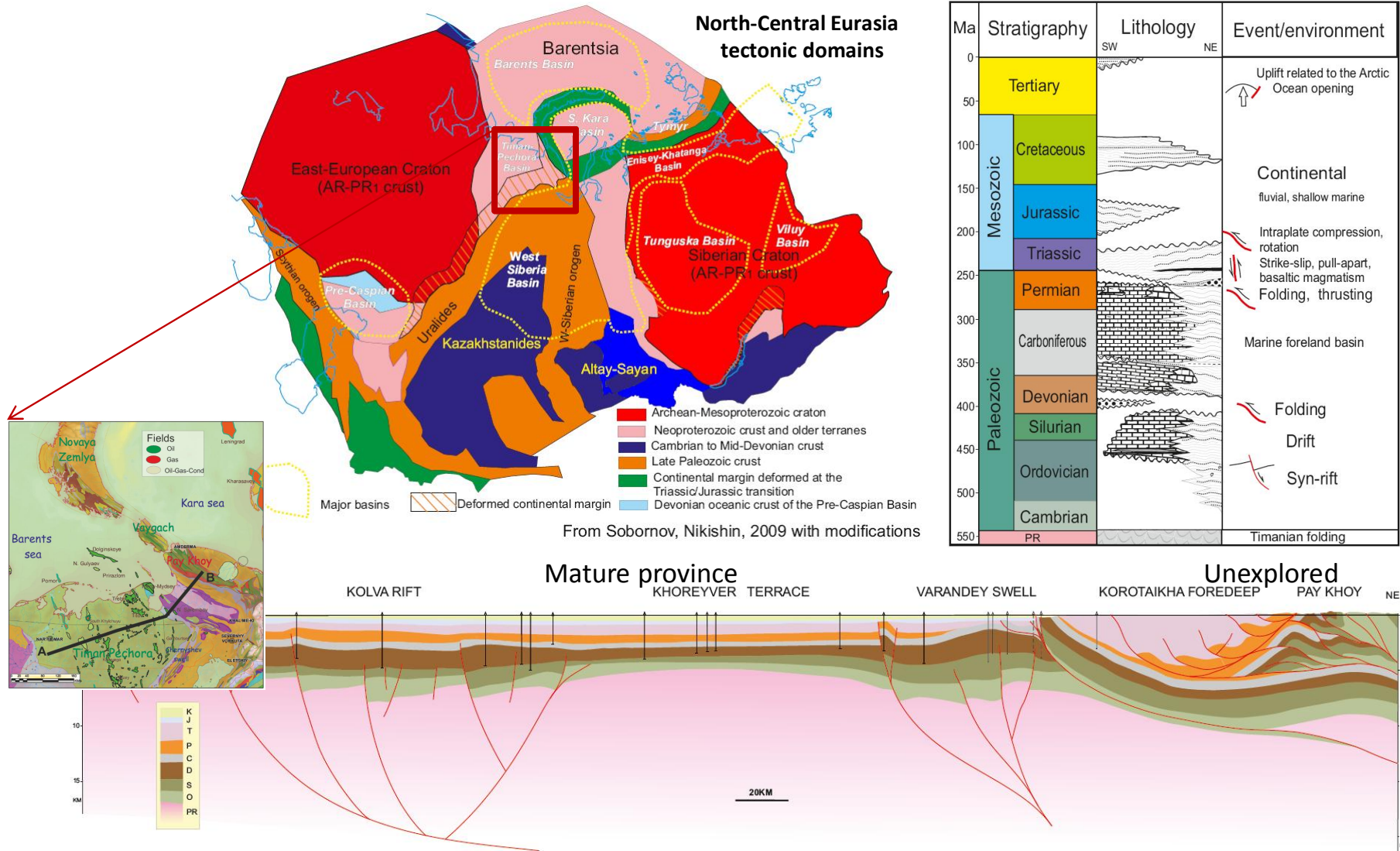
- Still poorly understood fold belt
- Untested part of a prolific petroleum province
- New data, new constrains



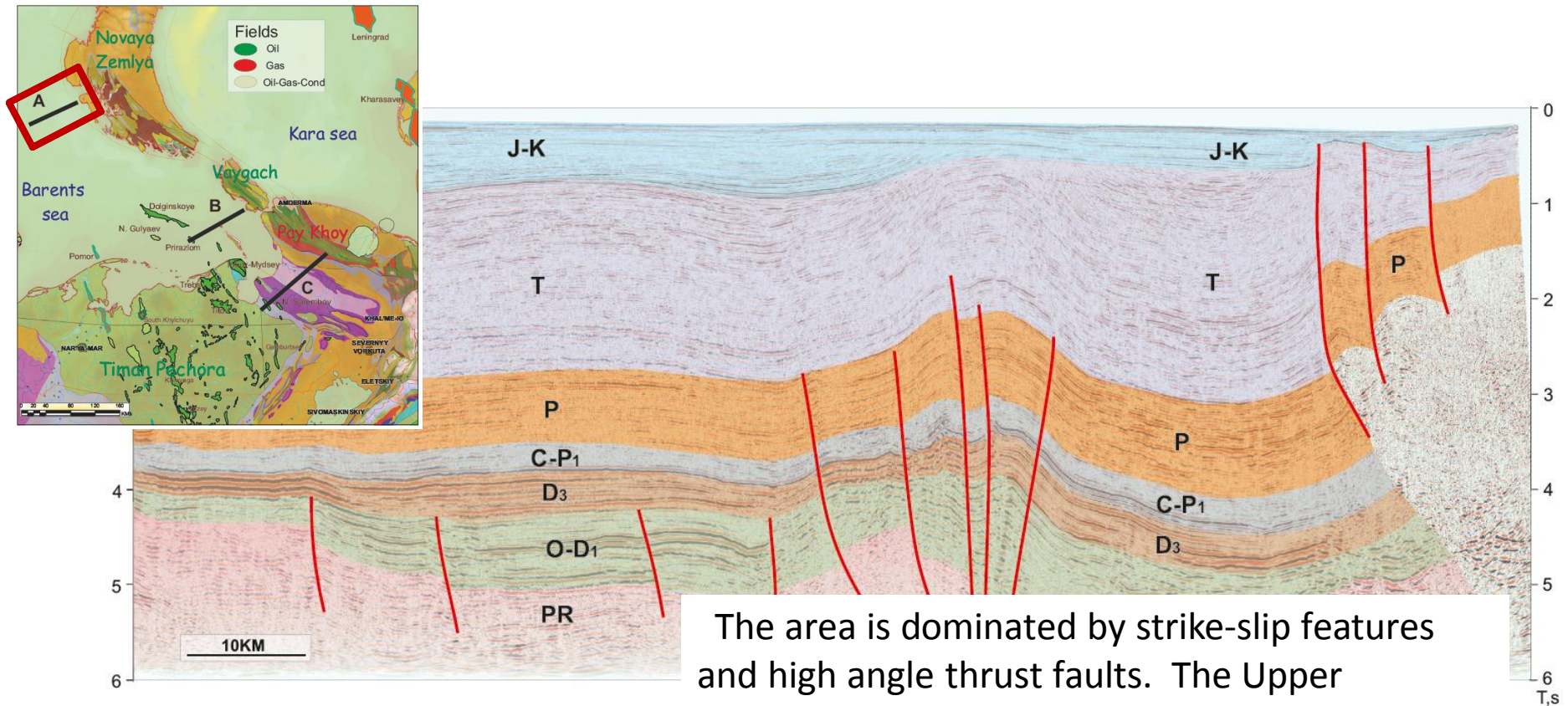
- Review of structural geology
- Timing of events, geodynamic development
- Petroleum habitat



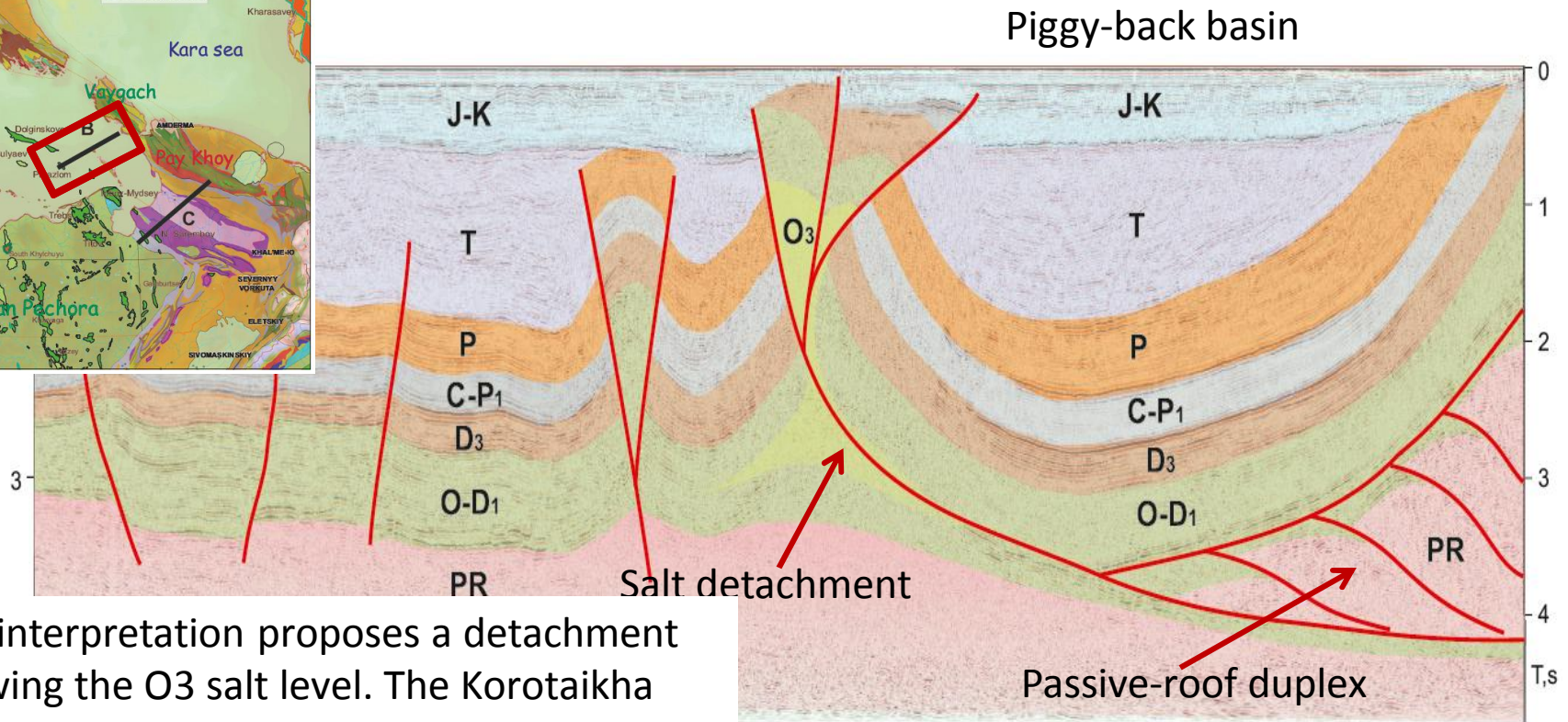
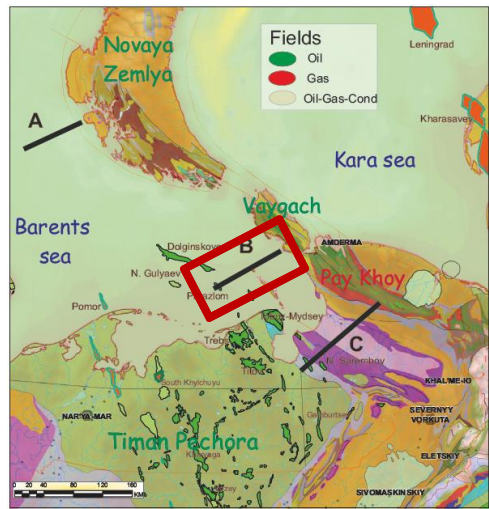
General setting



Off South Novaya Zemlya

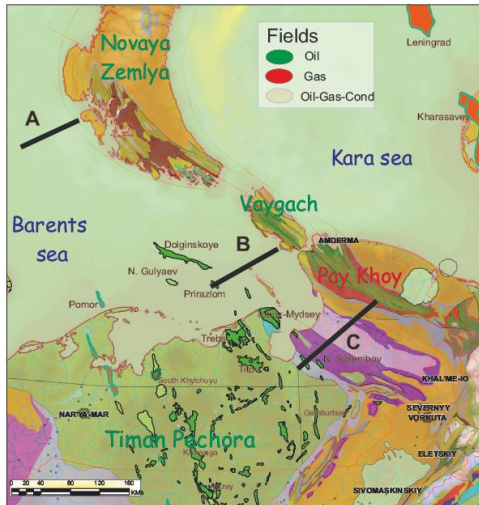


Off Vaygach Island

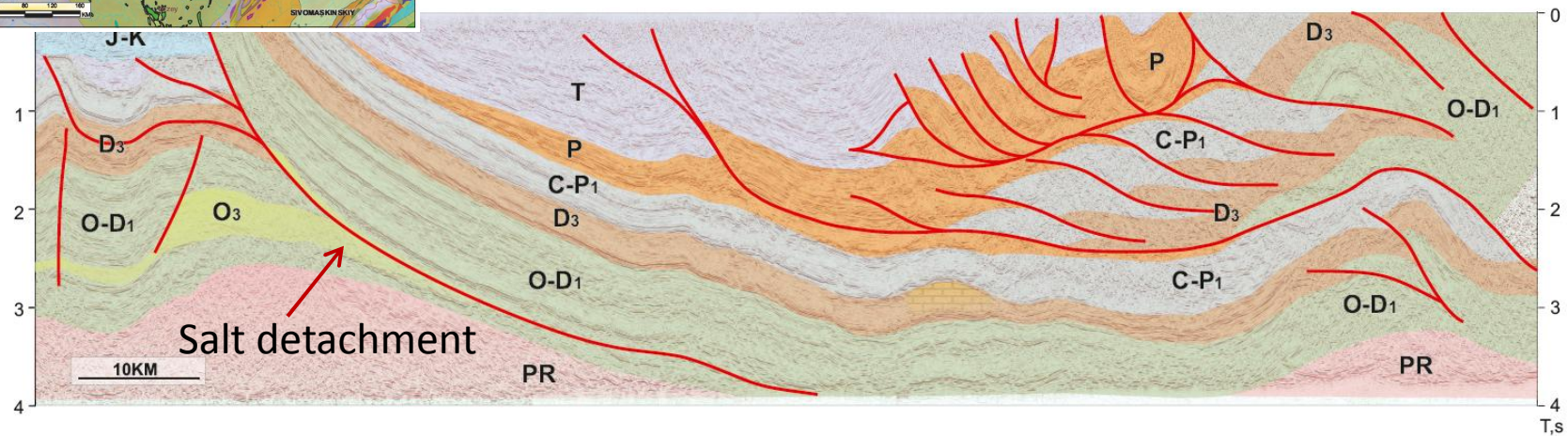


The interpretation proposes a detachment following the O₃ salt level. The Korotaikha basin could be referred to as a piggy back basin, there is passive roof duplex in the east.

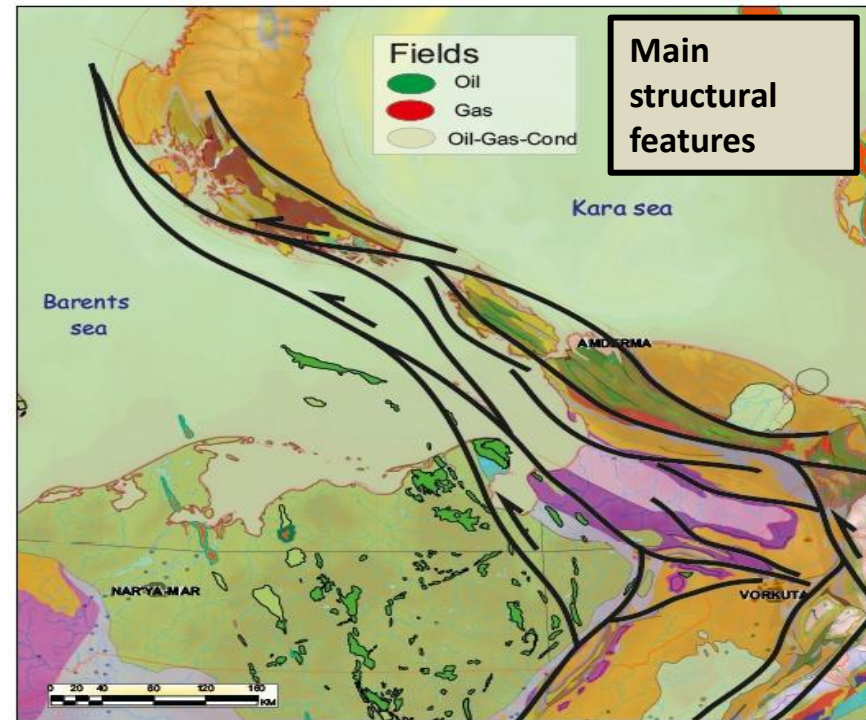
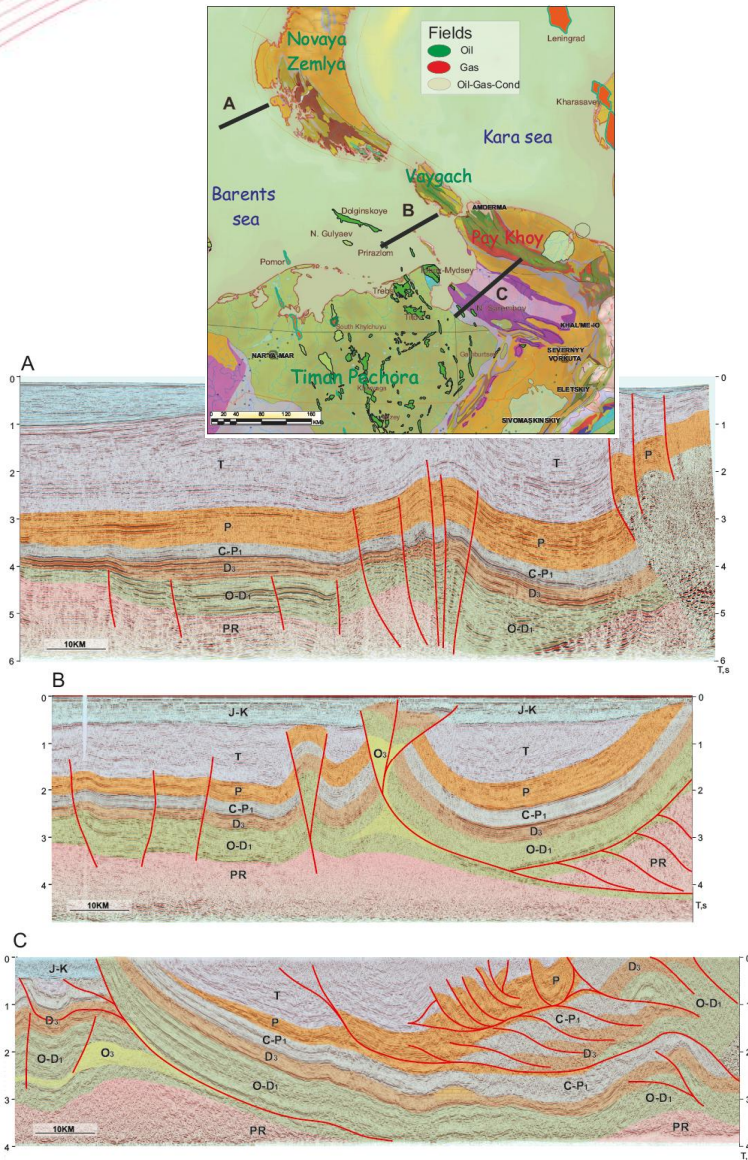
Korotaiikha foredeep onshore



Multiple delamination and disharmonic folding are interpreted in the eastern part of the area. The prominent structural culmination in the west is related the far travelling thrust sheet with detachment in the O3 evaporites.



Lateral segmentations



The map schematically shows main structural features based on available dataset involving mainly seismic data. Detachment faulting is widely developed in the SE part of the fold belt. The NW section is dominated by strike-slips deformation. Central part represents a transitional zone between the two.

Timing of events, megasequences

Interpretation of seismic data in the foreland west of the fold belt allows to put constraints on timing of events. Several major unconformities are interpreted in the foreland of the thrust belt. They are: Pre-Frasnian, Artinskian, pre-Triassic and pre-Jurassic. Last but not least – the late Tertiary uplift.

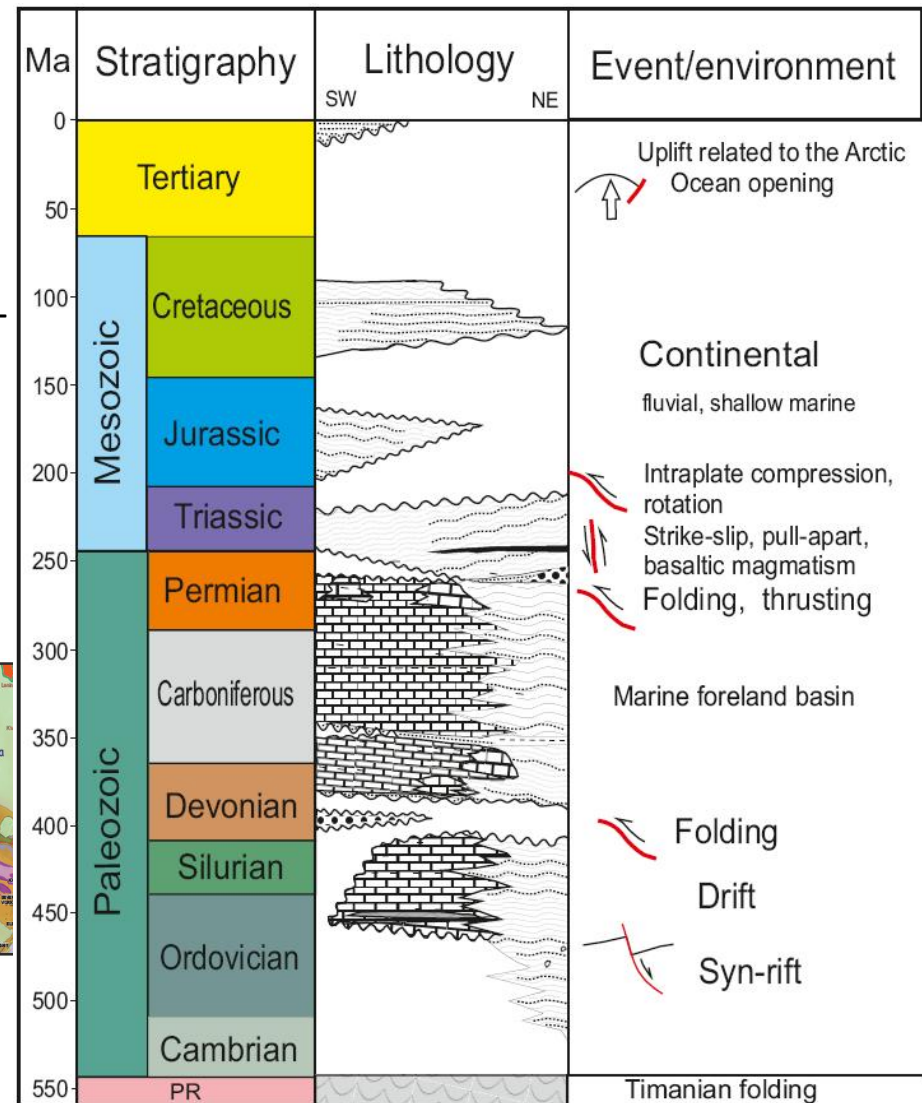
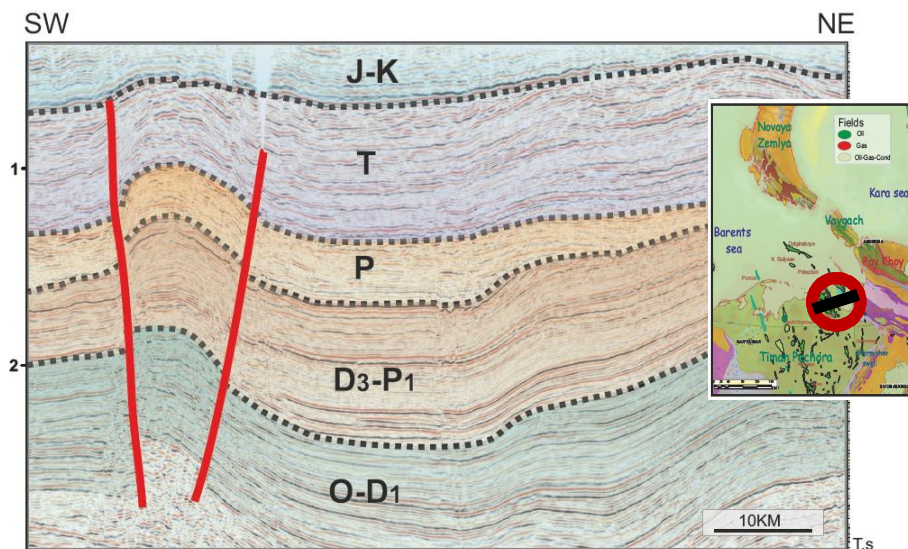
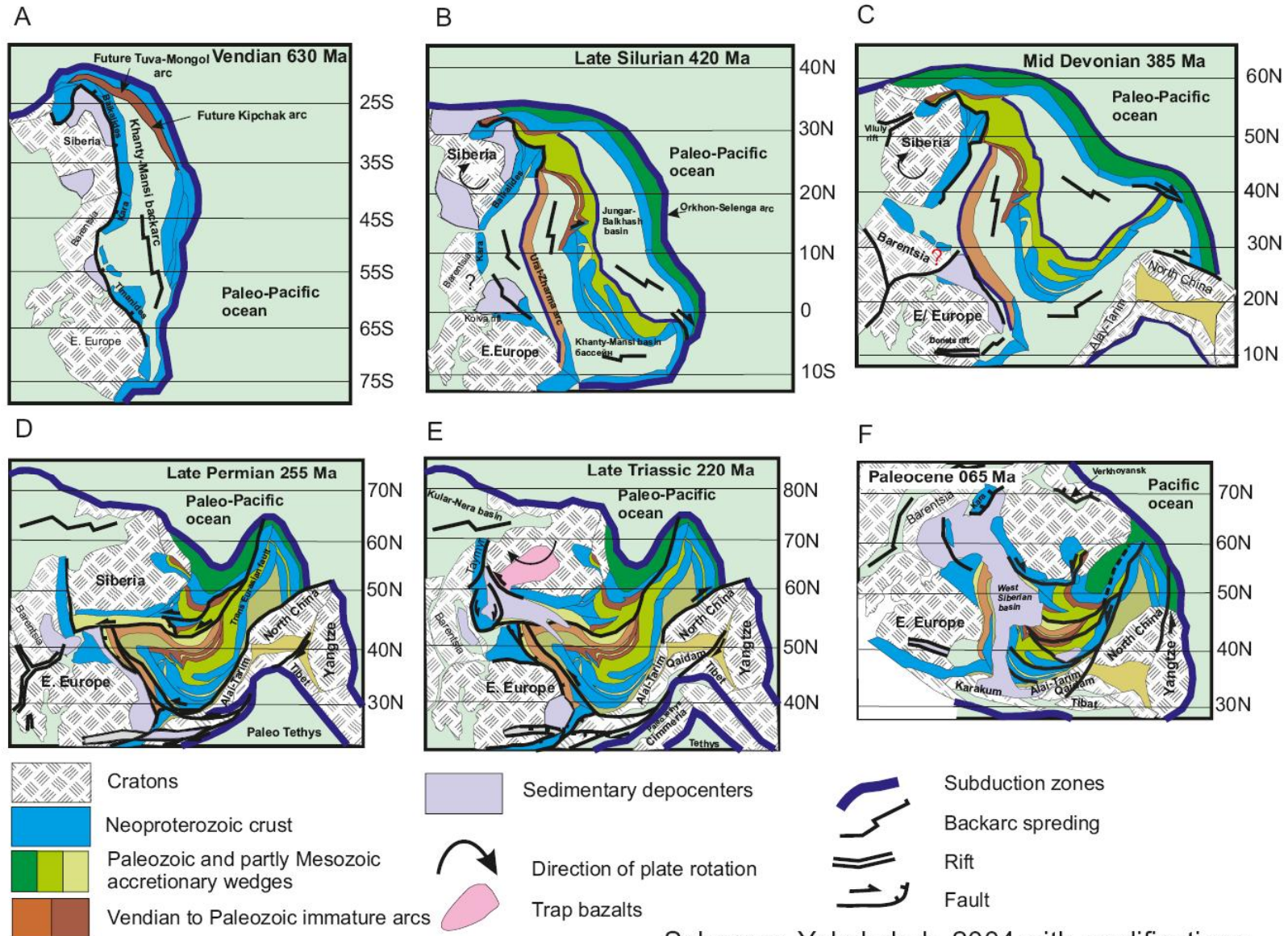
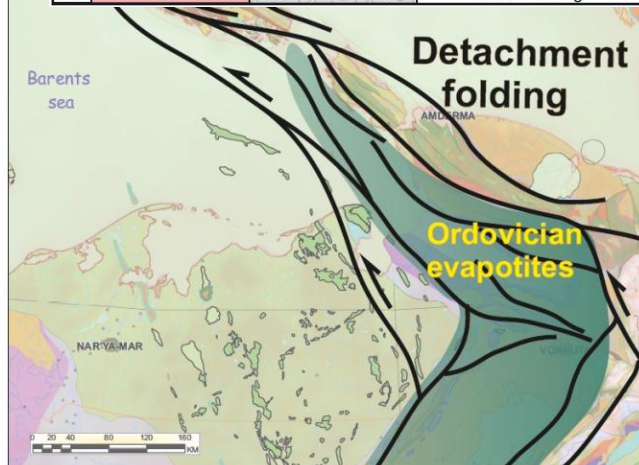
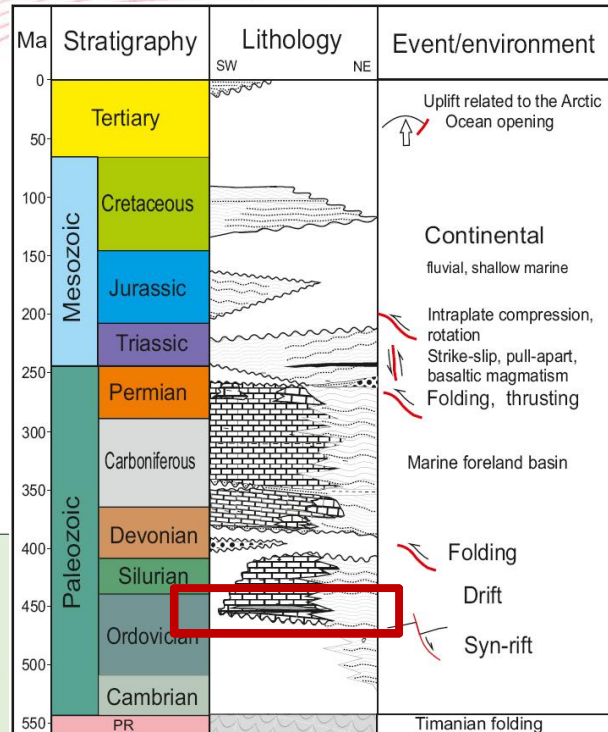


Plate tectonic evolution

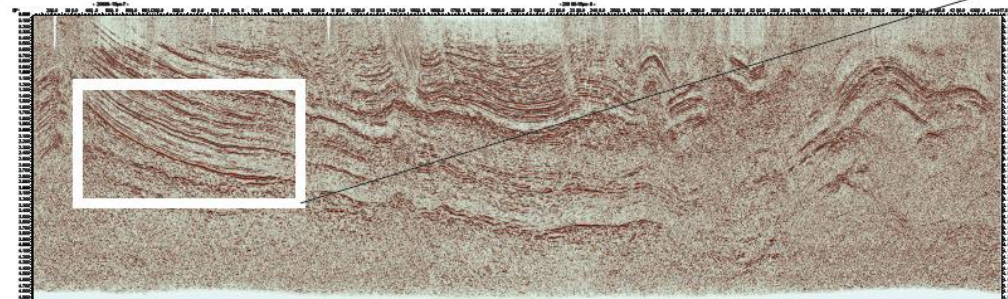
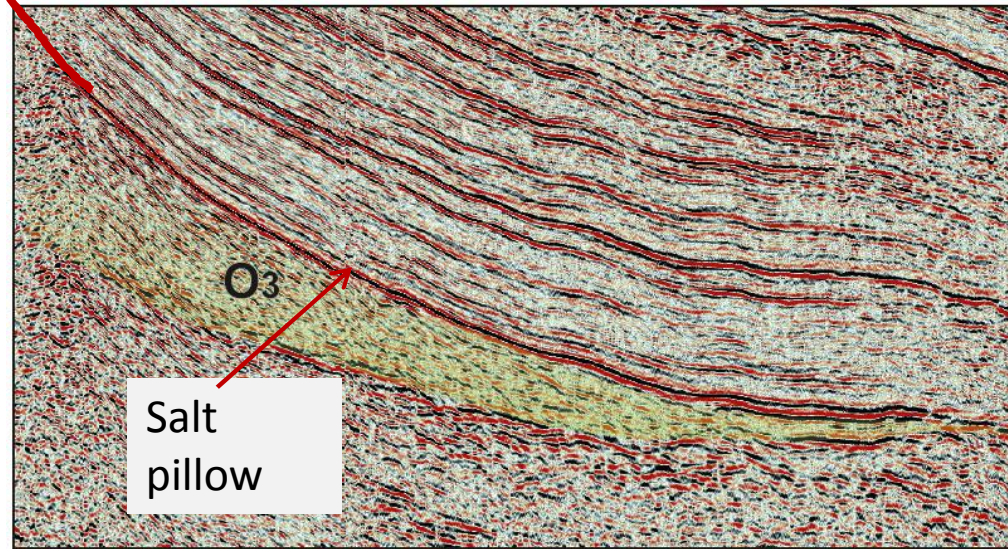


Sobornov, Yakubchuk, 2004 with modifications

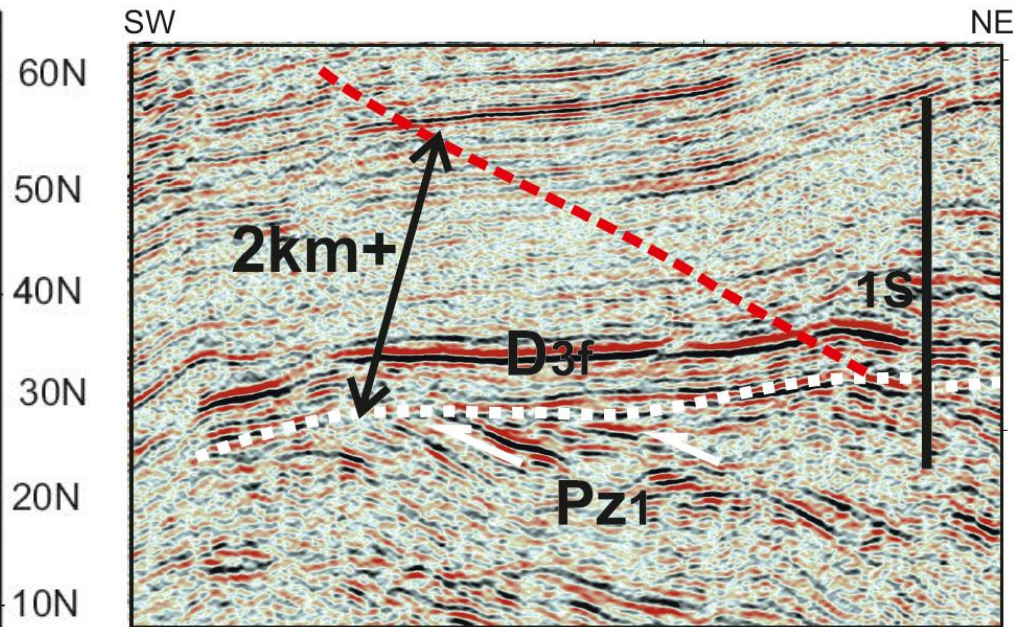
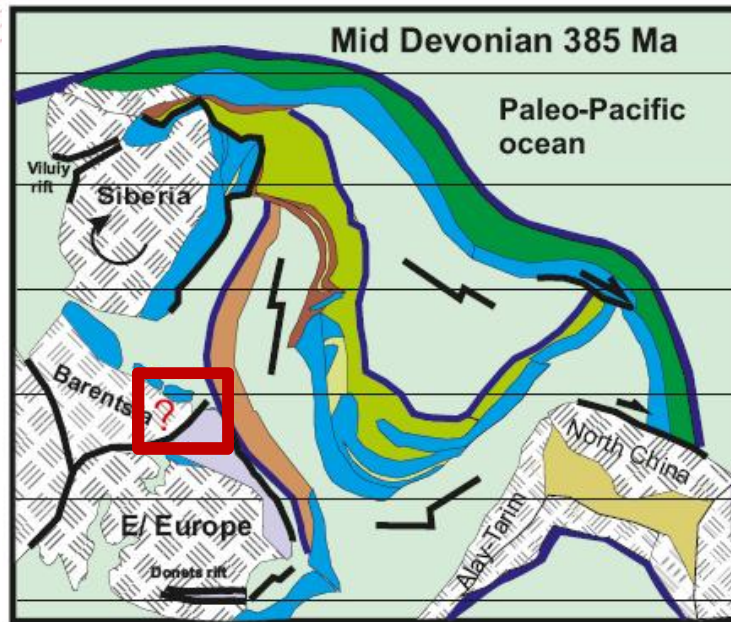
Upper Ordovician salt



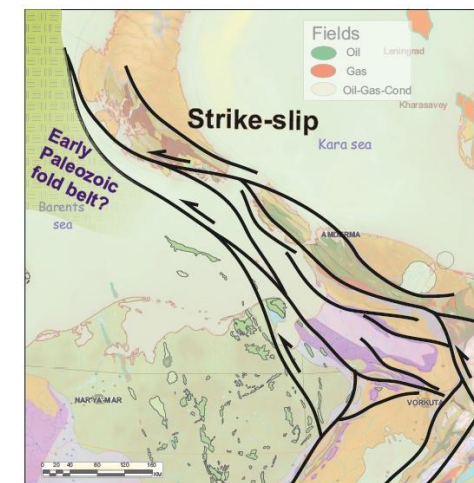
The salt layer provided an efficient detachment facilitating delamination of the sedimentary cover in the south of the belt.



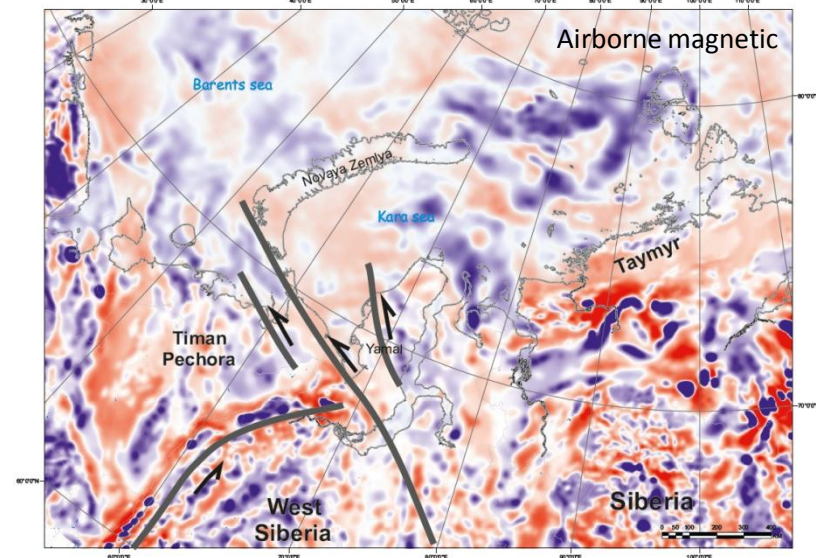
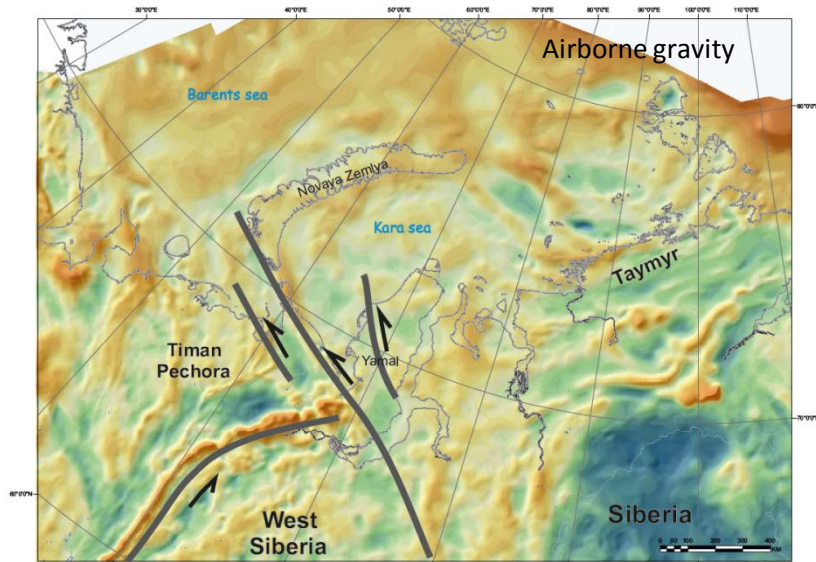
Barents pre-Frasnian folding



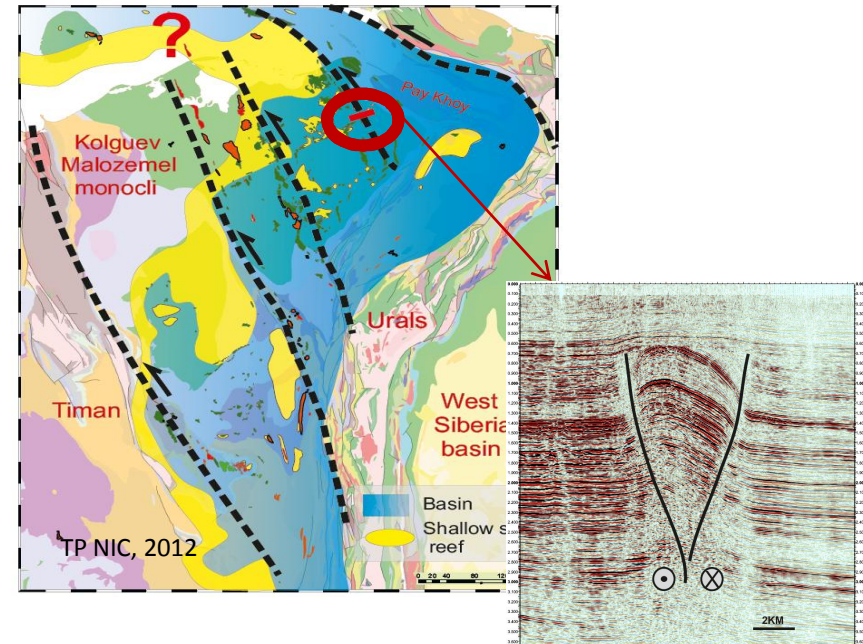
The NW strike-slip dominated structural segment appears to be related to the pronounced pre-Frasnian angular unconformity clearly seen in the South NZ foreland. Up to several kilometers of deposits had been removed prior to the onset of the Frasnian transgression. It would suggest the existence of a folded terrain which later influenced the shape of the Novaya Zemlya fold belt limiting detachment faulting.



Late Permian strike-slips

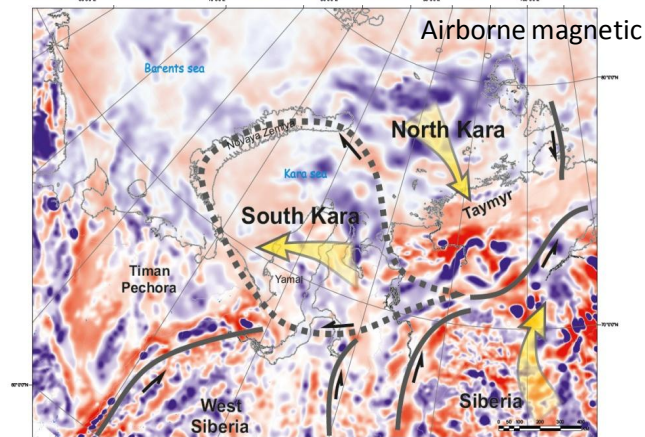
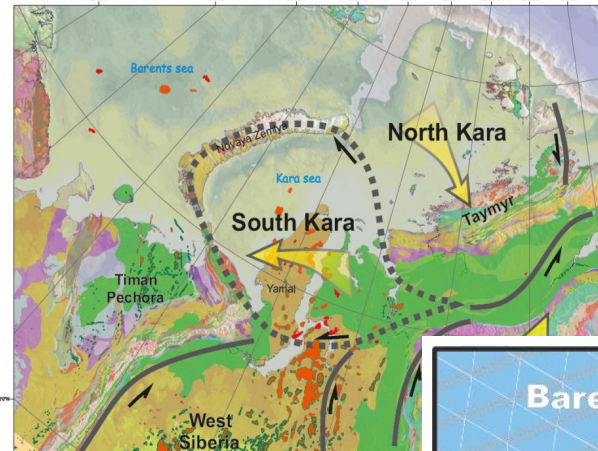


Domanik GDE

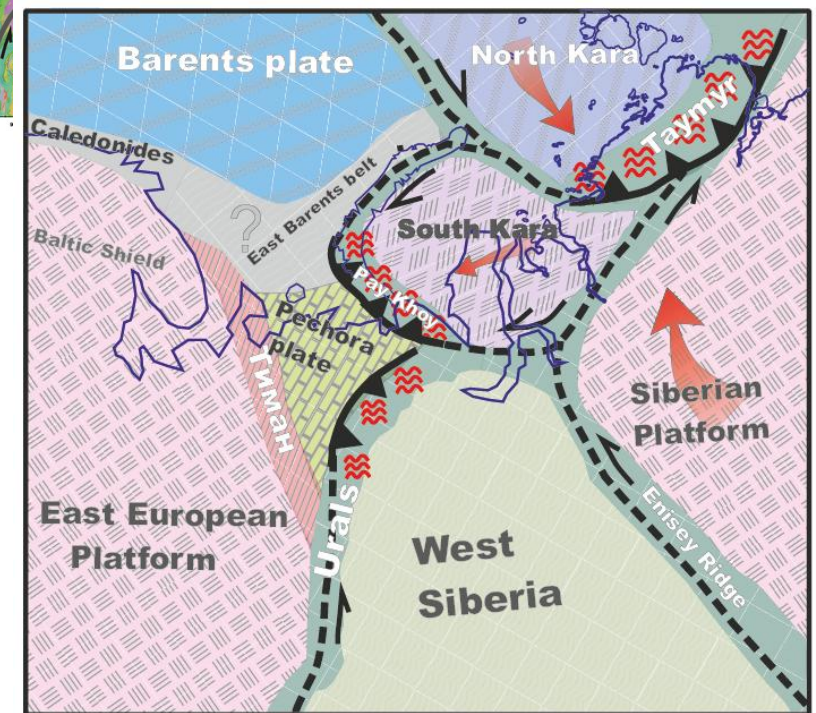


The Late Permian sinistral transpression is seen as principal process shaping the fold belt. This transpressional zone is a result of relative movement of the two principal domains in the North Eurasia – East European and Siberian Platforms.

Triassic, South Kara escape



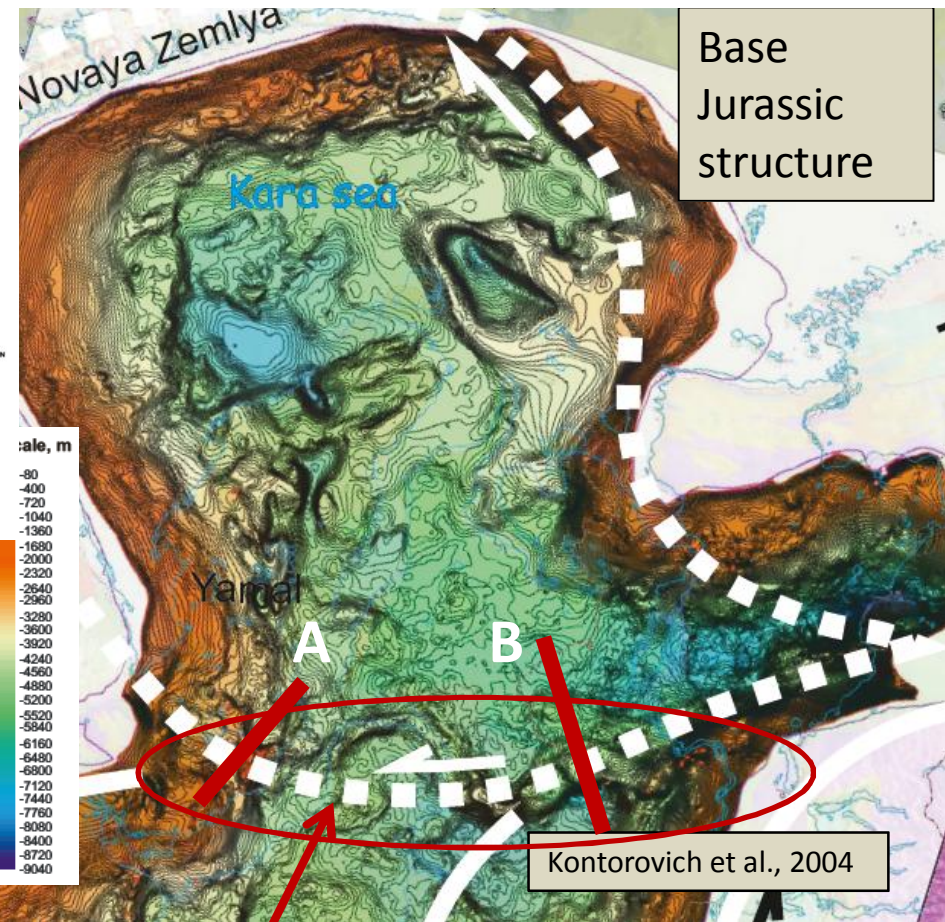
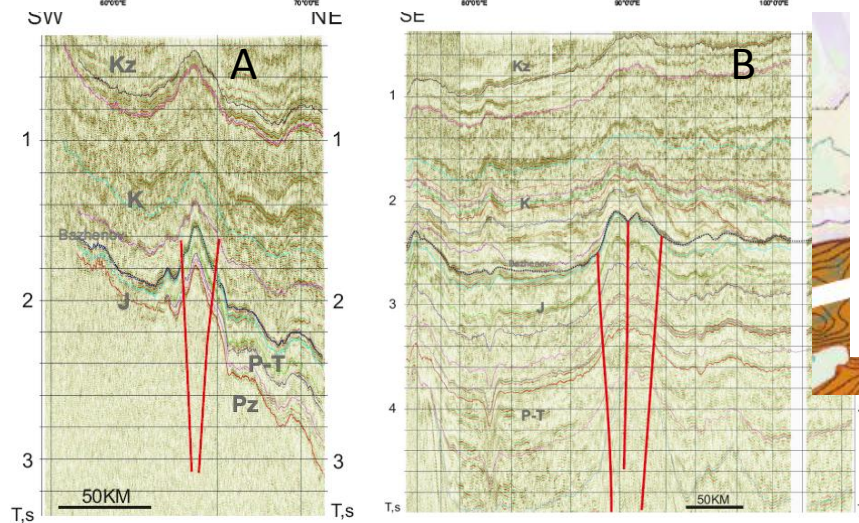
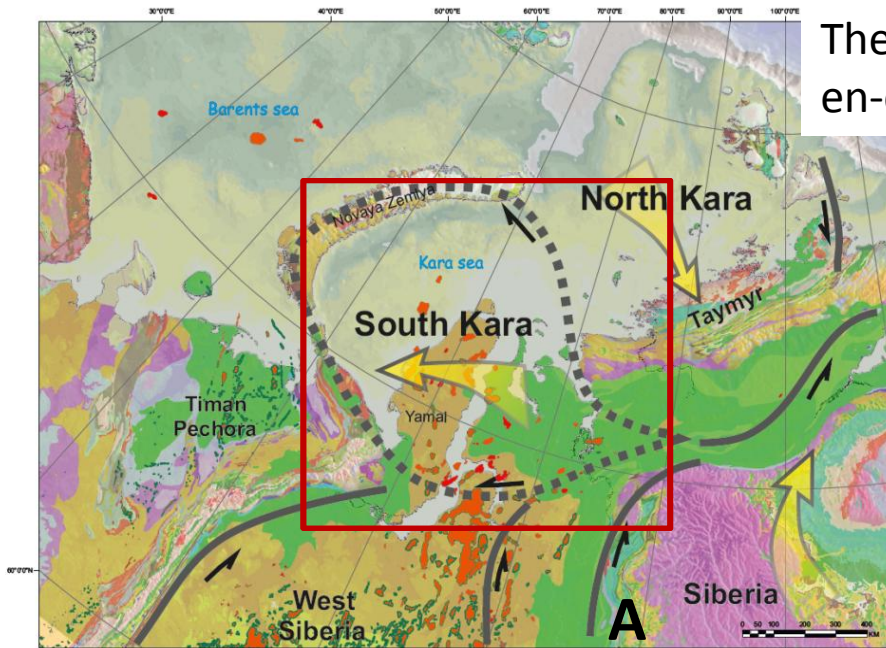
Triassic folding



The clock-vice rotation of Siberia and its progressive collision with the Kara forced the South Kara to escape and producing thrusting and folding in the Pay Khoy and Novaya Zemlya.

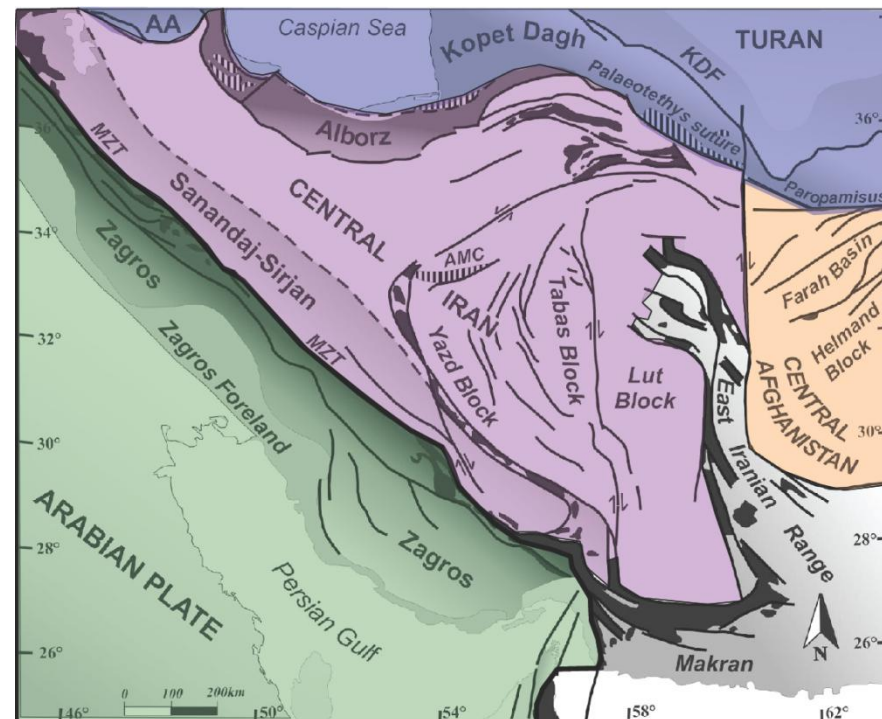
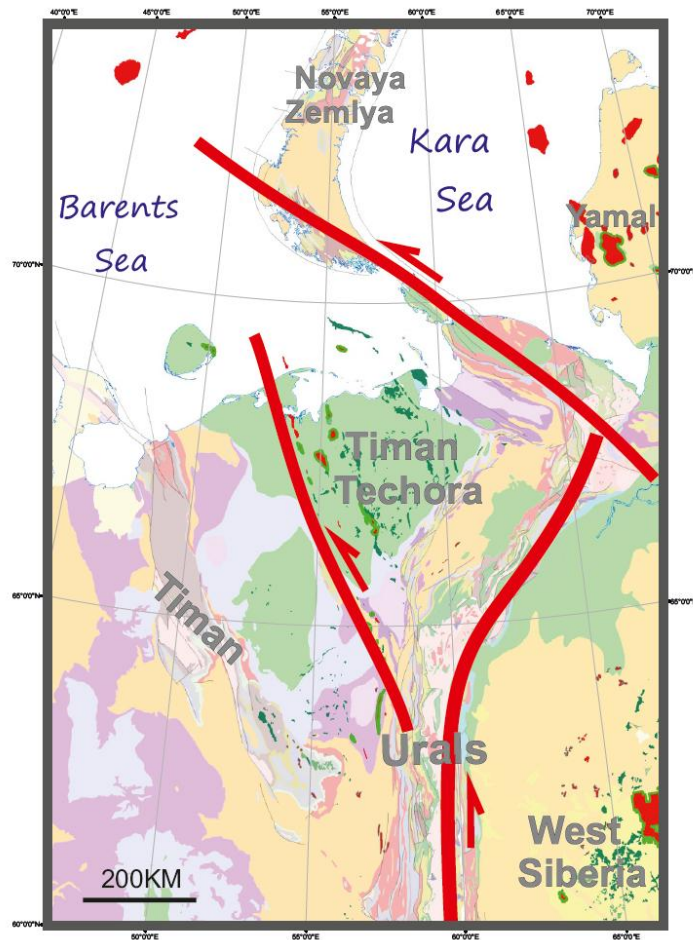
Triassic, South Kara escape

The south flank of the South Kara block is marked by en-echelon of high-relief swells reactivated in Tertiary



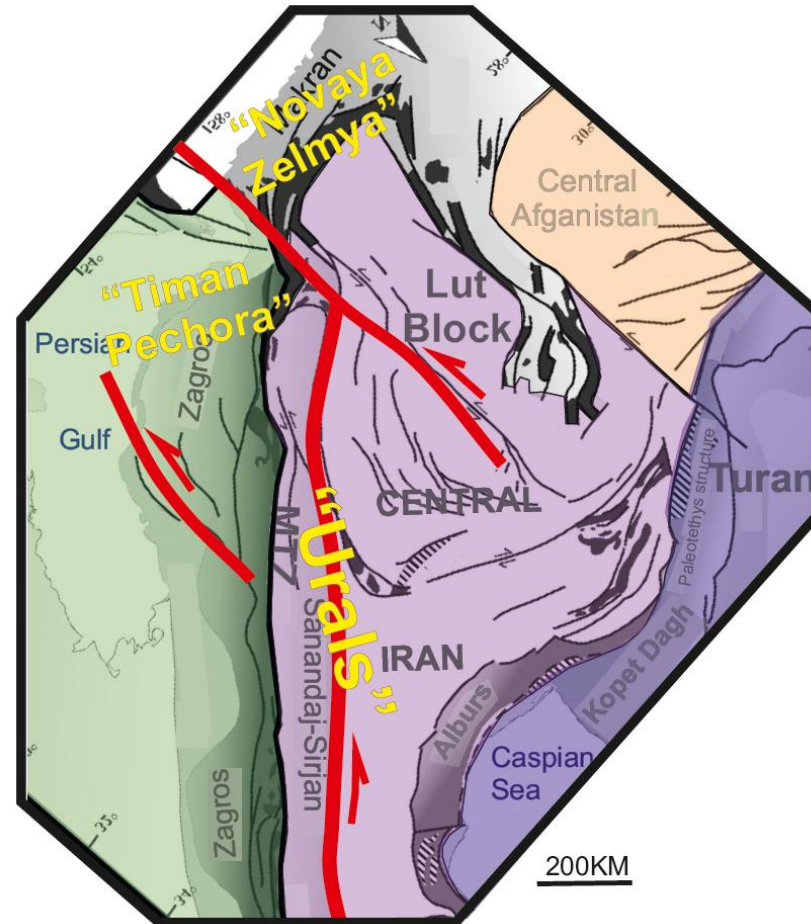
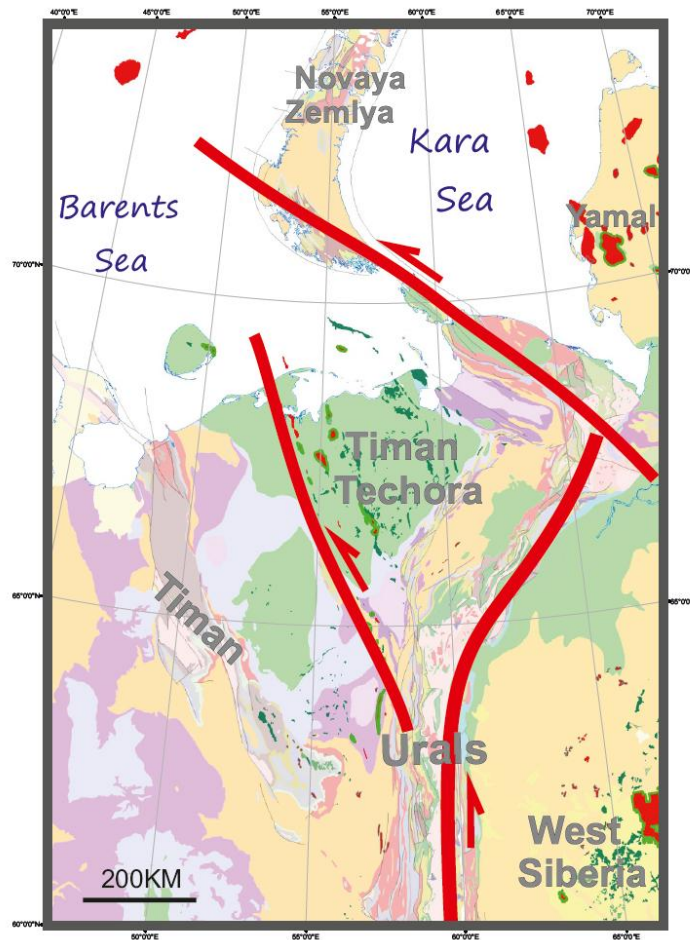
Zone of west-east trending high-relief swells, Mesozoic-Cenozoic overprint

Structural analog?



From Zanchi et al., 2012

Structural analog



Map of Zagros is mirrored and rotated

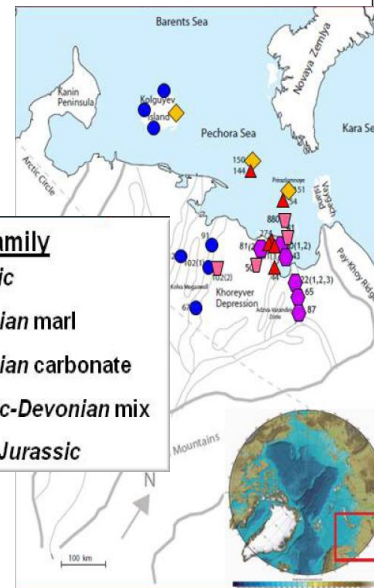
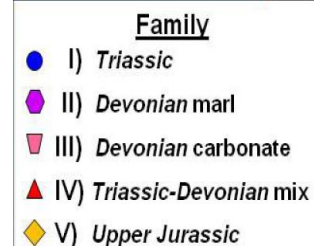
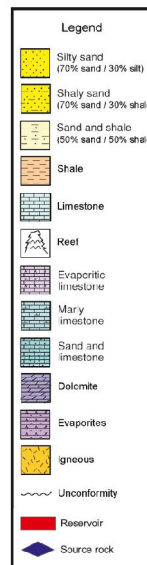


Good calibration onshore. Multiple source rocks, several oil families.

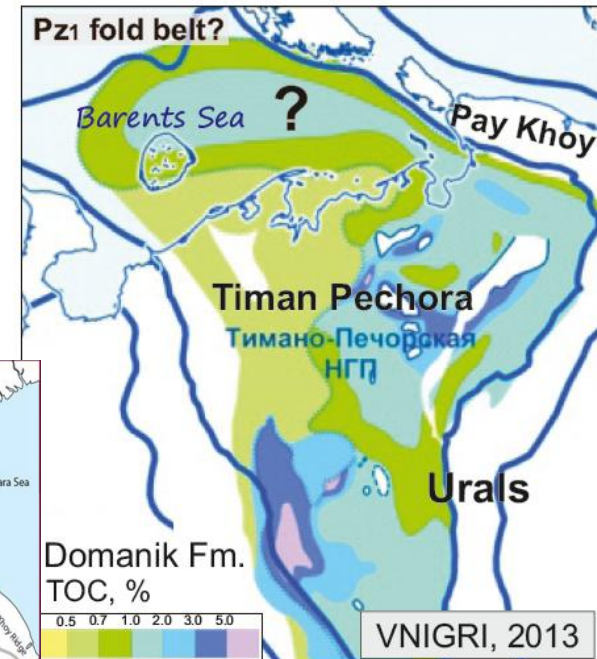
Offshore: risk of a degradation of the Domanik petroleum system, increasing importance of the pre-Frasnian (Silurian) and Mesozoic offshore sources.

Tectonic Activity	Lithology	System	Group	Stage	Plays
Tectonic Quiescence	Missing	Cretaceous	U	Timan Pechora stratigraphy	
			L		
			U		
			L		
Herzian Compression (Uralian Orogeny) Suturing of West Siberia along the Ural Mountains	Jurassic	Triassic	U	Narynmar-Anguran	Reservoir
			M		
			L		
			U		
Passive-margin	Permian	Carboniferous	L	Kharasak-Chankabozh	Source rock
			U	Tatarian - Kazanian	
			L	Ufimian	
			U	Kungurian	
Back-arc Setting with Intermittent Episodes of Compression	Devonian	Silurian	L	Artinskian	Reservoir
			U	Sakmarian	
			L	Kasimovian	
			U	Ozorian-Kasimovian	
Passive-margin	Ordovician	Cambrian	L	Viséan	Source rock
			U	Tournaisian	
			L	Famennian	
			U	Frasnian	
Extension-Proto-Uralian Ocean	Missing		L	Givetian	Reservoir
			U	Eifelian	
			L	Emekian-Pragian-Lochovian	
			U		

Modified after Swiryczuk et al., 2003



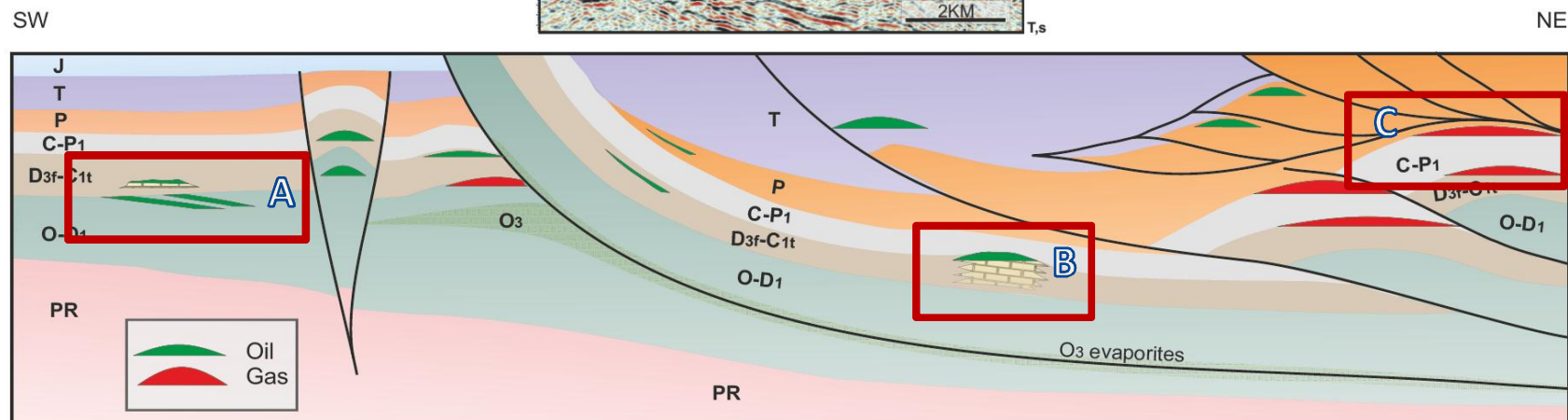
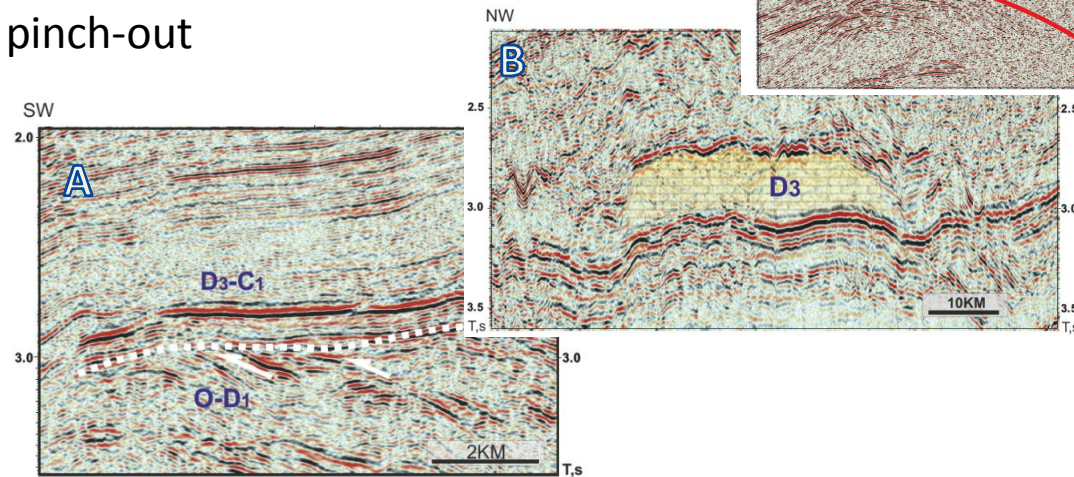
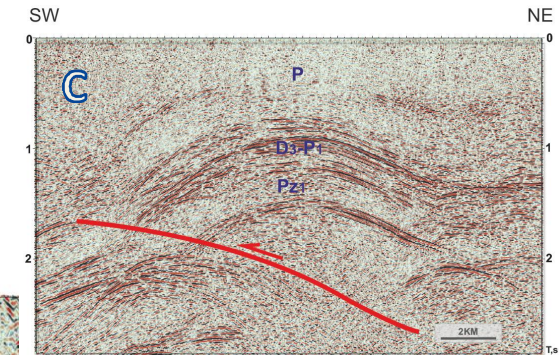
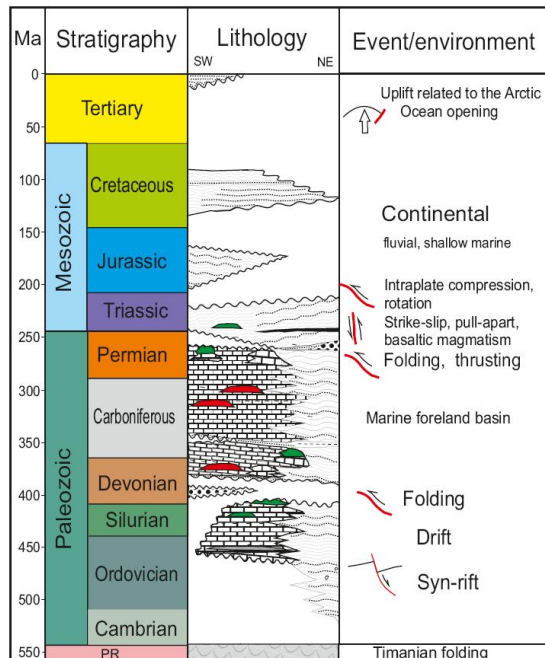
From He *et al.*, 2011





Principal conventional trap types

thrust-related 4-dips
flower structures
carbonate build-ups
subcropping unconformities
pinch-out



Summary

- Complex, laterally segmented fold belt
- Main structuration drivers:
 - Pre-Frasnian folding in the north
 - Late Permian transpression
 - Triassic thrusting, the South Kara escape
 - Presence of the Upper Ordovician salt in the Pay Khoy foreland
- Large petroleum potential
 - Multiple petroleum systems
 - Diverse trap types



Thank you!

**Acknowledgement
TP NIC, SMNG, NMSR, A. Nikishin**