JSC Siberian Research Institute of Geology, Geophysics and Mineral Resources (SNIIGGiMS)”

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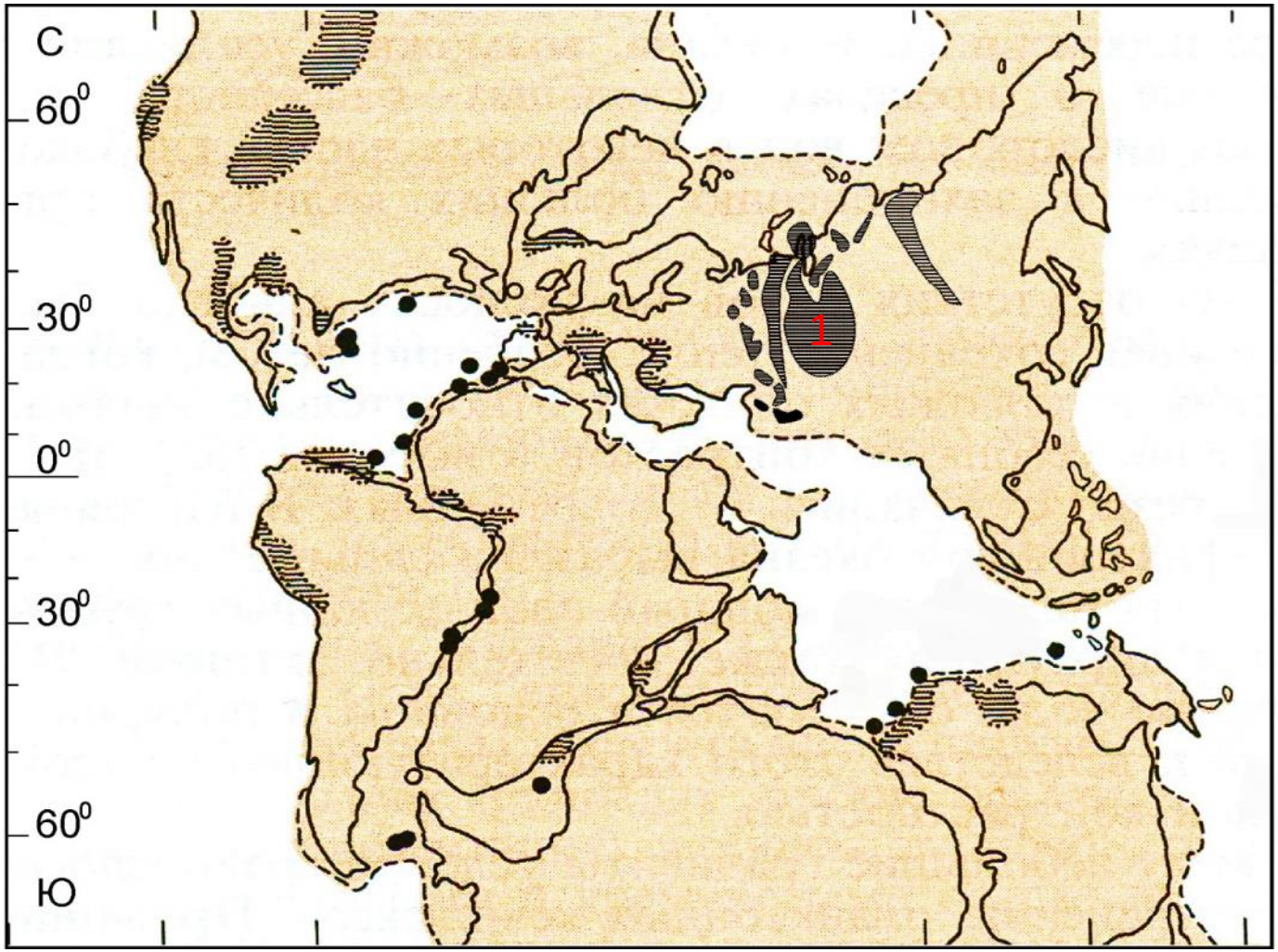
BAZHENOVO FORMATION AS AN INTERMEDIATE HYDROCARBON RESERVOIR IN FAULT ZONES (West Siberia)

Novosibirsk, Russian Federation
2016

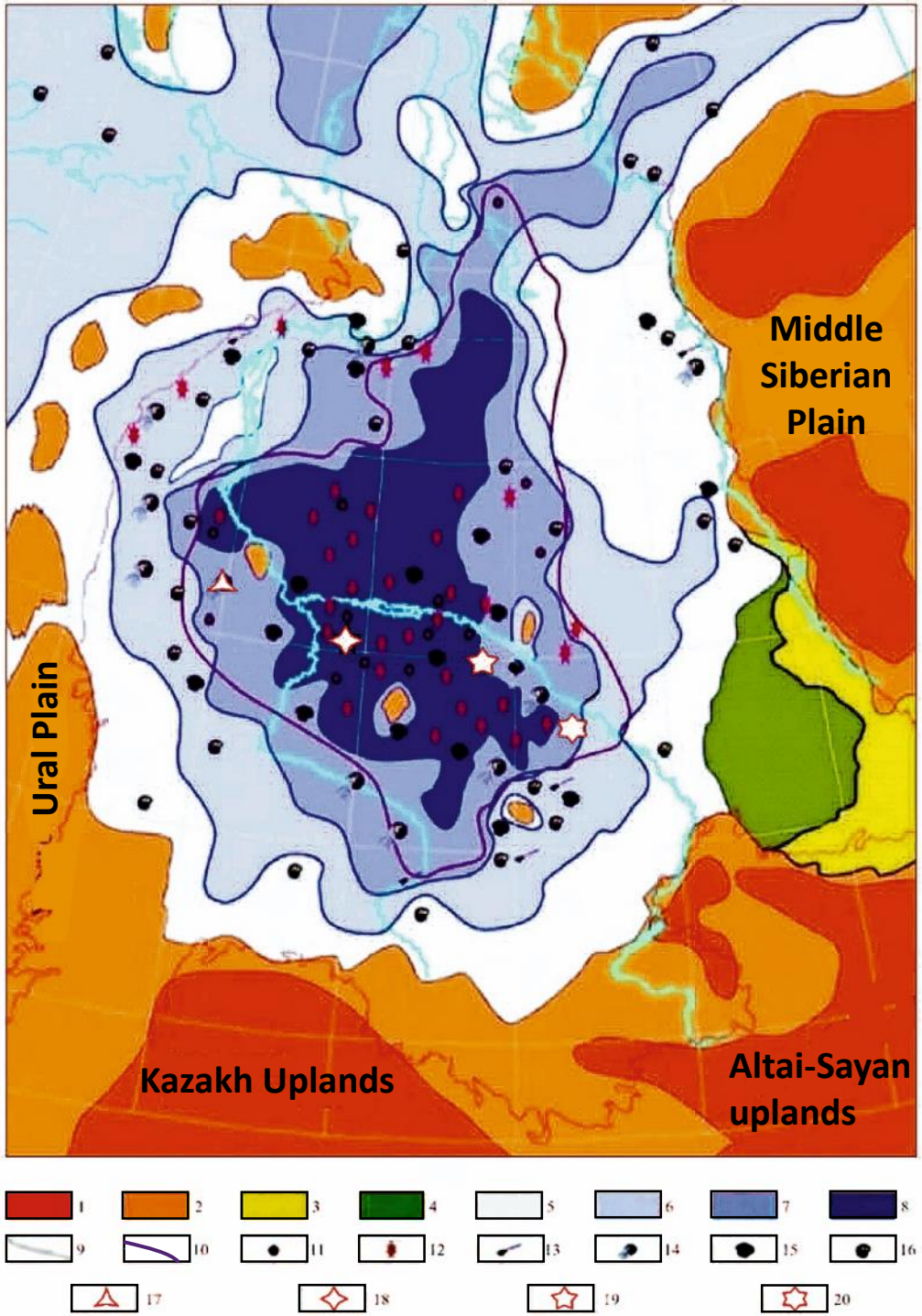


Sketch map of the Cambrian-Paleogene domanikites on continents (hatching) and offshore (black circles are wells of deep drilling)

By J.P. Kennett (1987) and F.G. Gurarie (1981)

1 – West Siberian sedimentary basin

Highly bituminous argillites and silicites as a part of domanikoid formations occur in pre-Cambrian through Eocene age and can be found in every continent.



Paleogeographic map of West Siberia in the Late Volga time

LEGEND

Paleogeographical environments:

1 – plateaus, uplands, mountain regions (>600m);
2 – denudation areas (undulating plateau) (200-600m);
3 – alluvial-lacustrine-swampy plain (up to 200m);
4 – marshes, lagoons;
5 – upper sublittoral zone (< 100 m);
6 – middle sublittoral zone (100-200 m);
7 – lower sublittoral zone (200-400 m);
8 – pseudobathyal zone (>400 m).

Boundaries:

9 – West Siberia;10 – bituminous sediments.

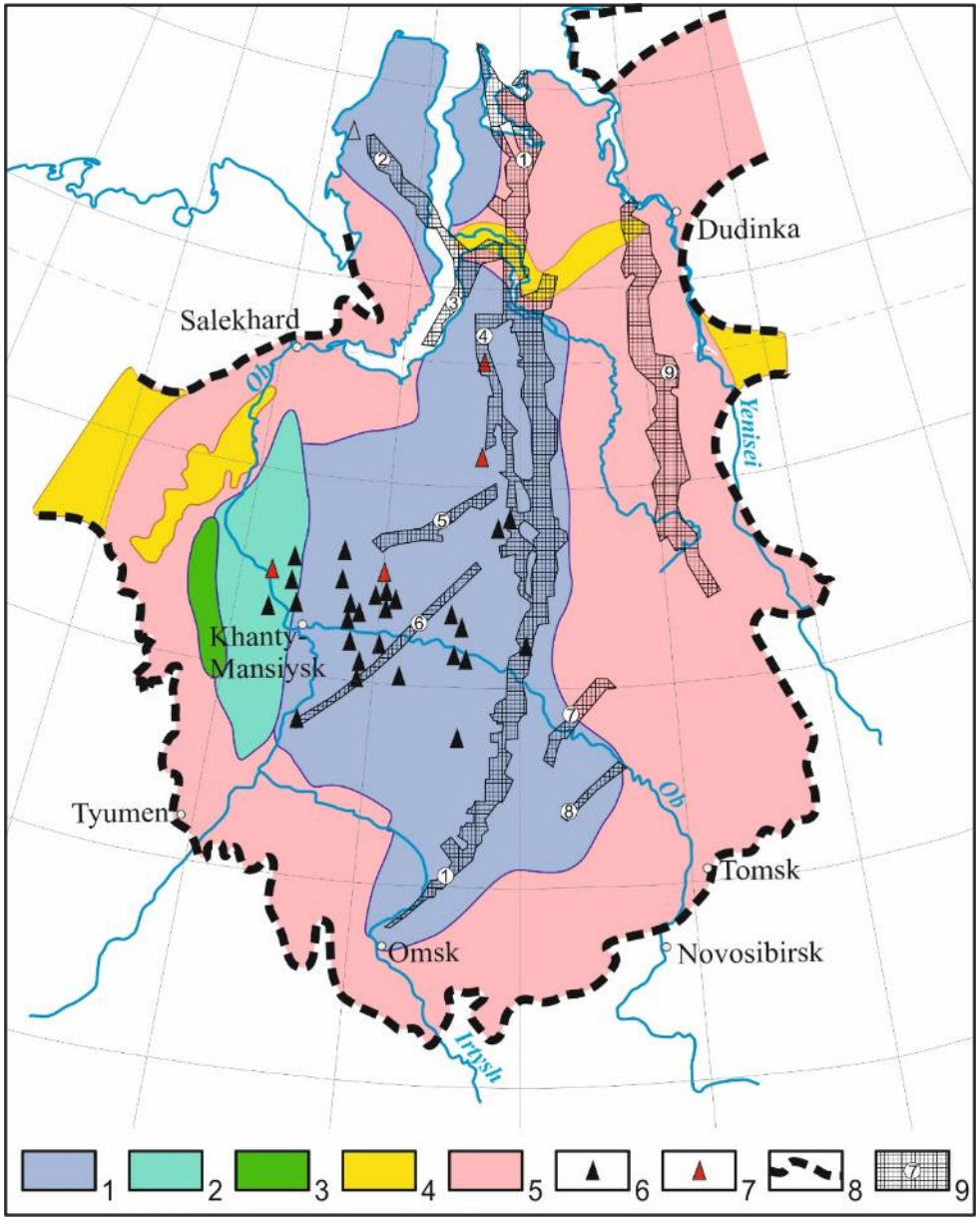
Organic remains:

11 – coccoliths; 12 – radiolaria; 13 – belemnites; 14 – ammonites; 15 – bivalves; 16 – foraminifera.

Area:

17 – Danilovskaya; 18 – Salymskaya; 19 – Medvedevskaya; 20 – Chkalovskaya

There are at least 10 to 12 epochs when clay sediments of marine origin saturated with sapropelic organic matter had deposited. Tithonian-Early Berriasian high-carbon siliceous argillites and silicites of the *Bazhenovo Formation* are widely distributed within the West-Siberian Plate. They are often considered as source beds.



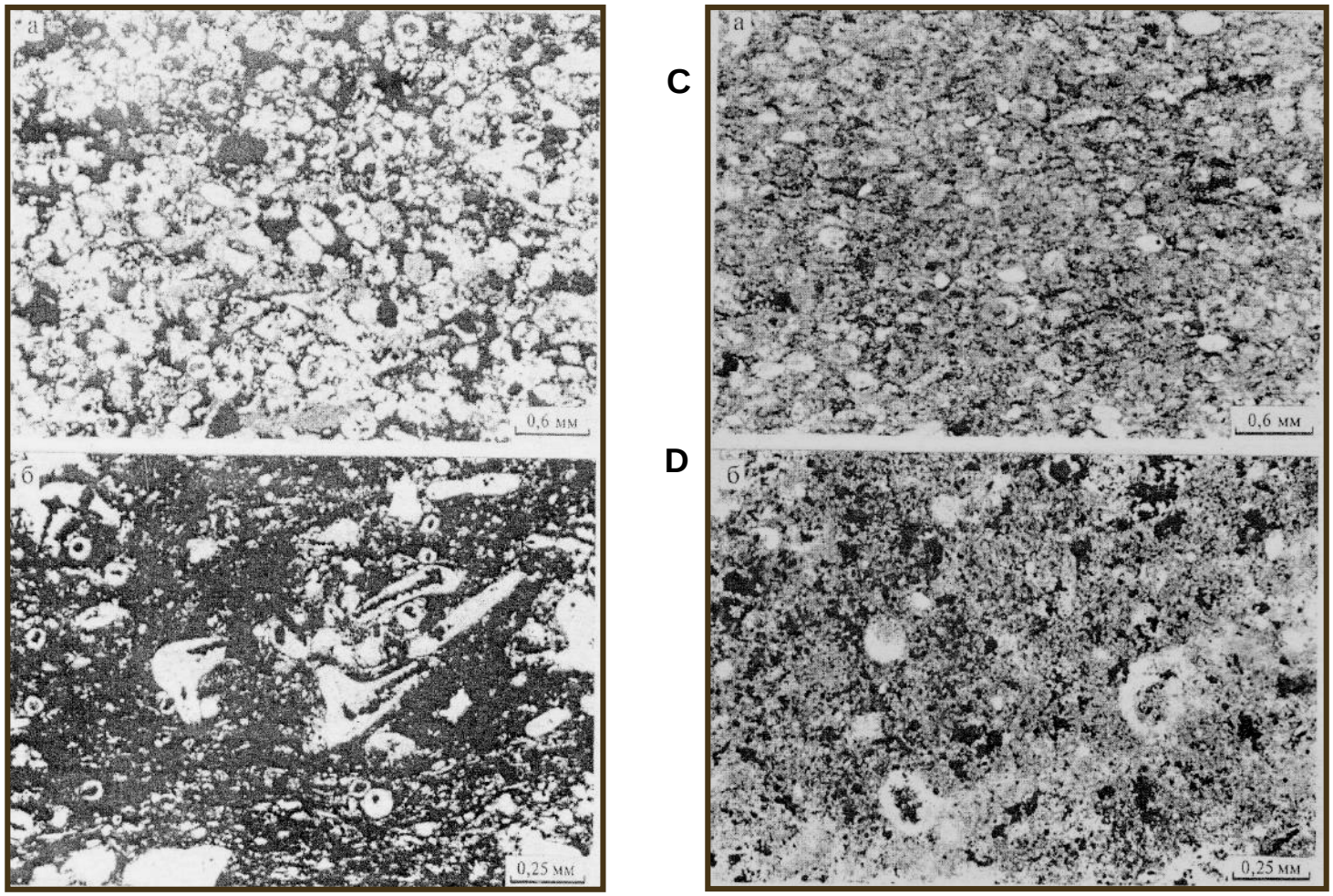
Ancient domanikites extend at an immense distance of 500 thousand sq. km and more, and had been forming for 8-10 mln years at a very slow sedimentation rate of 5-6 mm per one mln years.

Combination of the spread scheme of Bazhenov horizon bituminous deposits and rift structures of the pre-Jurassic basement of the West Siberian Plate (Brekhuntsov, Nesterov, 2010; Surkov, Smirnov, 2003)

Legend

1- Bazhenov Formation, 2- Tutleymskaya Formation, 3- Shaim and Igrimskaya Formation, 4- area of the absence of tithonian-lowerhauterivian deposits, 5- gray-colored analogs of tithonian-lowerhauterivian deposits, 6- major industrial deposits of oil in bituminous rocks, 7- oil shows, 8- border of the West Siberian Mesozoic-Cenozoic oil and gas province, 9- major Permo-Triassiac rift structures: ① - Koltogorsky-Urengoyskii, ② - Yamalskii, ③ - Sailing, ④ - Hudutteyskii, ⑤ - Pyakipurskii, ⑥ - Aganskii, ⑦ - Ust-Tymskii, ⑧ - Chuzikskii, ⑨ - Hudoseyskii.

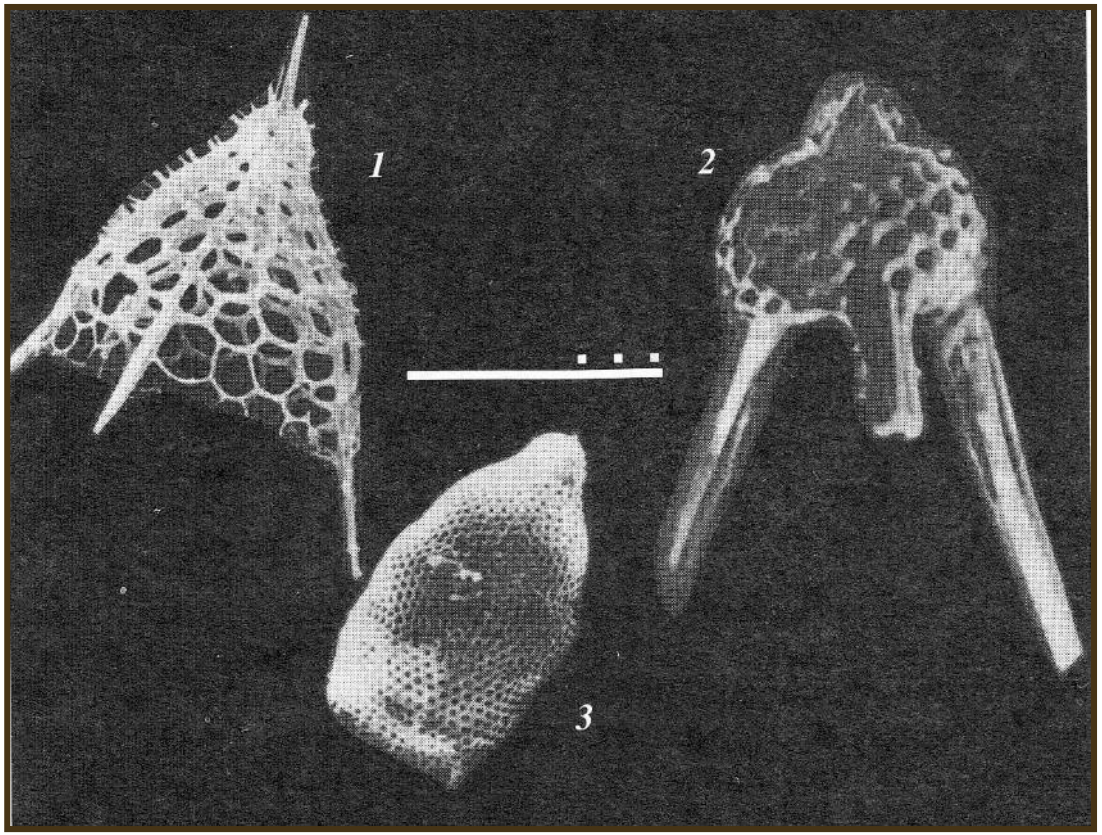
Radiolarian and spongy clays with biomorphic structure



Clays pyritized with biomorphic microstructure. Kamennoye area: A, C, D – radiolarian (well 201, interval 2348 – 2350 m), B– spongy (well 308, interval 2449 – 2456,5 m), nicoli parallel.
(Karnyushina, 2003)

High-carbon *siliceous argillites and silicites of the Bazhenov Formation* are rich in aquagene organic matter and biogenous silica and are characterized by elevated resistivity and natural radioactivity, especially in oil-field areas. *Radiolarian silicites* and bituminous argillites with silicate and carbonate interlayers are often confined to the lower or middle part of the Bazhenov section.

Suborder Nassellaria (Radiolaria)

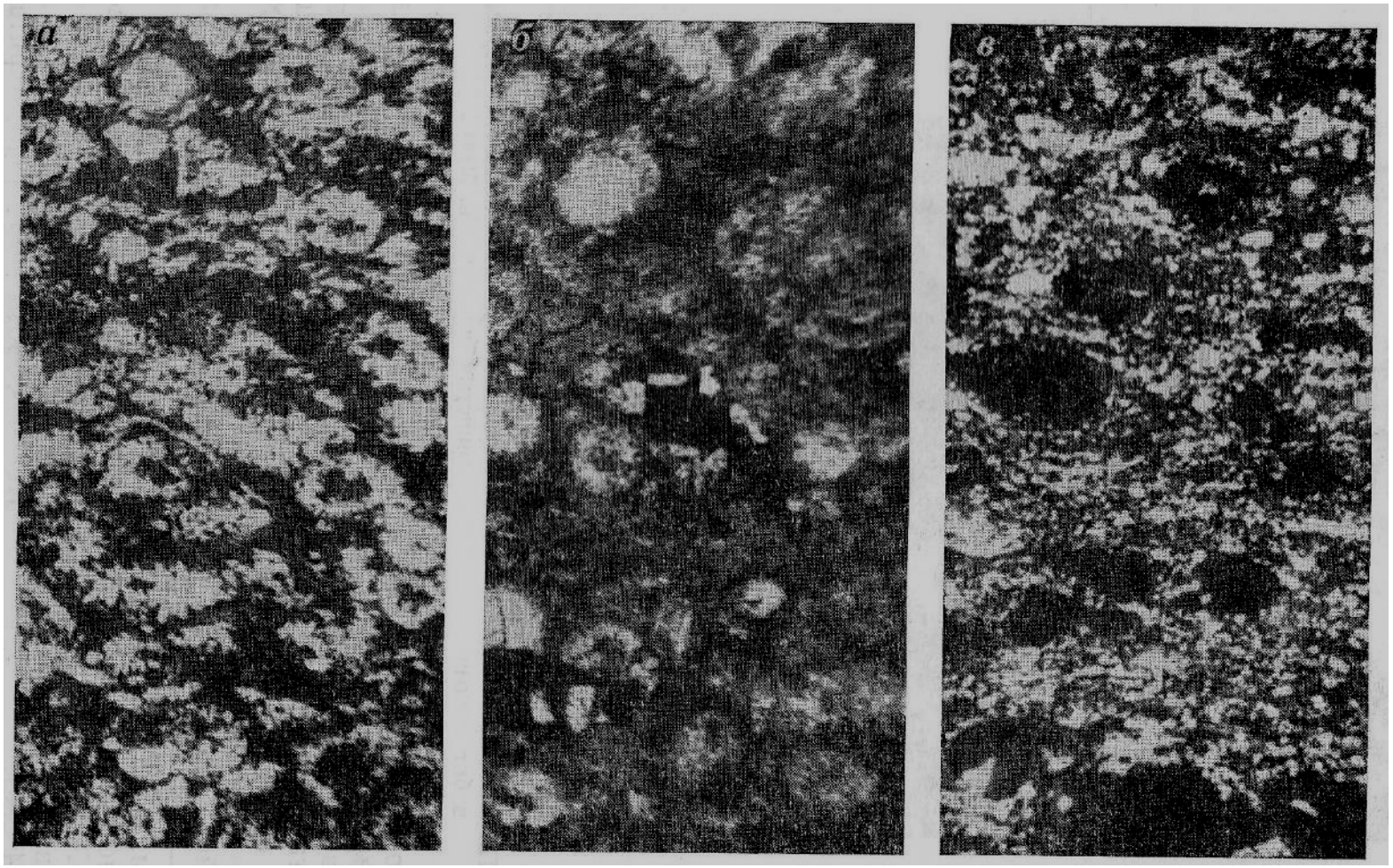


Specimens: 1 – Dictyophimus crisae Ehr. (class Trisymmetris), 2 – Lychnocanium grande Clark, Campbell (class Trisymmetris), 3 – Eucyrtidium ex gr. Acuminatum Ehr. (class Axisyvvetris).

As per E. Zeibold, V. Berger, 1984

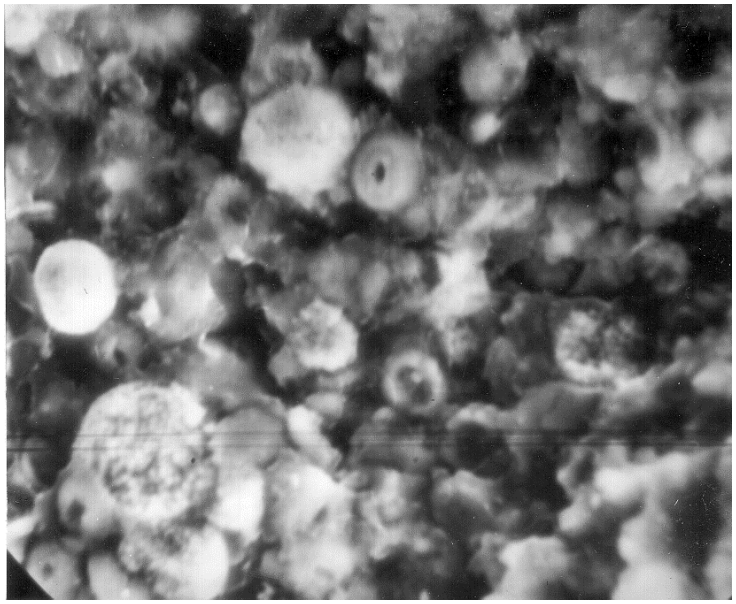
As for remains of organisms with silica skeletons**,** the Bazhenov rocks are dominated by radiolaria appertaining to the suborders Nassellaria and Spumellaria, the class Rhizopoda.

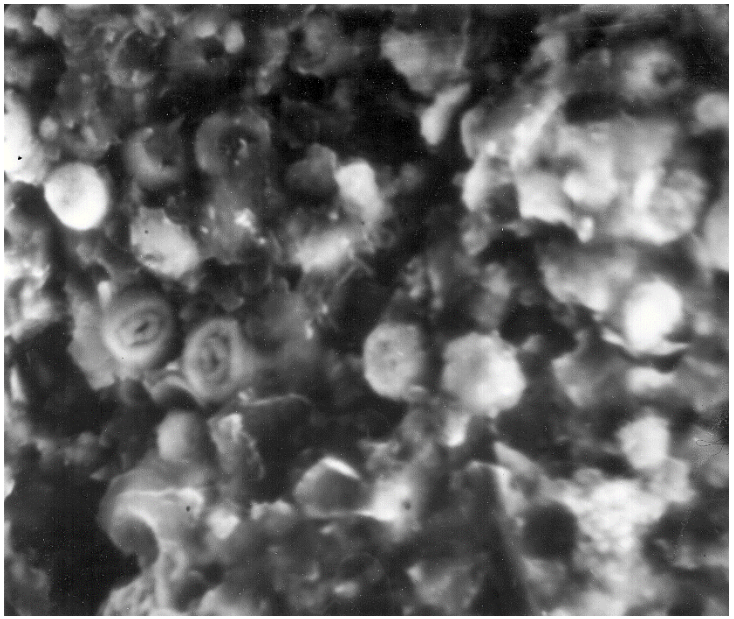
Silicites: a - bituminous, b – carbonized, c - pyritized



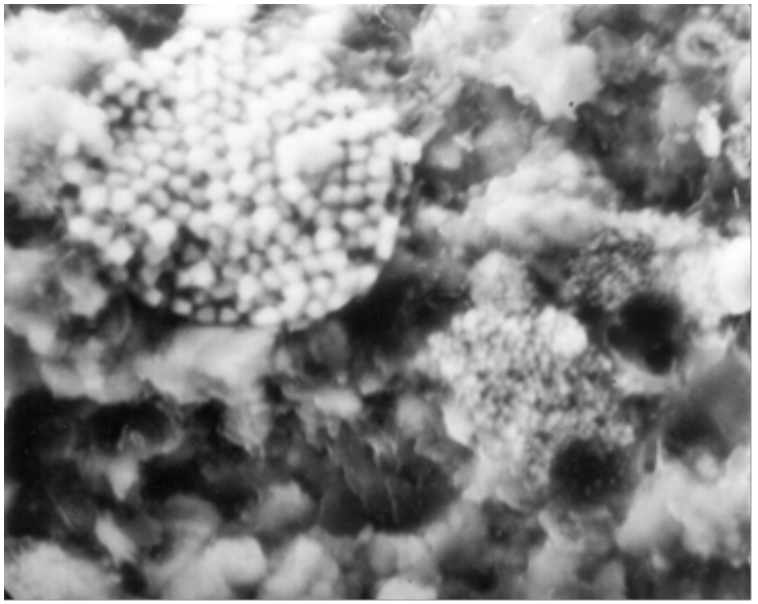
a **b** **c**

Less common are silicic algae – silicoflagellates, diatoms and silicic sponges. Radiolaria remains make up 1-5% in poorly siliceous argillites and up to 50-80% in radiolarite interlayers. In some areas radiolarian remains are partially or fully pyritized, argillized or replaced by carbonates.



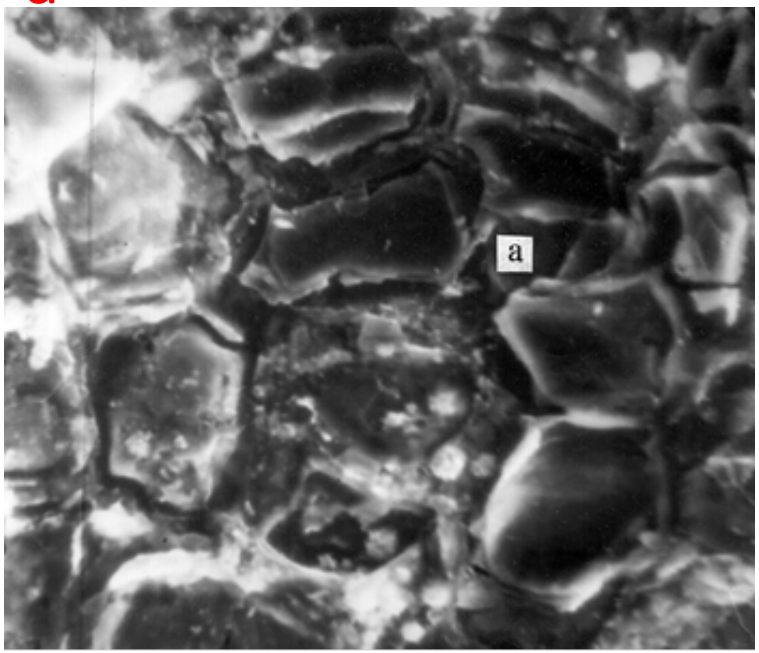


Electron micrographs of Diatomeae and small Radiolaria remains replaced by carbonate and pyrite, magn. *1500. Koimlykhskaya 31 well, specimen 128, depth 2,523.5 m, radiolarian bituminous silicite.

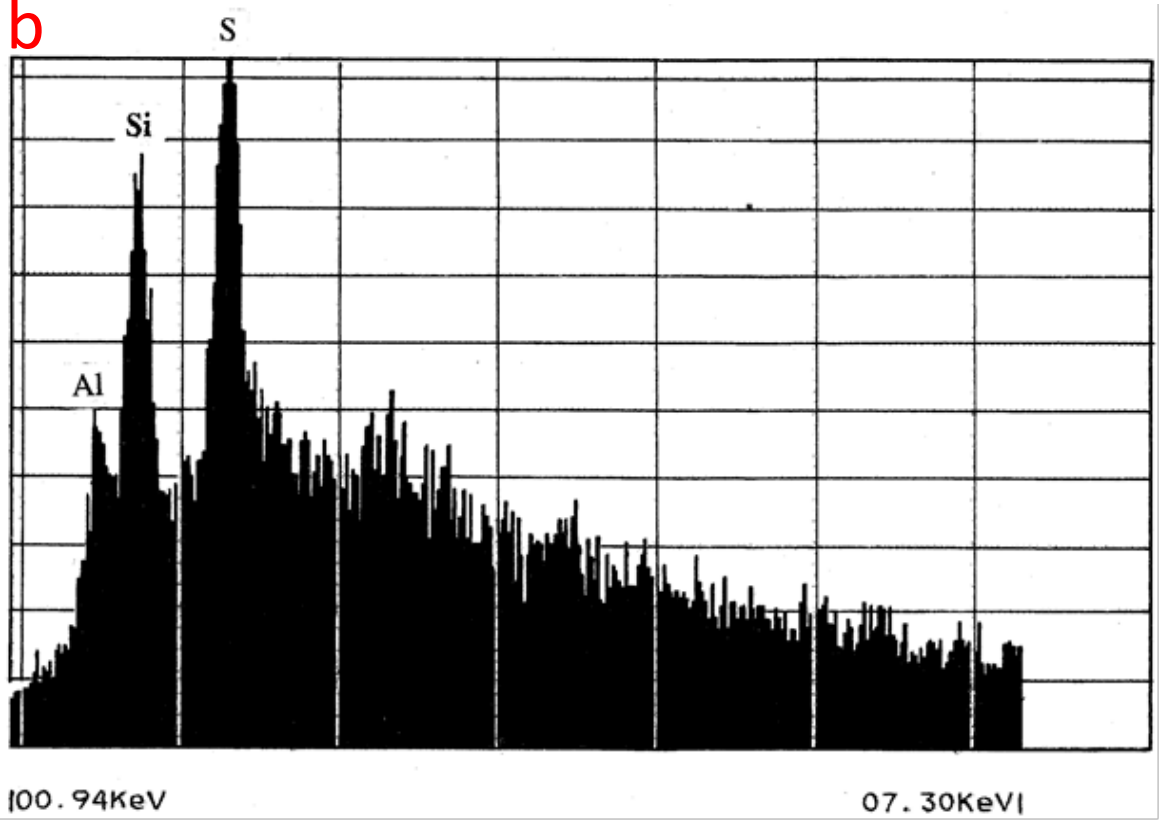


Electron micrographs of Radiolaria remains with relict meshwork replaced by pyrite, magn. *3200. (b) Koimlykhskaya 31 well, specimen 128, depth 2,523.5 m, radiolarian bituminous silicite.

a

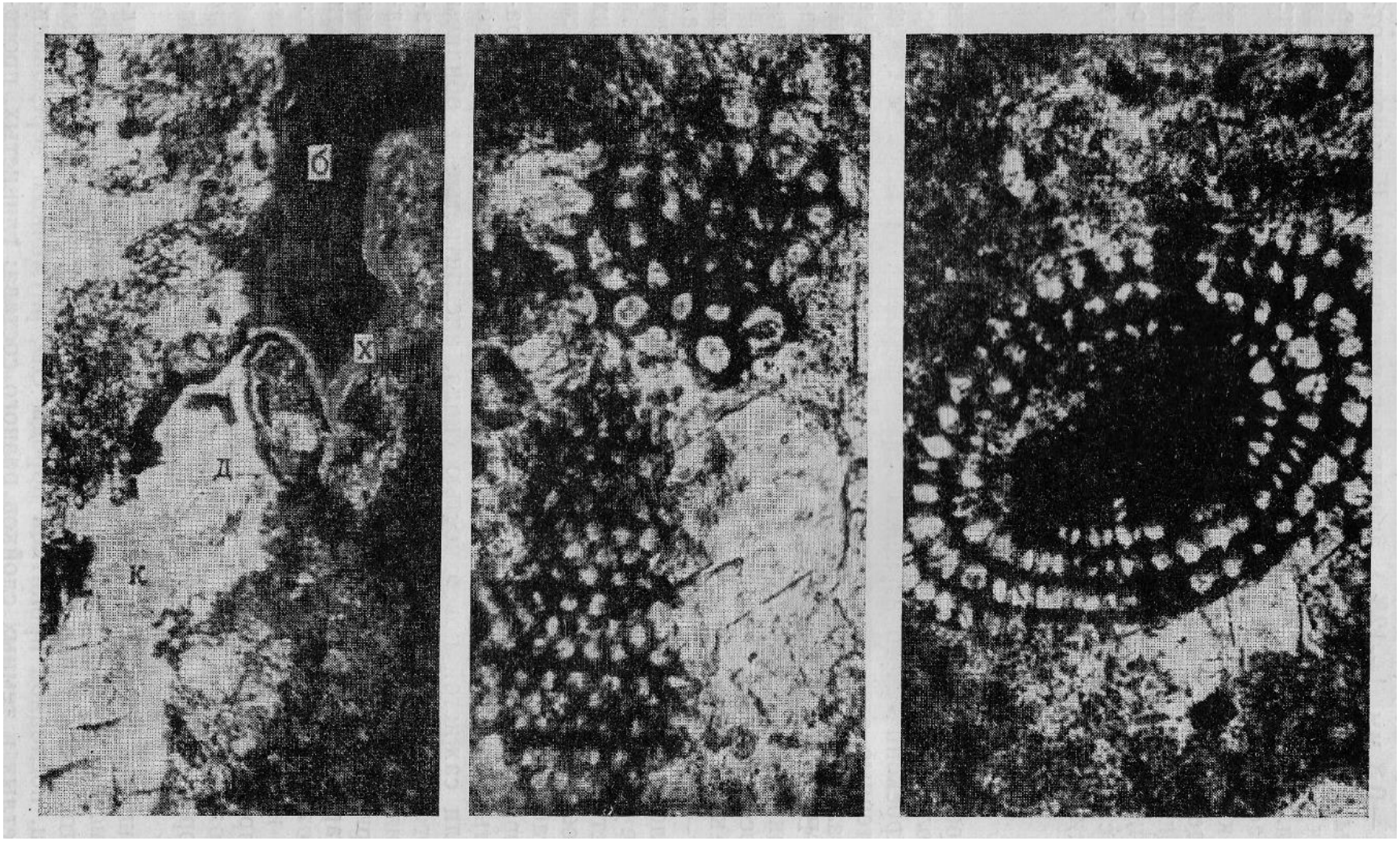


b



Electron micrograph of the Radiolaria remains surface saturated with bitumen (a), magn. *600, energy-dispersive spectrum (b). Koimlykhskaya 31 well, specimen 128, depth 2,523.5 m.

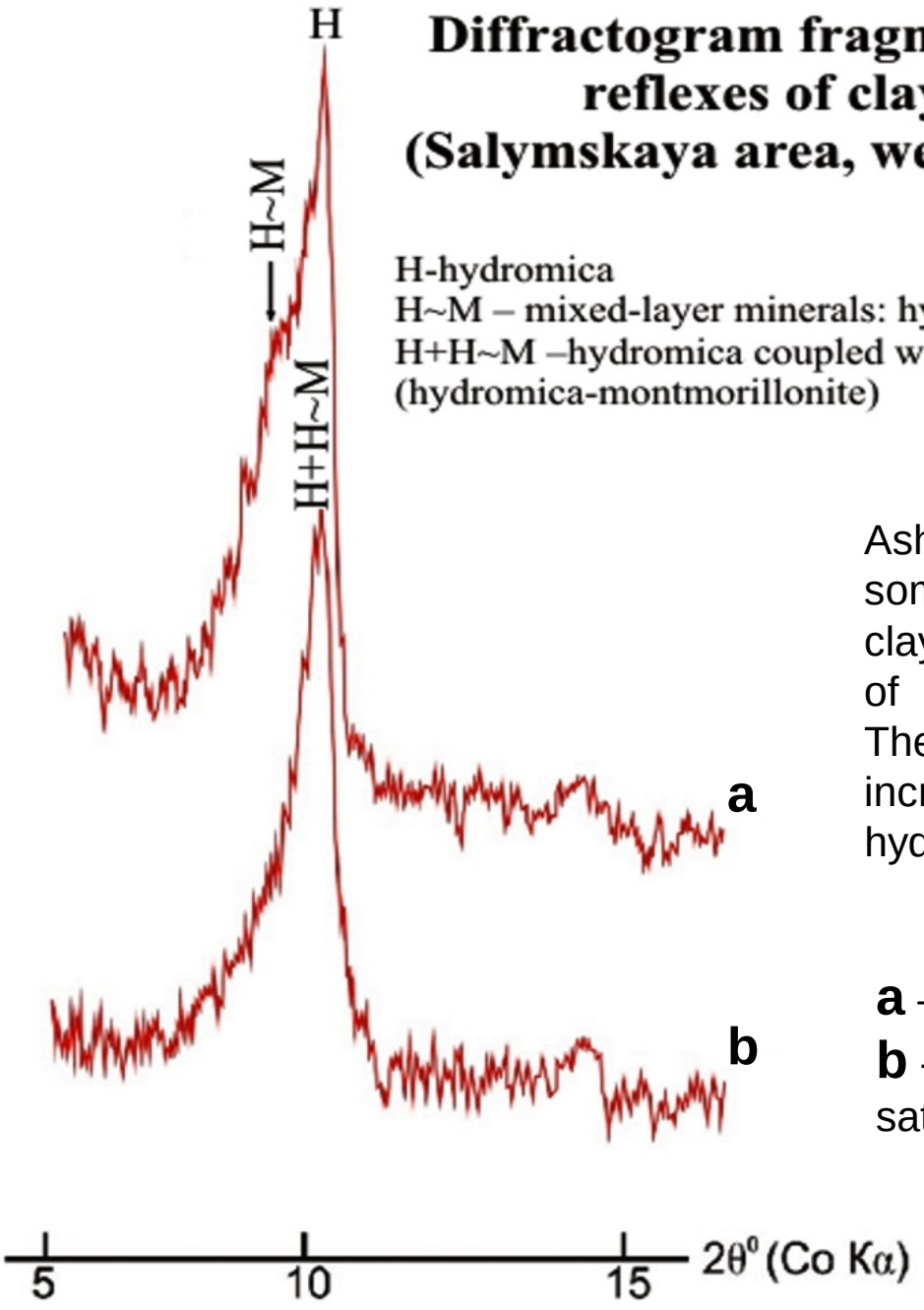
Relict lacy structure of radiolarites



They often are well-preserved, have clear internal structure and, which is less common, large spine-like processes.

Patchy-string distribution of organic matter (black) in bituminous argillaceous-siliceous rocks.
REM, enl. 5000x.

Core and thin sections often evidence oil-saturated siliceous rocks, especially along the line of contact with interlayers abundantly containing radiolarian remains.



Diffractogram fragments with basal reflexes of clay minerals (Salymskaya area, well 127, sample 25)

H-hydromica
H~M – mixed-layer minerals: hydromica-montmorillonite
H+H~M –hydromica coupled with mixed-layer minerals (hydromica-montmorillonite)

Ash particles in the interlayers, according to some researchers, are abundantly replaced by clayey minerals containing increased amount of *mixed hydromica-montmorillonite phase*. These “swelling out” minerals have an increased sorption capacity and restrain liquid hydrocarbons well.

a - X-ray analysis in the normal mode;

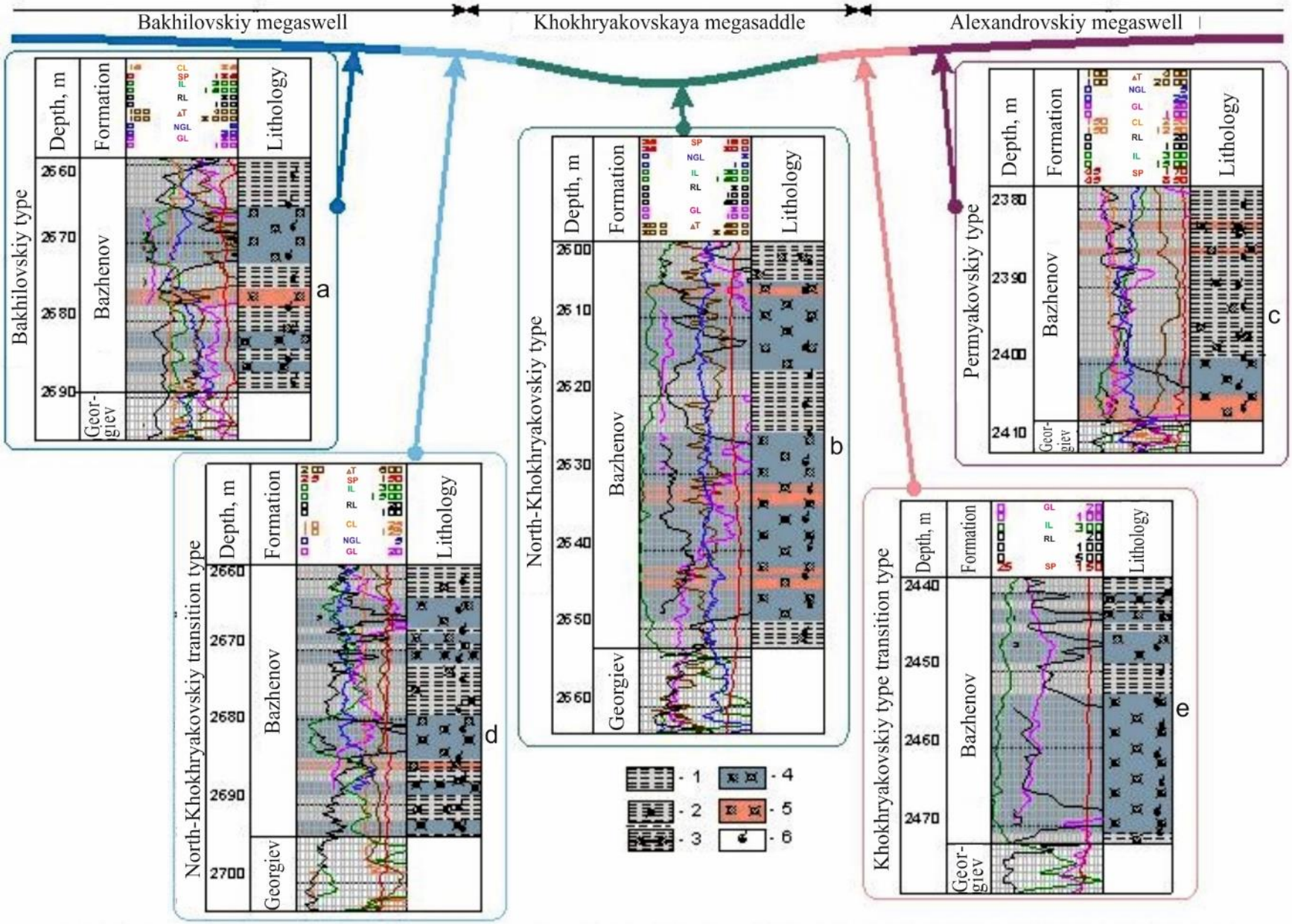
b - X-ray analysis of the sample after saturation with glycerin

Main section types distinguished by GWL in eastern regions of KHMAO

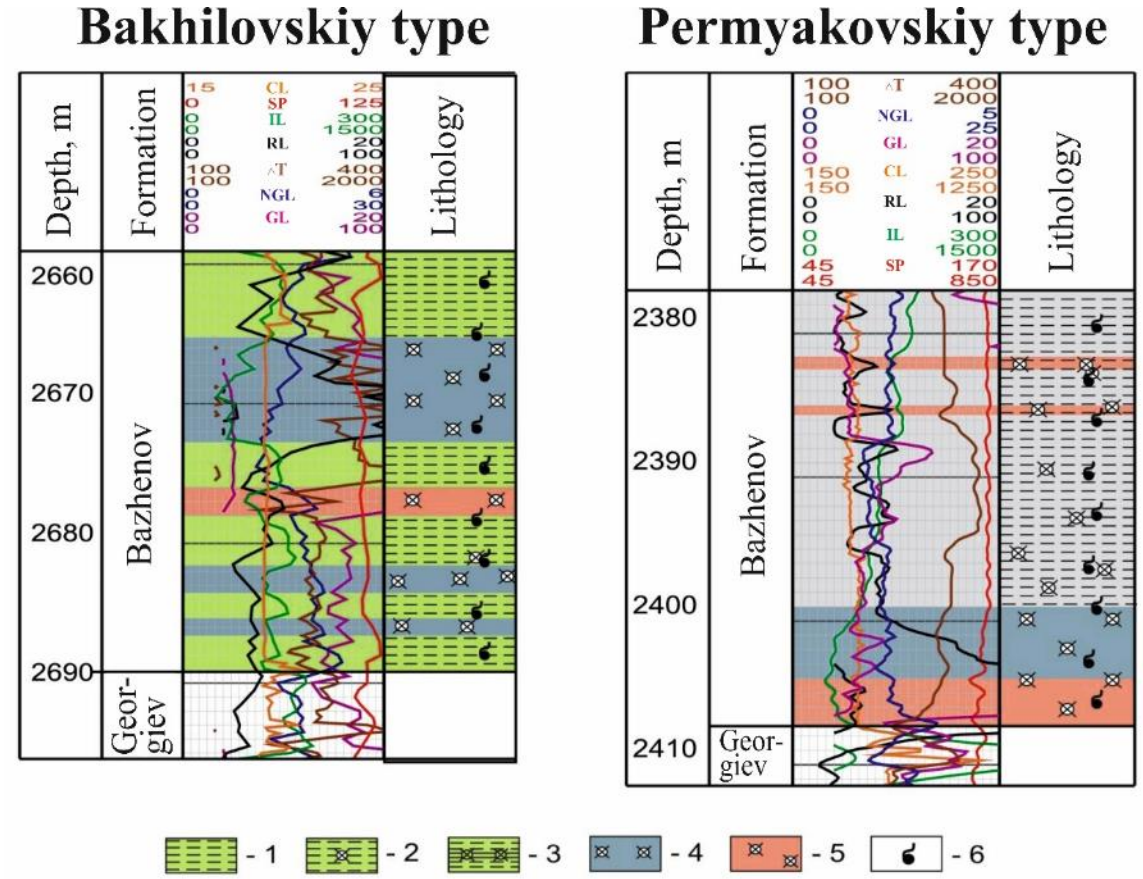
Siliceous argillites and silicites of the Bazhenov Formation are well identified in sections by geophysical well logging (GWL) - standard, induction, radioactivity, acoustic, neutron gamma-ray, data of well caliper logging for more than 200 wells drilled in eastern regions of the Khanty–Mansi Autonomous Okrug (KMAO). The following types of sections are defined for this territory (from north to south): *Bakhilovskiy, North-Khokhryakovskiy, Permyakovskiy* (basic ones) *with Kolik-Yeganskiy and Koshilkiy subtypes,* and two intermediate *ones-North-Khokhryakovskiy and Khokhryakovskiy.*

Reservoirs are not only fractured argillaceous matrix, but also beds and interbeds rocks composed of permeable and secondary altered radiolarites and pelecipoda shell deposits having a biogenic structure, which occur in the central plate regions, in particular, in the eastern regions of the Khanty-Mansi Autonomous District. According to geophysical well logging data, their features are characteristic of fine-grained sandstones and siltstones. These beds are well-defined in logs by anomalous NGL, AL, IL, and SP parameters.

Main section types distinguished by GWL in eastern regions of KHMAO



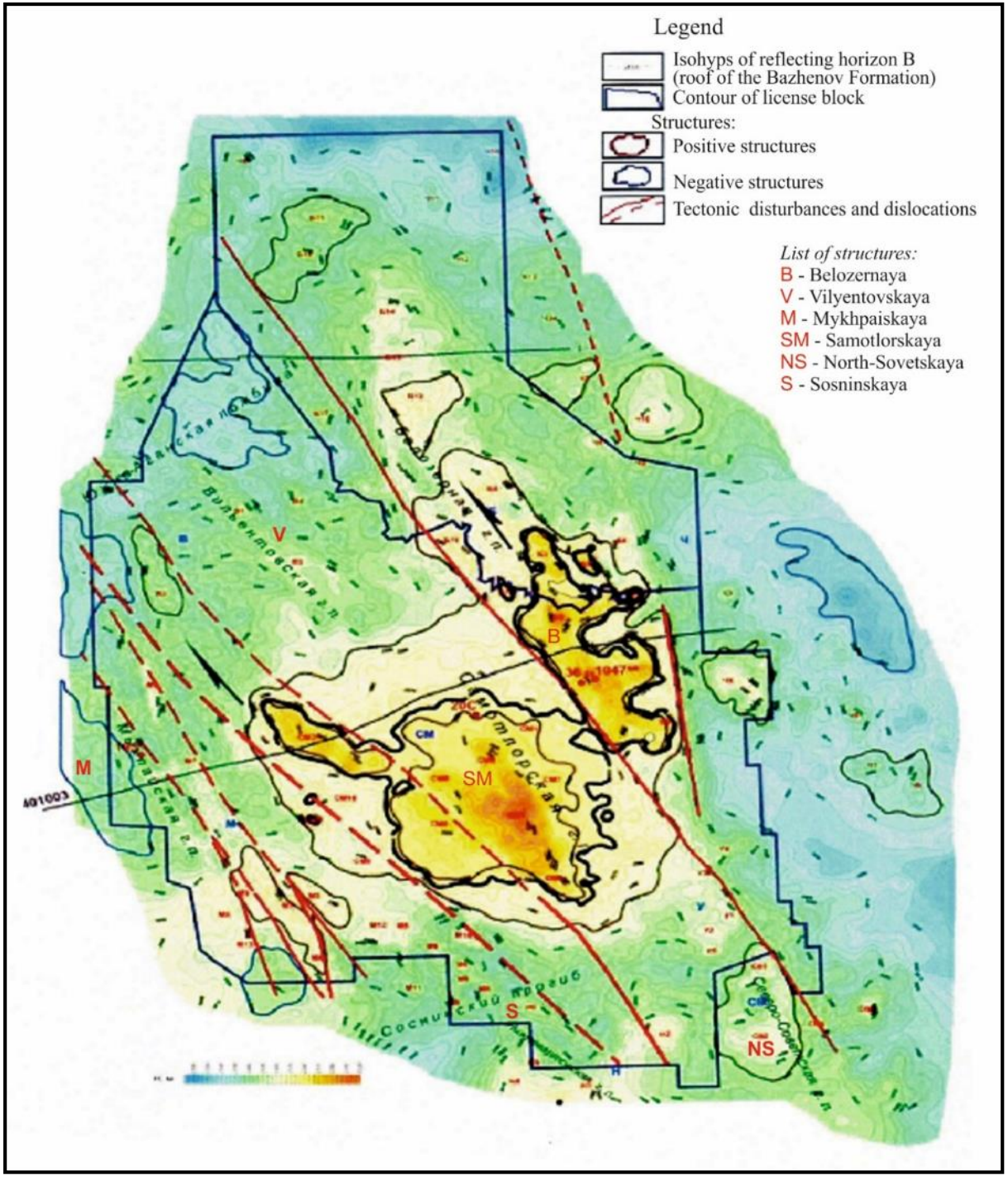
1- homogeneous thinly-levigated clays; 2 - argillites with dispersed radiolarias; 3 - argillites with radiolarite interbeds; 4 - radiolarian silicites (radiolarites); 5 - carbonized silicites; 6 - rock bituminity



1 - homogeneous thinly levigated argillites; 2 - argillites with dispersed radiolarias; 3 - argillites with radiolarites interbeds; 4 – radiolarian silicites; 5 - carbonized silicites; 6 - rock bituminity

Bakhilovskiy type is characterized by an increased values of RL in the two-scale curve and decreased ***values by IL*** *in the middle or upper section types, determined by the occurrence of radiolarian silicite interbeds.* The section is divided conditionally into three members. *Lower member* is composed of argillaceous bituminous argillites with silicite interlayers, carbonated in the upper part, *the middle member* is represented by silicites with high RL, *the upper one* contains finely levigated bituminous argillites.

Permyakovskiy type with Kolik-Yeganskiy and Koshilskiy subtypes are characterized by an increase of the section general clay content and by the presence of relatively thick interlayers of carbonated radiolarites in the formation base. Bituminous siliceous argillites interbedded with silicites and carbonate metasomatites prevail among the rocks. The Permyakovskiy and Koshilskiy subtypes sections are characterized by the presence of ***SP negative anomaly varying from 5 to 20 mV,*** as well as a certain ***decrease of values by NGL*** in the formation roof, ***that may be associated with cavernous rocks***.

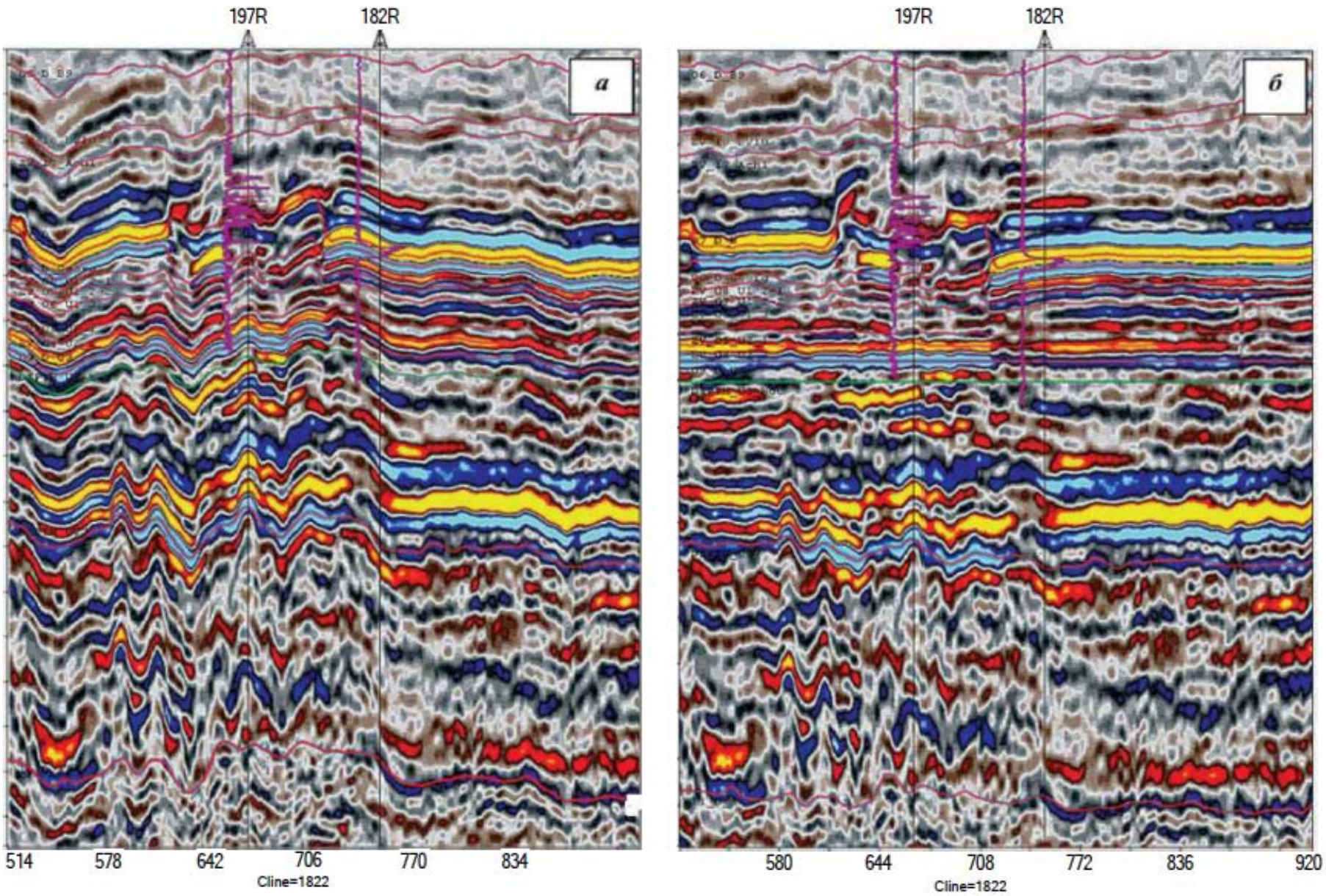


Structure-tectonic map of the Bazhenov Formation roof (reflecting horizon B)

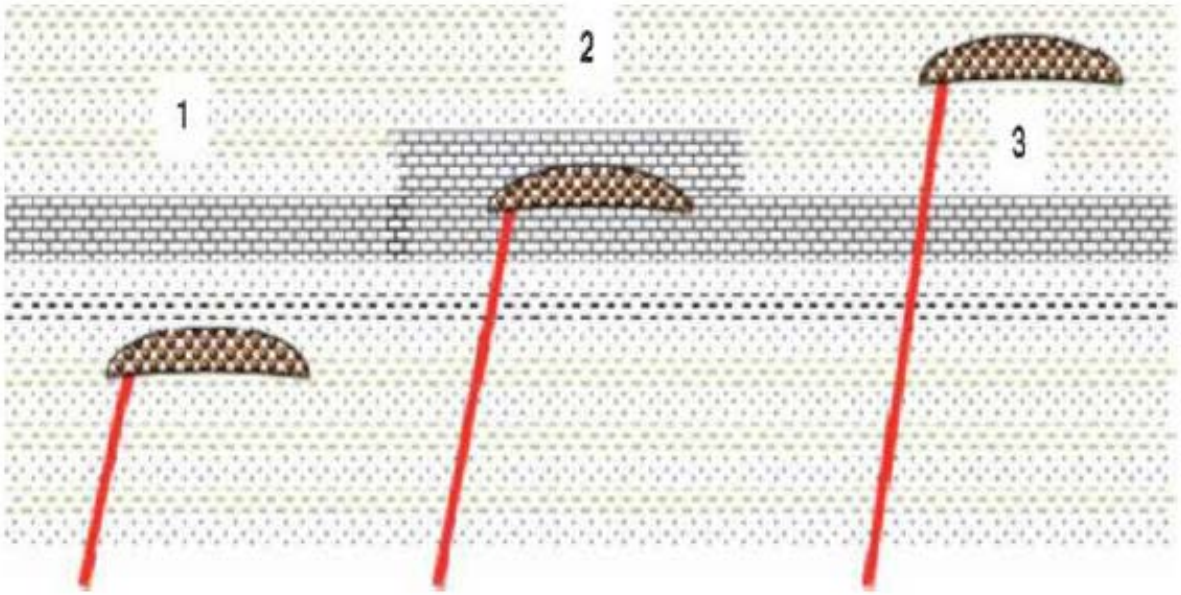
Samotlorskiy license block (joint stock co. Sibneftegeofizika).

By Z.I. Gromova, 2001, supplemented by N.V. Nassonova, 2008

Enrichment of rocks by certain elements including Si could be the result of *hydrolysis of pre-Jurassic basement aluminosilicate rocks* as a consequence of influence of superheated hydrothermal solutions that circulated in the deep fault zones and escaped through fluid-permeable channels on the surface of the Bazhenov basin bottom. Deep faults reaching the Bazhenov Formation are well-mapped in several petroleum areas (Salymskaya, Krasnoleninskaya, North-Sosvinskaya, Samotlorskaya, etc.). Below there is a diagram showing pool formation in the Bazhenov deposits overlying the pre-Achimov and the underlying Georgiev deposits affected by disjunctive tectonics (as per Timurziev, 2015).

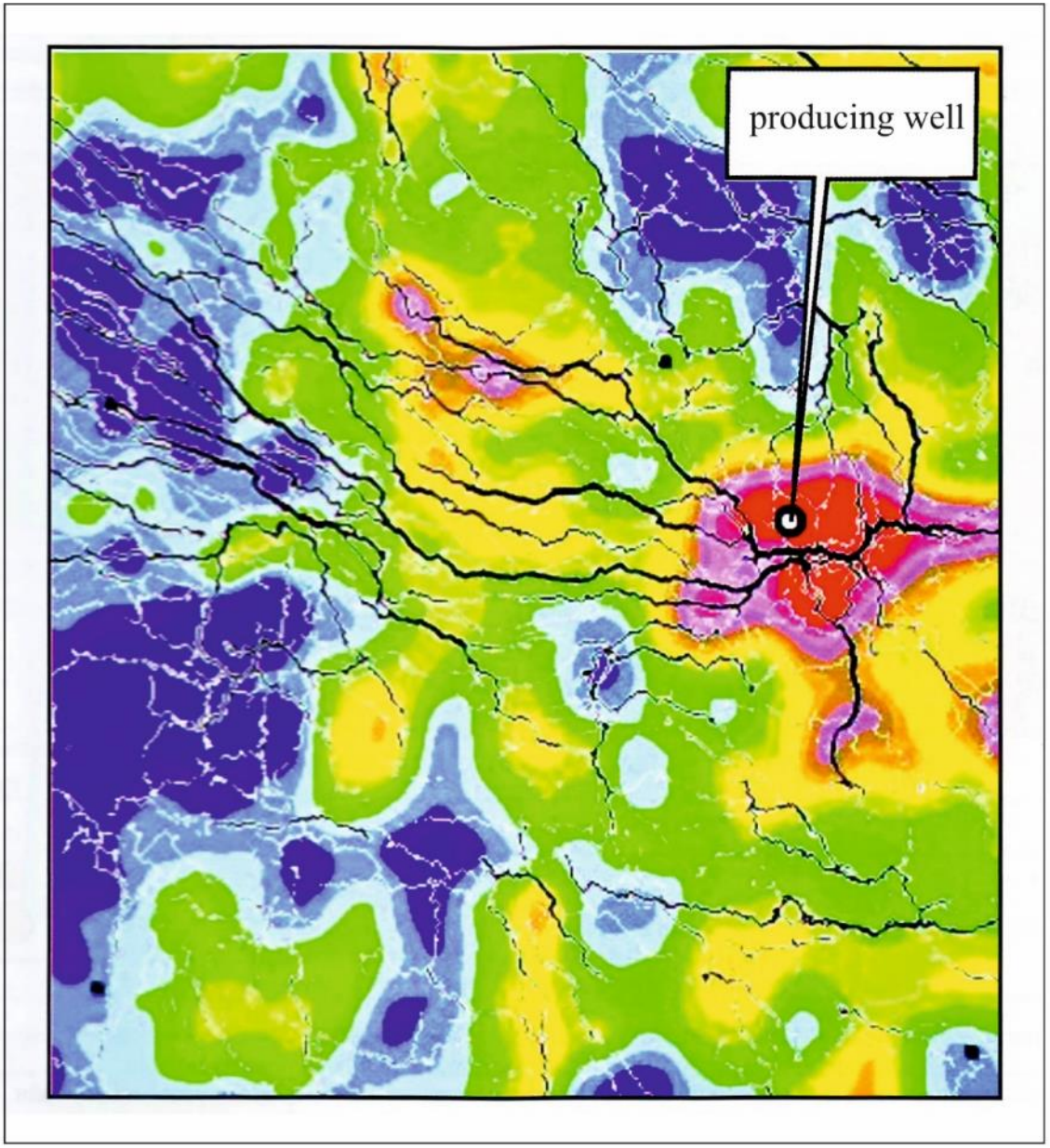


The West-Varyegansky license block. Deep seismic section (Cline = 1822), crossing the anomalous Bazhenov Formation area between wells 197-R and 182-R. The left figure (a) shows true occurrence of horizons, the right one (b) shows the leveled YuV3 horizon top. According to A.I. Timurziev, 2015.



Models of pools formation and structure of the Bazhenov Formation depending on the height of penetration of en echelon faulting from the basement into the sedimentary cover and depending on stratigraphic level of deep petroleum fluids discharge. *According to Timurziev, 2015*.

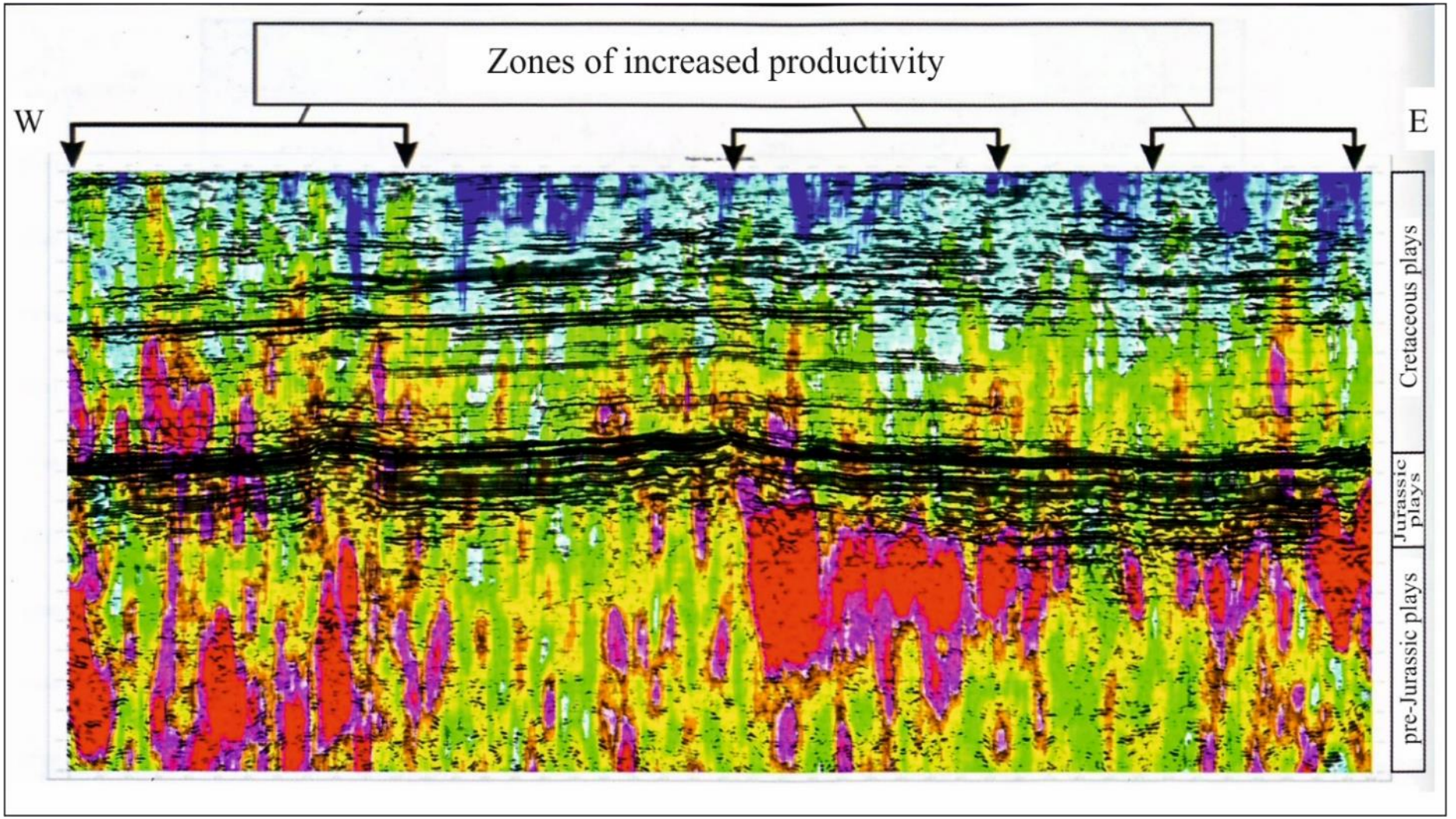
Hydrothermal processes are often connected with a neotectonic stage of tectonic activization and caused by vertical migration of deep fluids. Siliceous (radiolarites), carbonate (shelly) and microlaminated silica-clay rocks of the Bazhenovo Formation undergone hydrothermal changes can serve as reservoirs accepting allochthonous hydrocarbons in addition to autochthonic ones. When the pressure forced by deep fluids exceeds the reservoir pressure in «oil-source» strata, there occurs a fluid fracturing, HCs migrate up the section and accumulate in overlying porous reservoirs. From this standpoint the Bazhenovo Formation may be thought of as ***an intermediate hydrocarbon reservoir.***



Shirotnoye Priobye (Latitudinal Ob River Region). One of the Salym group fields.

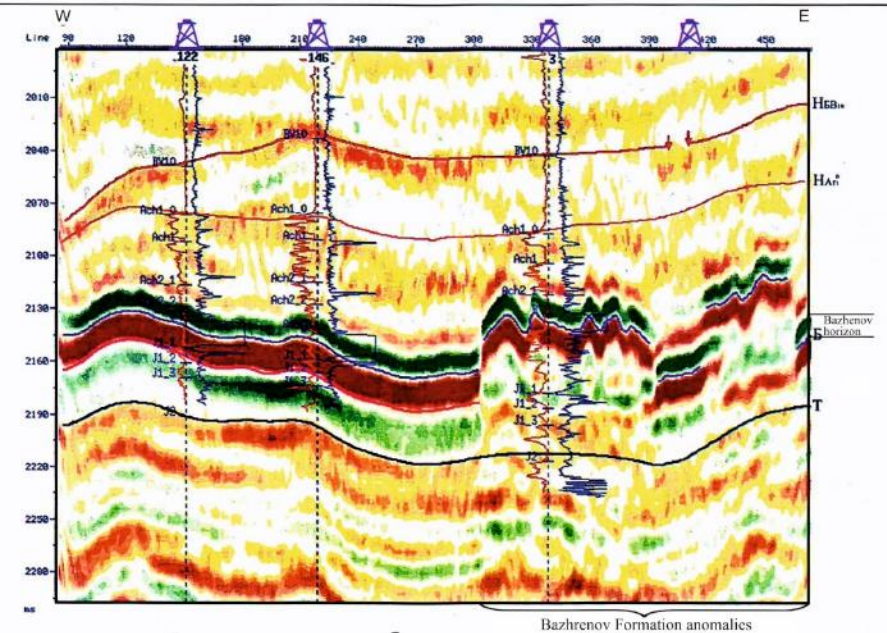
A comprehensive characteristic of medium disintegration in the Bazhenov Formation interval (scattered wavefields and singularity (black lines) of seismic field). According to V.V. Charachinov et al., 2015

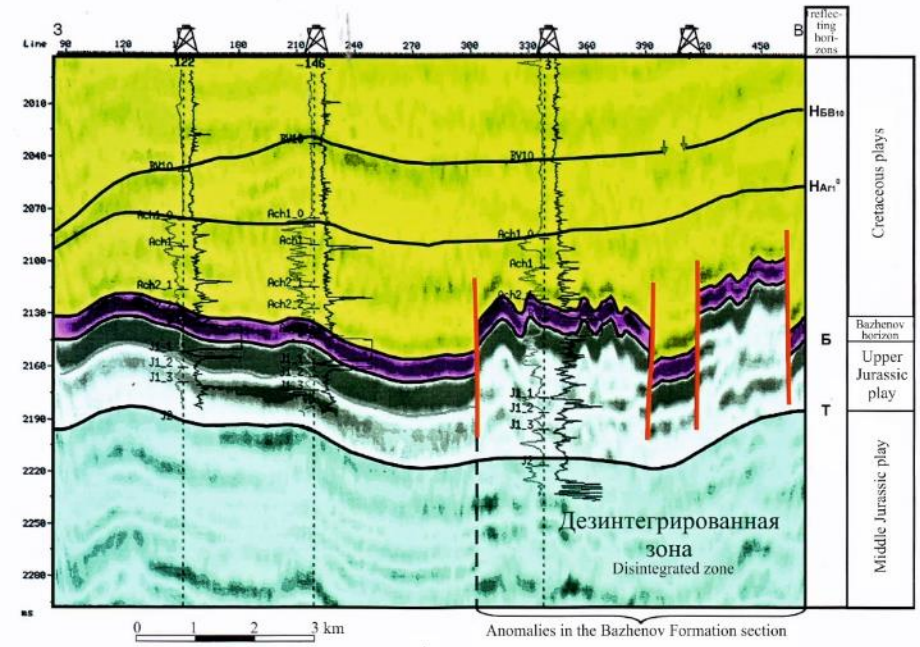
Warm colours highlight the most disintegrated areas.



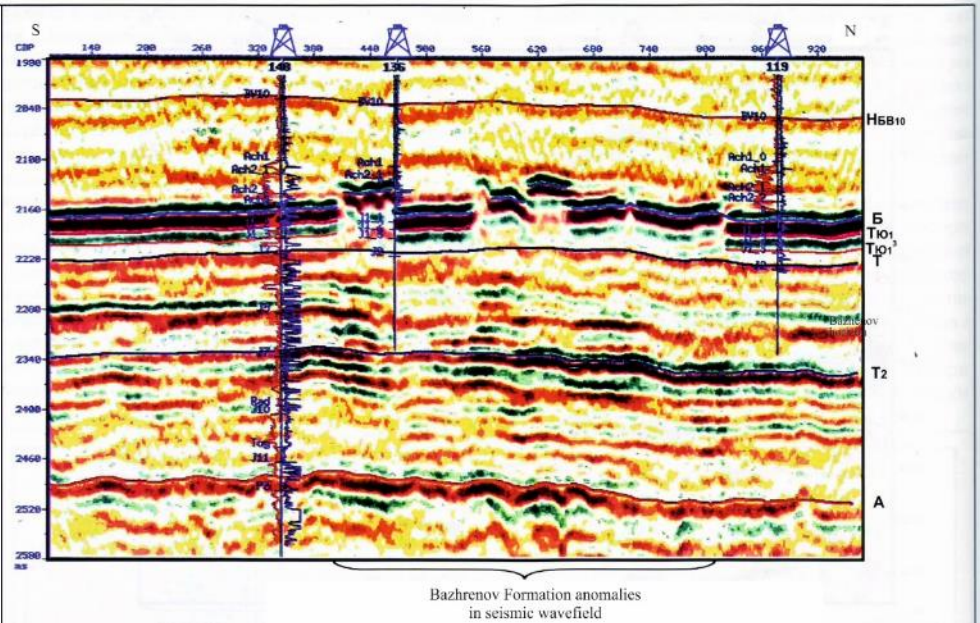
Aganskoye field. Integrated time section of reflected and scattered wavefields. Red colours highlight the most disintegrated areas of the section—fluid-conductive structures.

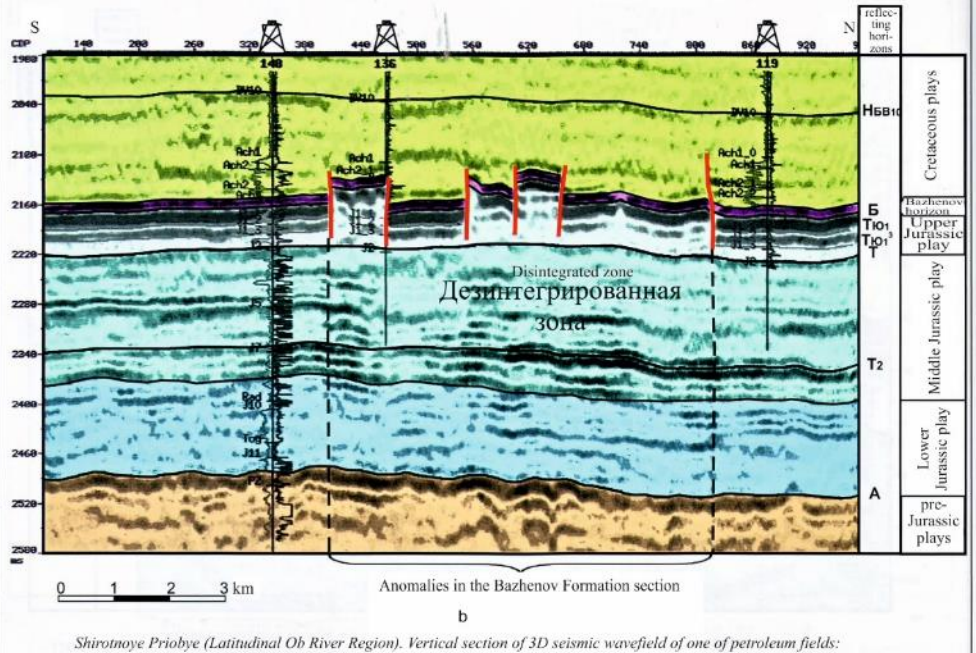
According to V. V. Charachinov et al., 2015





Shirotnoye Priobye (Latitudeinal Ob River Region). Vertical section of 3D seismic wavefield of one of petroleum fields:
a – time seismic section; *b* – geo-seismic interpretation. *According to V.V. Charachinov et al., 2015.*





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THANK YOU FOR YOUR ATTENTION!