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Geochemistry of oil-and-gas seepage in Lake Baikal: towards understanding fluid migration system

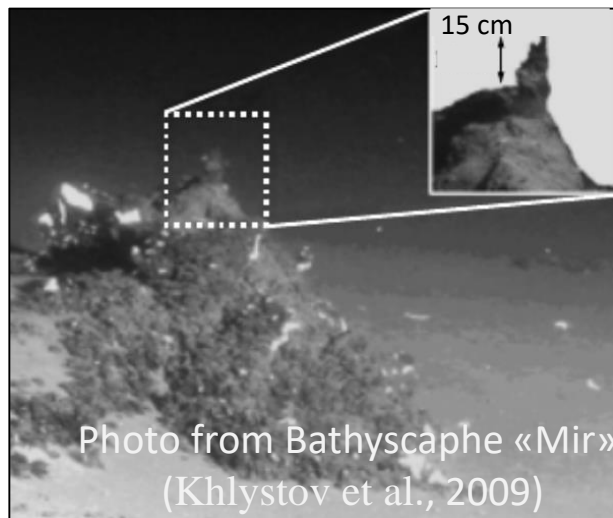
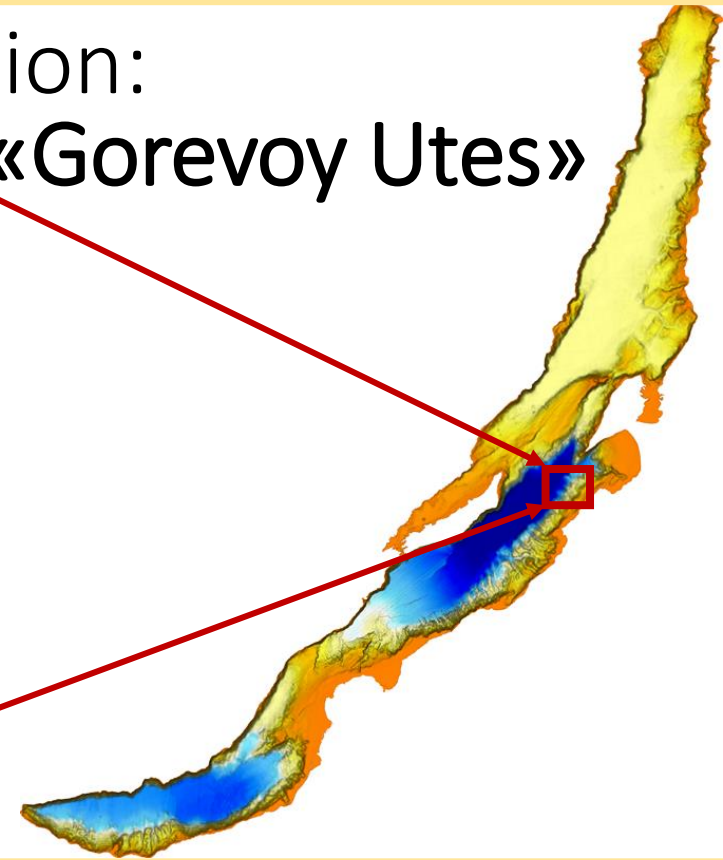


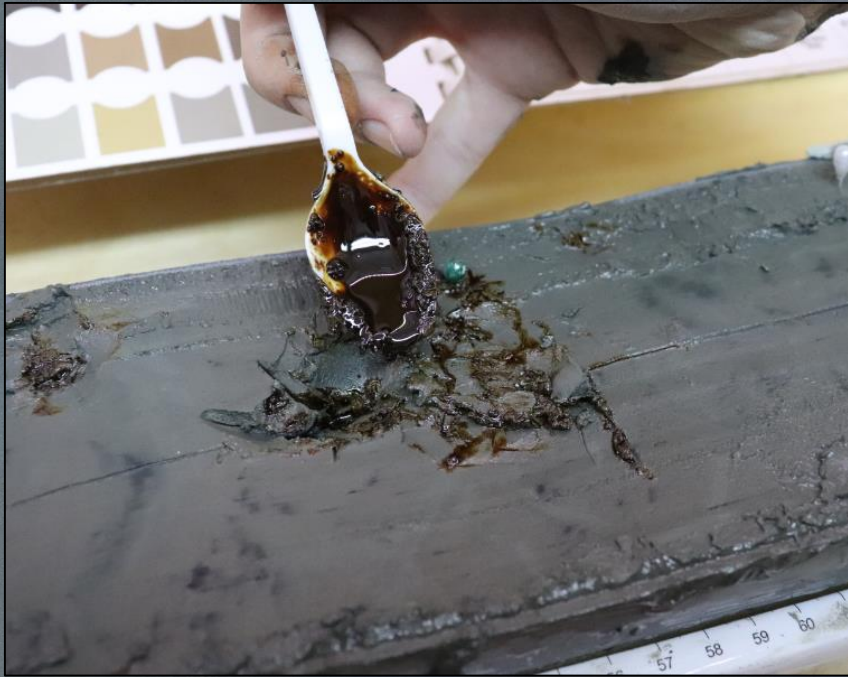
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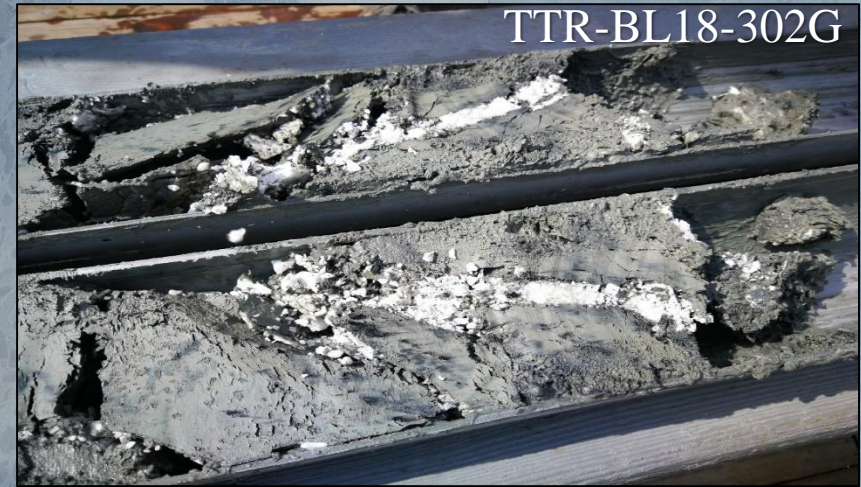


location:
«Gorevoy Utes»





Filling the fractured space with fluid

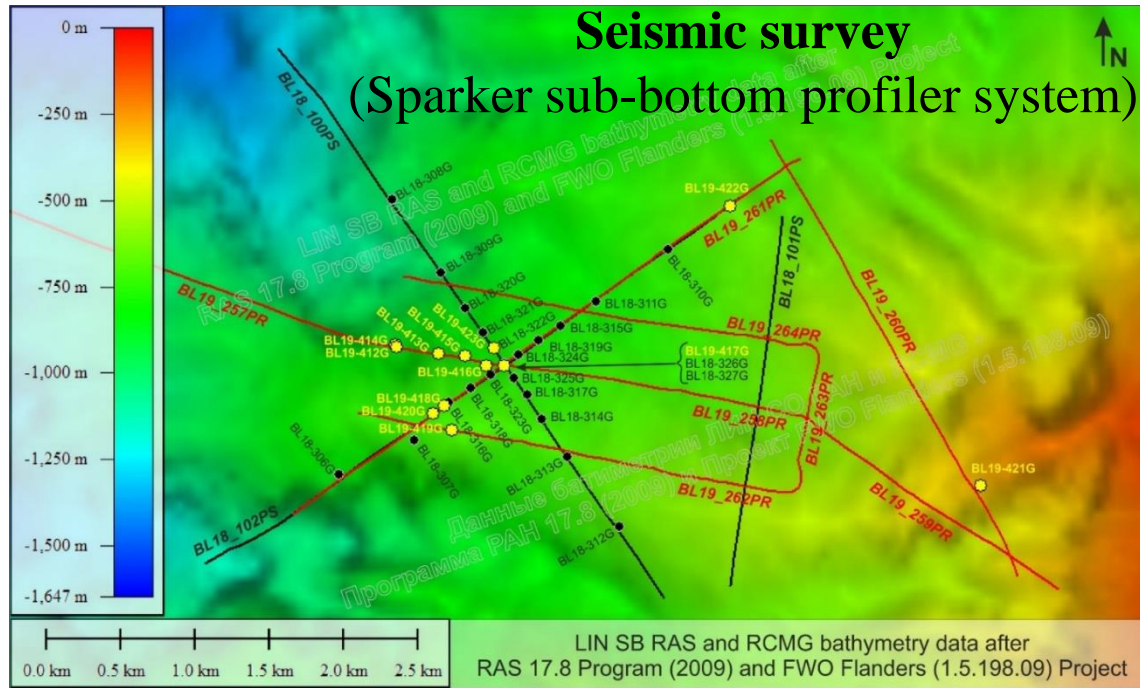


Gas hydrates in bottom sediments



Oil slicks on Lake Baikal
near Gorevoy Utes

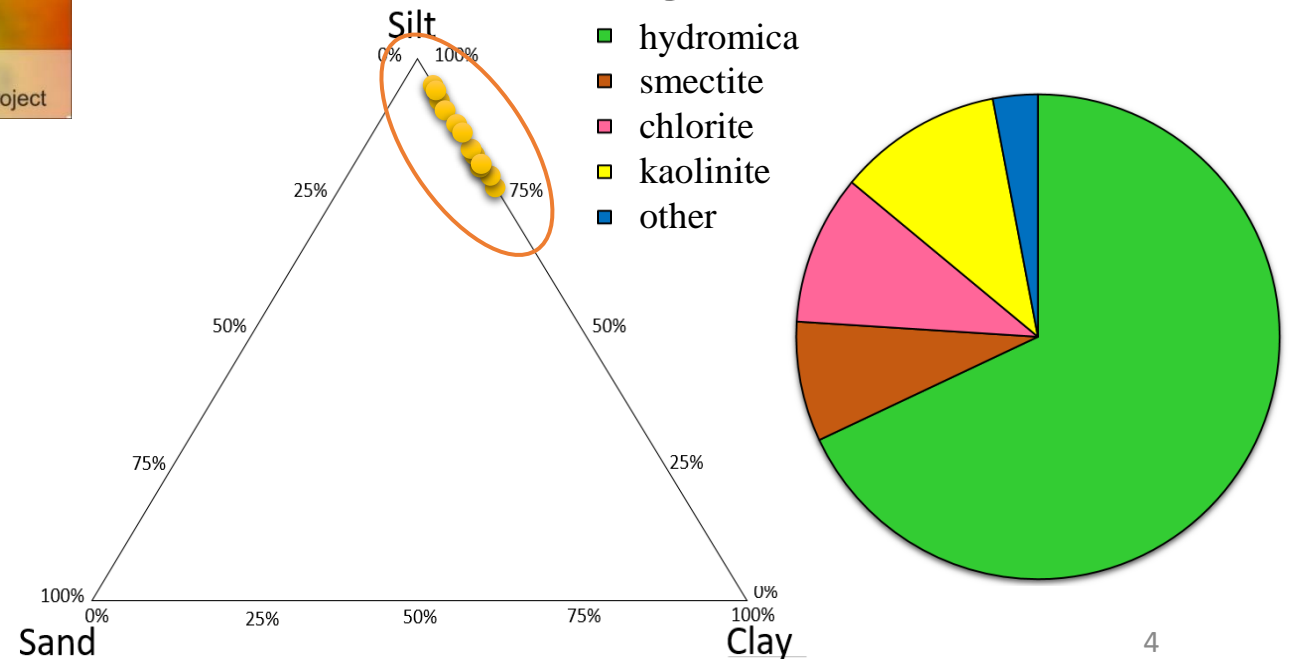
research methods



Complex of geochemical studies

- Fluorescent-bituminology analysis
 - Extraction
- Gas chromatography–mass spectrometry
 - Rock-Eval pyrolysis
 - Isotopic studies
- Gas chromatography

Lithological studies





TTR-BL18-326G

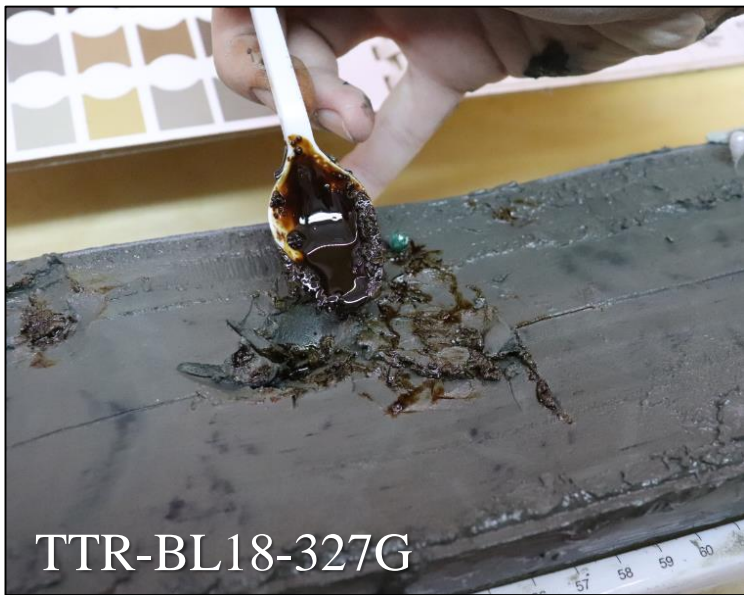
Filling the fractured space with fluid



TTR-BL18-327G

Oil concentrates along micro-discharges

Filling out the channel migration gas



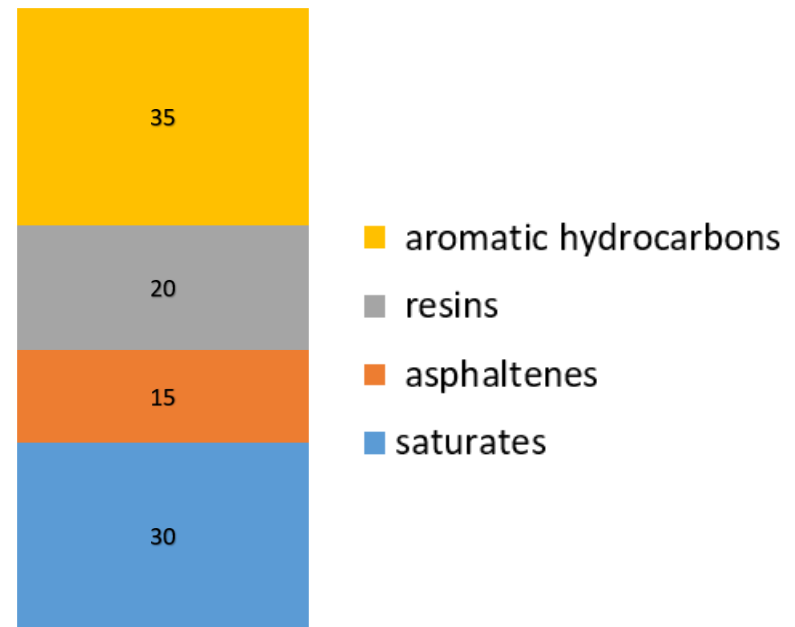
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composition of oil from the core TTR-BL18-327G

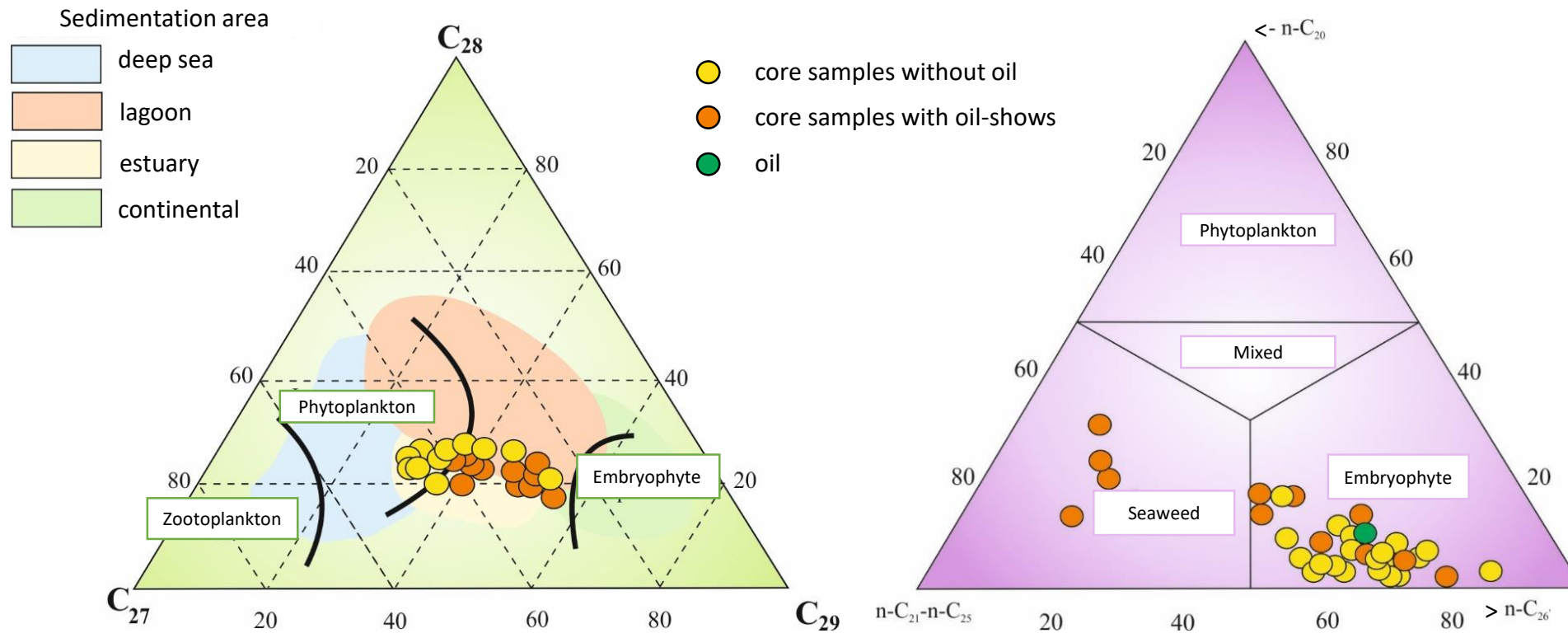
elemental composition characteristics

C	H	N	S
83.84%	10.67%	0.37%	<0.08%

molecular compounds



oil characteristics



Biomarker parameters indicate:

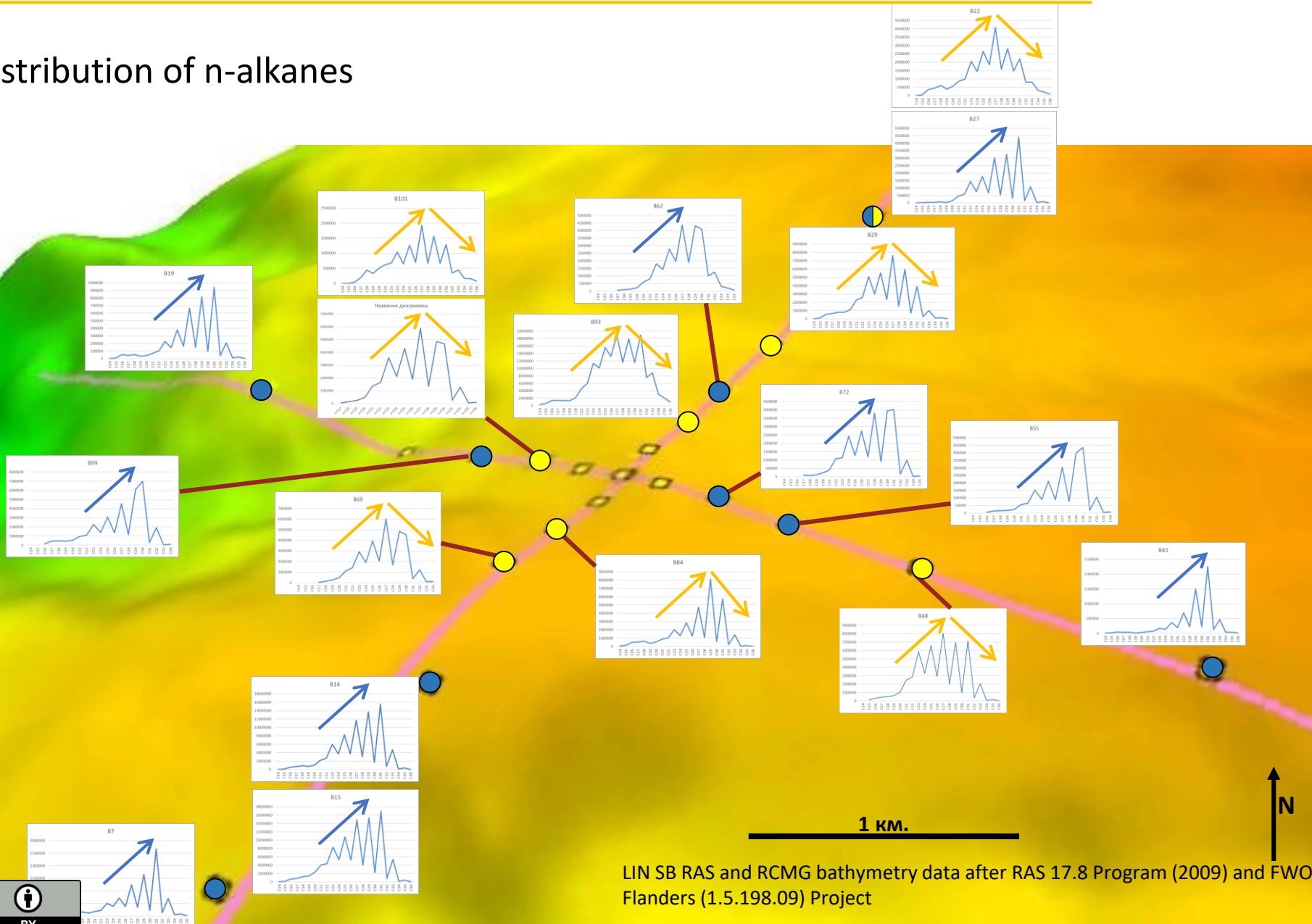
- **freshwater** sedimentation conditions
- high role of **plant waxes** in the organic matter

Migratory component is marked out in all the samples from the central part of the structure and the slopes

According to biomarker parameters, the source rock reached the oil window zone (stages MK₂-MK₄)

chromatography - mass spectrometry

Distribution of n-alkanes

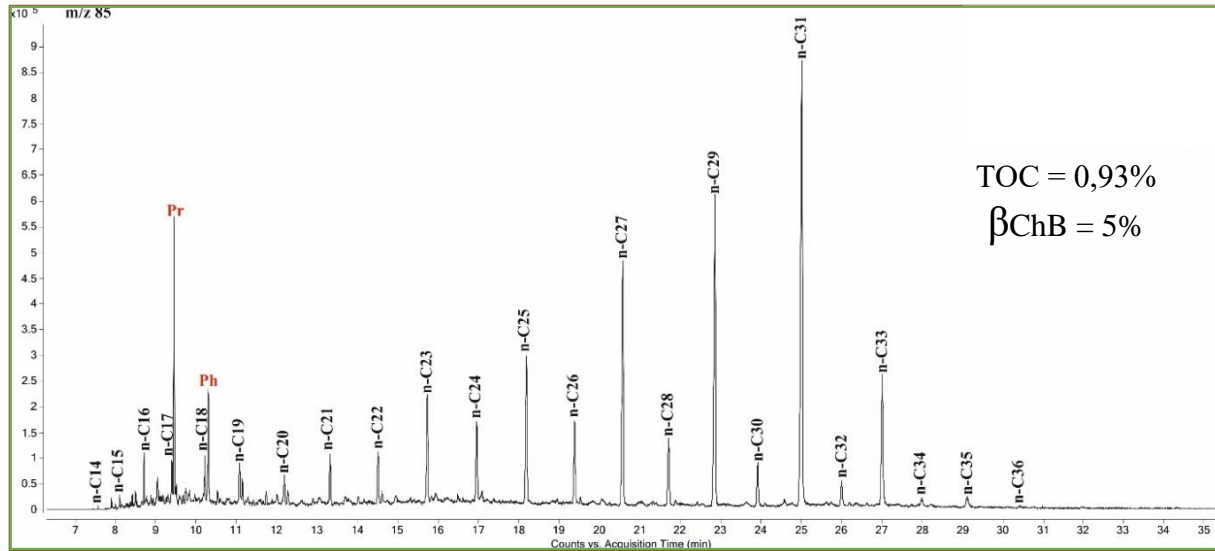


2 general groups of n-alkane distribution in the samples is distinguished:

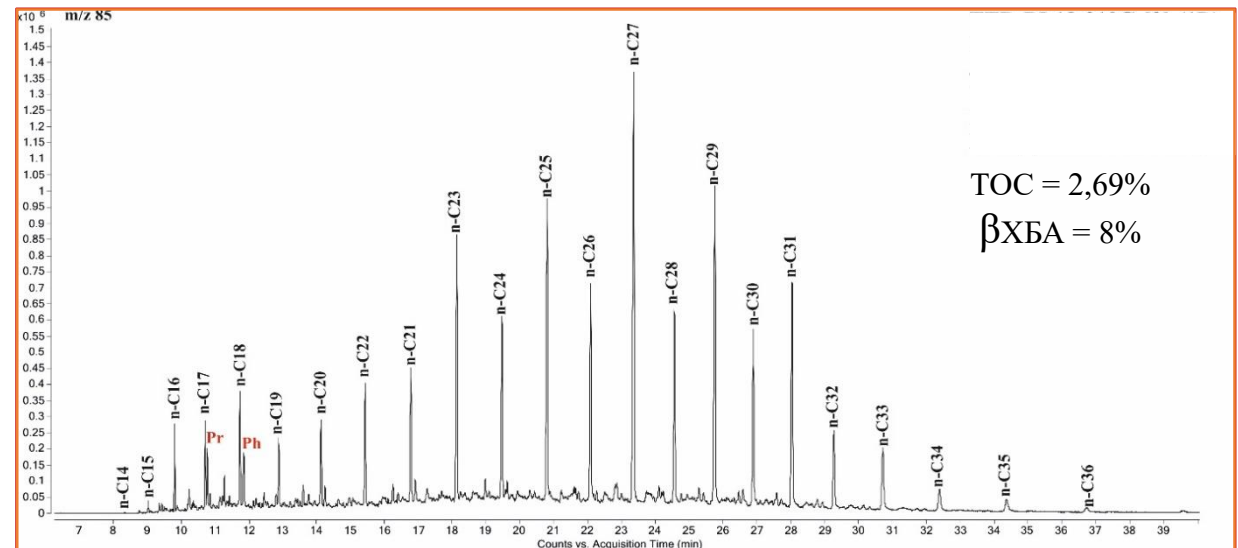
- modern organic matter of lacustrine sedimentation
- ancient organic matter with predominance of middle-molecular weight n-alkanes – mostly characteristic for the central part of the area (including samples with evident oil manifestations)
- Both groups observe sawtooth distribution with predominance of odd n-alkanes
- The low molecular weight part is biodegraded

LIN SB RAS and RCMG bathymetry data after RAS 17.8 Program (2009) and FWO Flanders (1.5.198.09) Project

chromatography-mass spectrometry



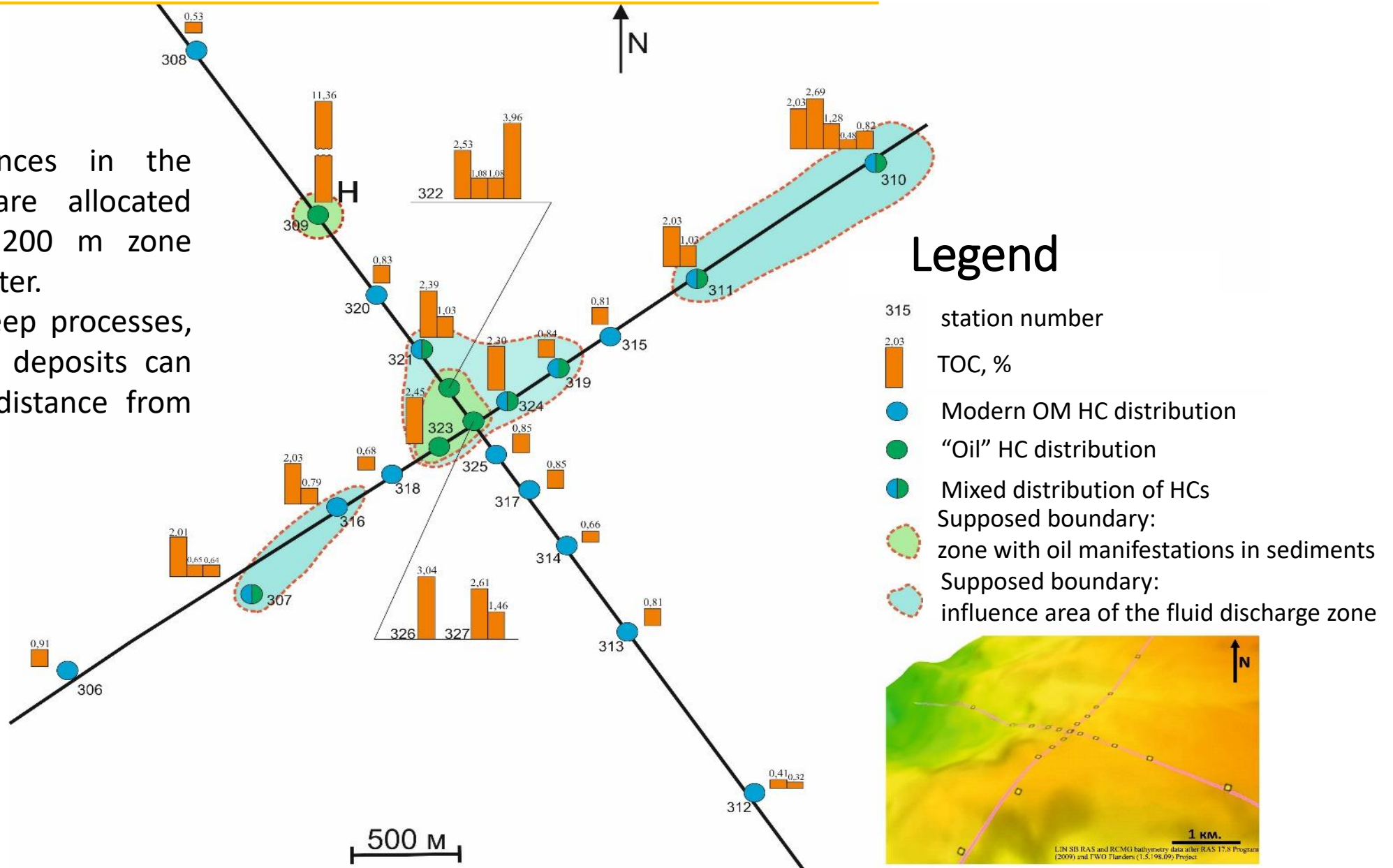
Sawtooth distribution of n-alkanes in samples from stations taken at a distance from the proposed center



“Oil” distribution of n-alkanes in the samples from the center of the structure with high TOC values

geochemical parameters distribution

- Oil occurrences in the sediments are allocated within the 200 m zone from the center.
- Due to creep processes, oil-saturated deposits can occur at a distance from the structure



methane concentration in sediments: 100 cm

- Increasing of methane concentrations towards the center of the structure
- The high content of methane homologues (ethane and propane) and carbon dioxide is characteristic and indicative for all samples from the center.
- A few samples outside of the central zone demonstrated the high thermogenic methane concentrations, carbon dioxide content and presence of methane homologues.

7 - methane, ml/l

-45,8‰ - methane isotopy

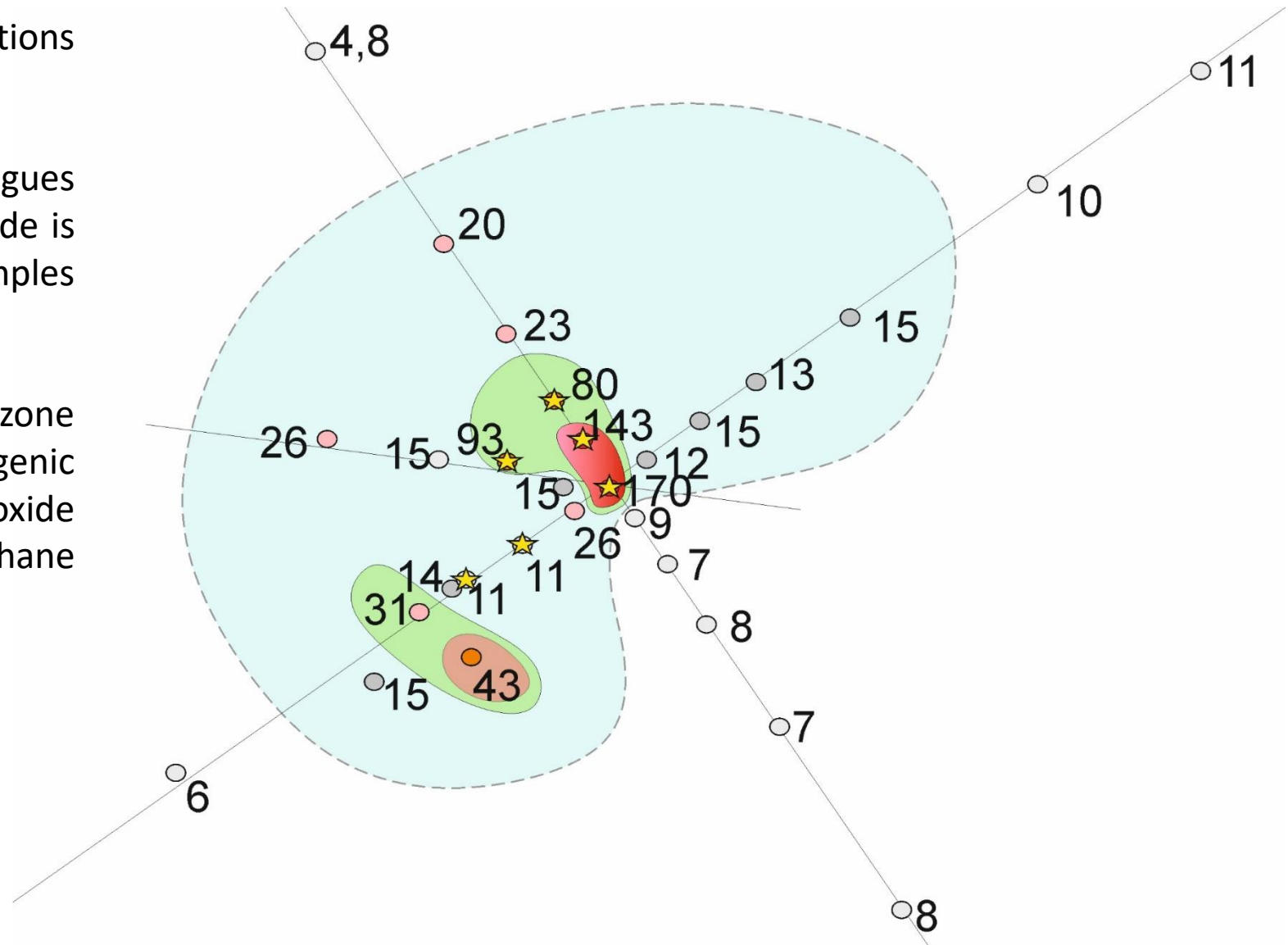
★ stations in which were discovered
iC₄H₁₀, C₄H₁₀, neo-C₅H₁₂

methane content is above average

high methane content

prospective second seep

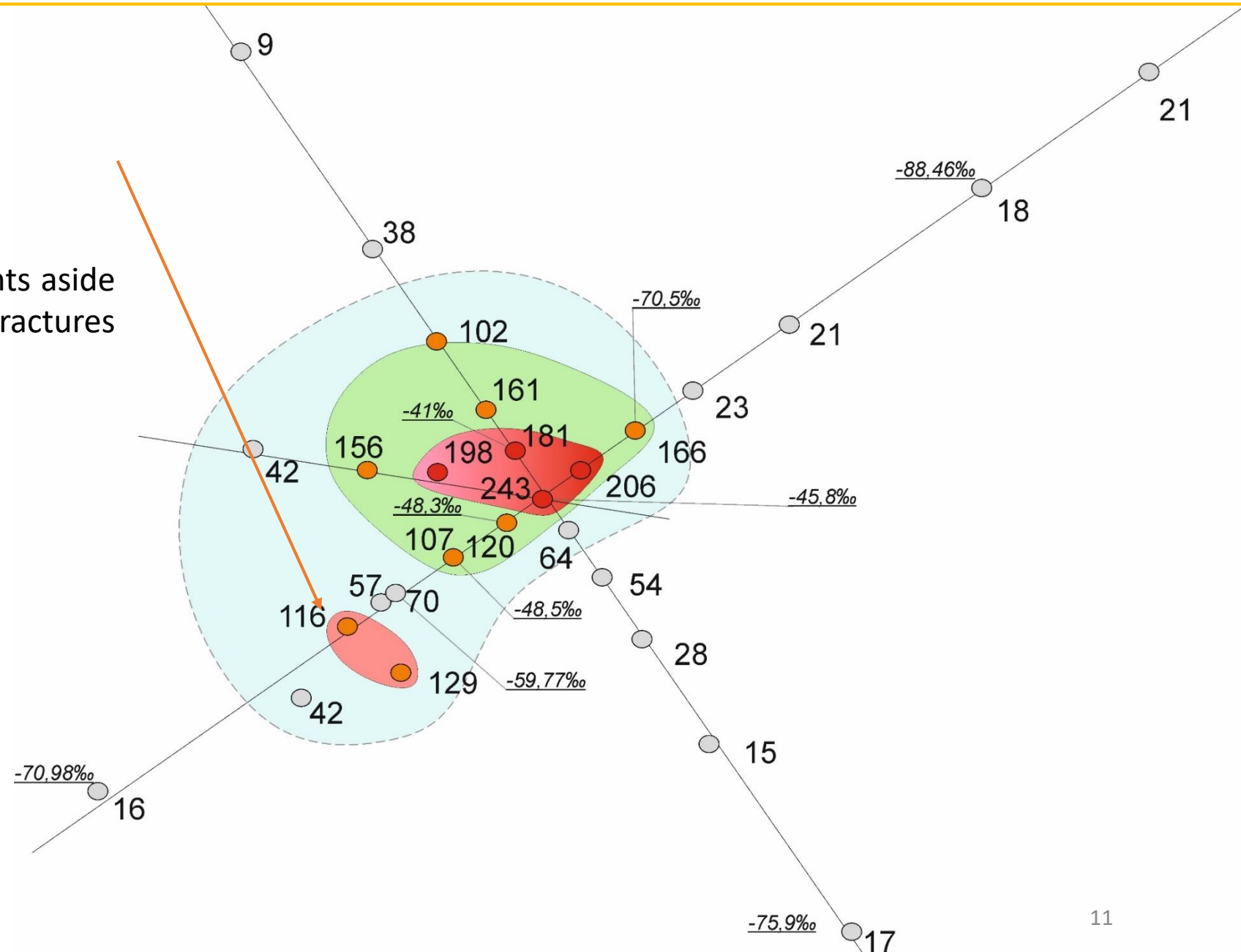
focused gas seep



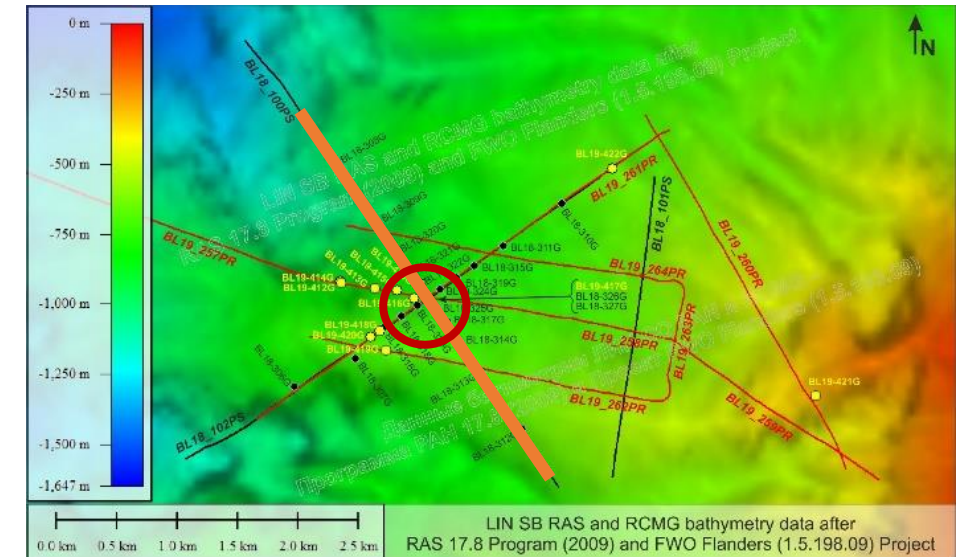
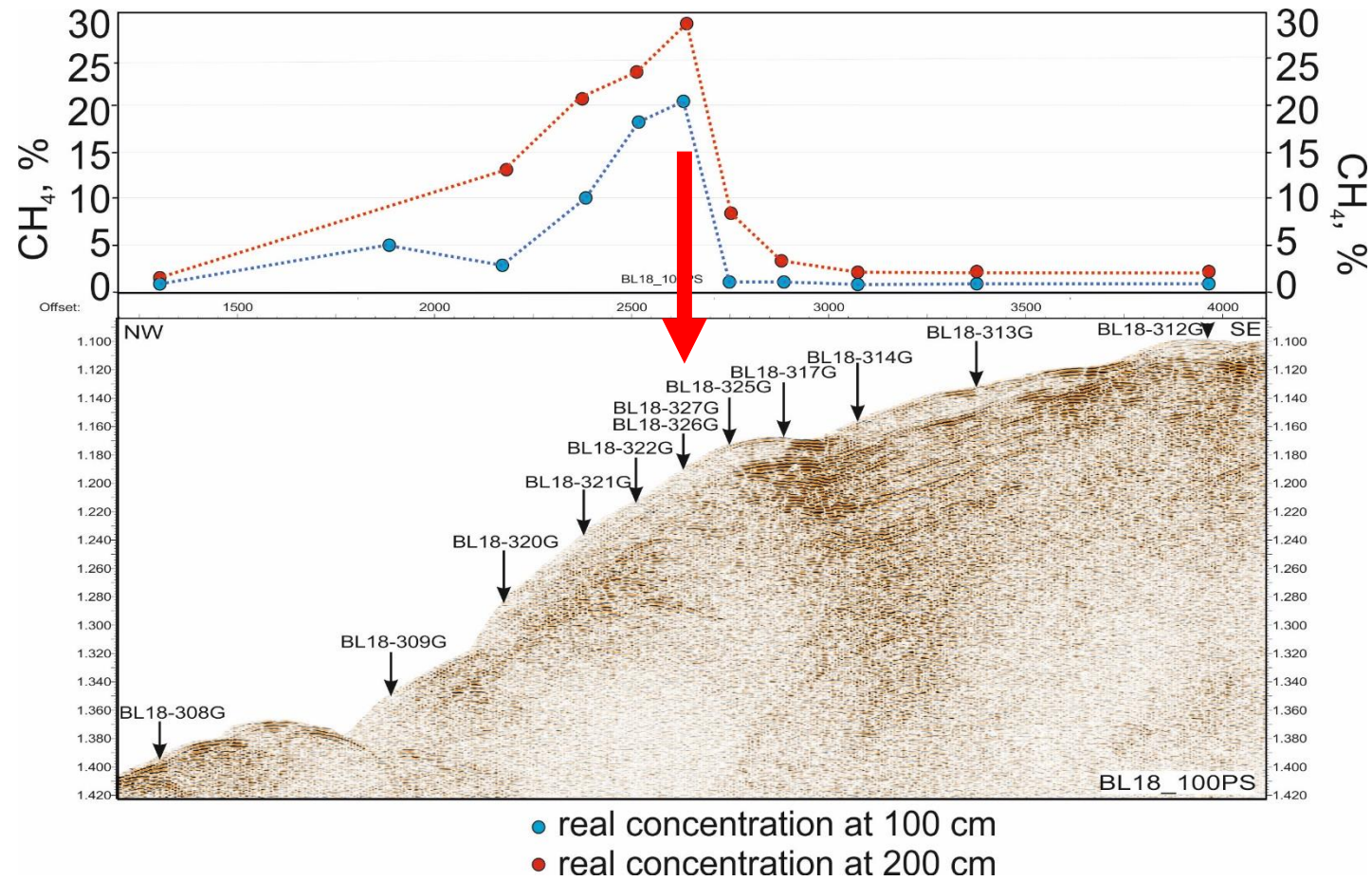
methane concentration in sediments: 200 cm

Existence of locally permeable segments aside of the main conduit, probably some fractures accompanying the central pathway.

- 7 - methane, ml/l
- -45.8‰ - methane isotopy
- ★ stations in which were discovered iC₄H₁₀, C₄H₁₀, neo-C₅H₁₂
- methane content is above average
- high methane content
- prospective second seep
- focused gas seep

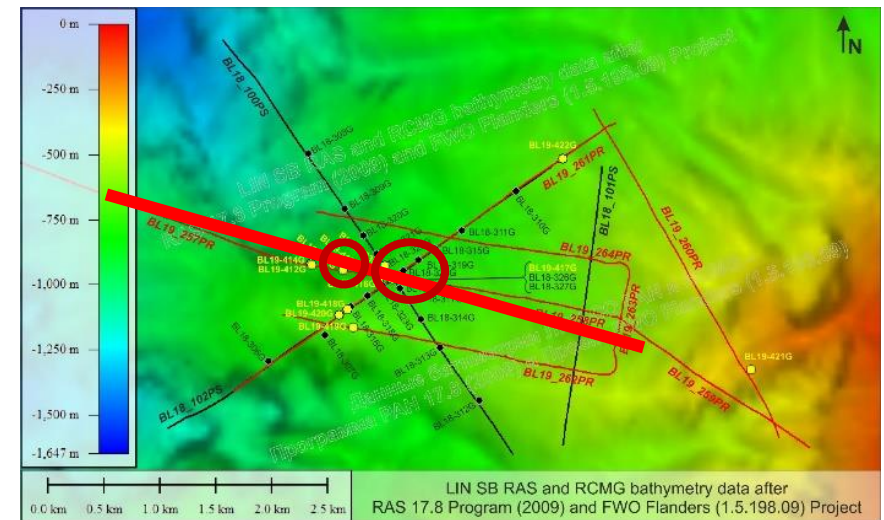
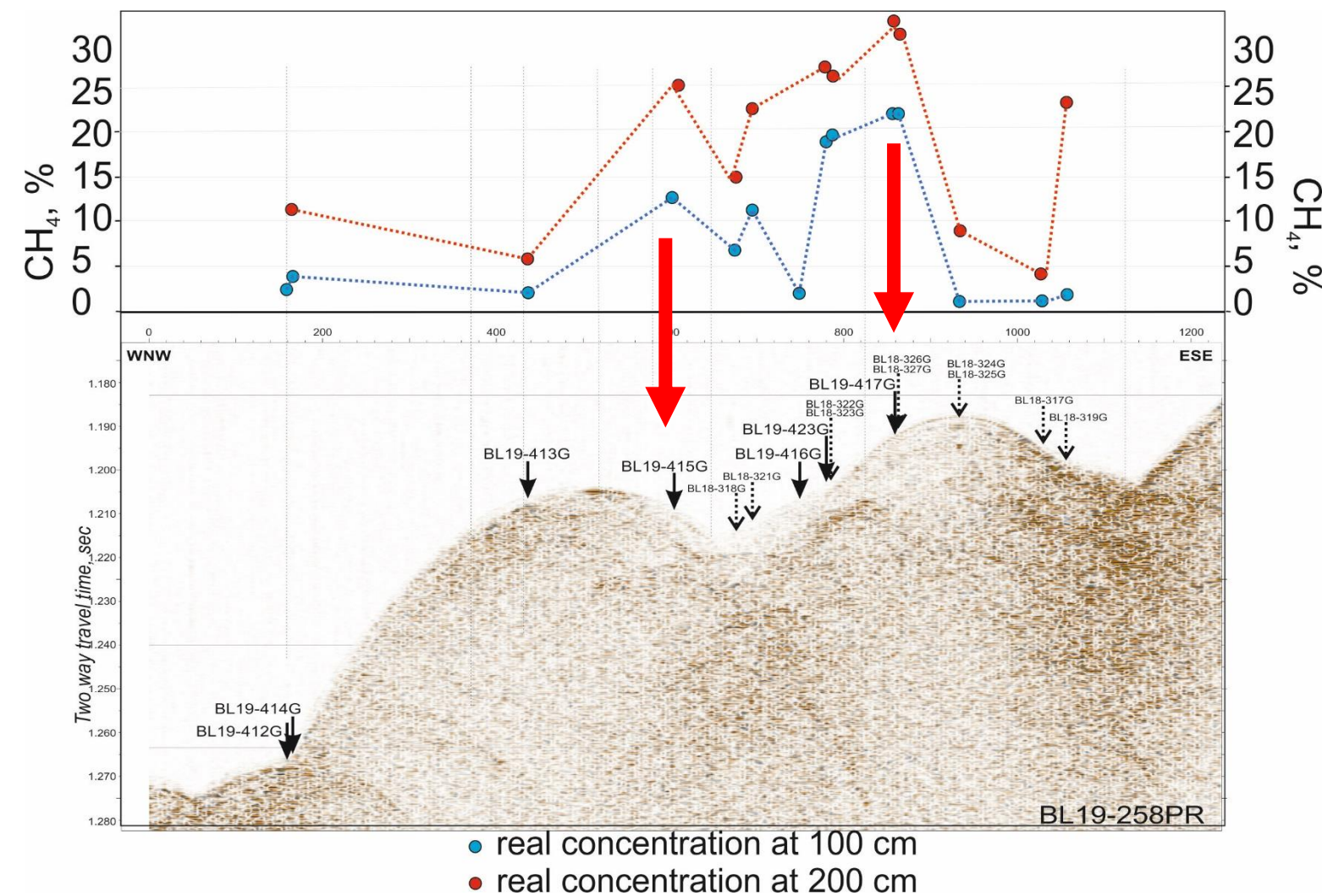


focused gas seeps «Gorevoy Utes»

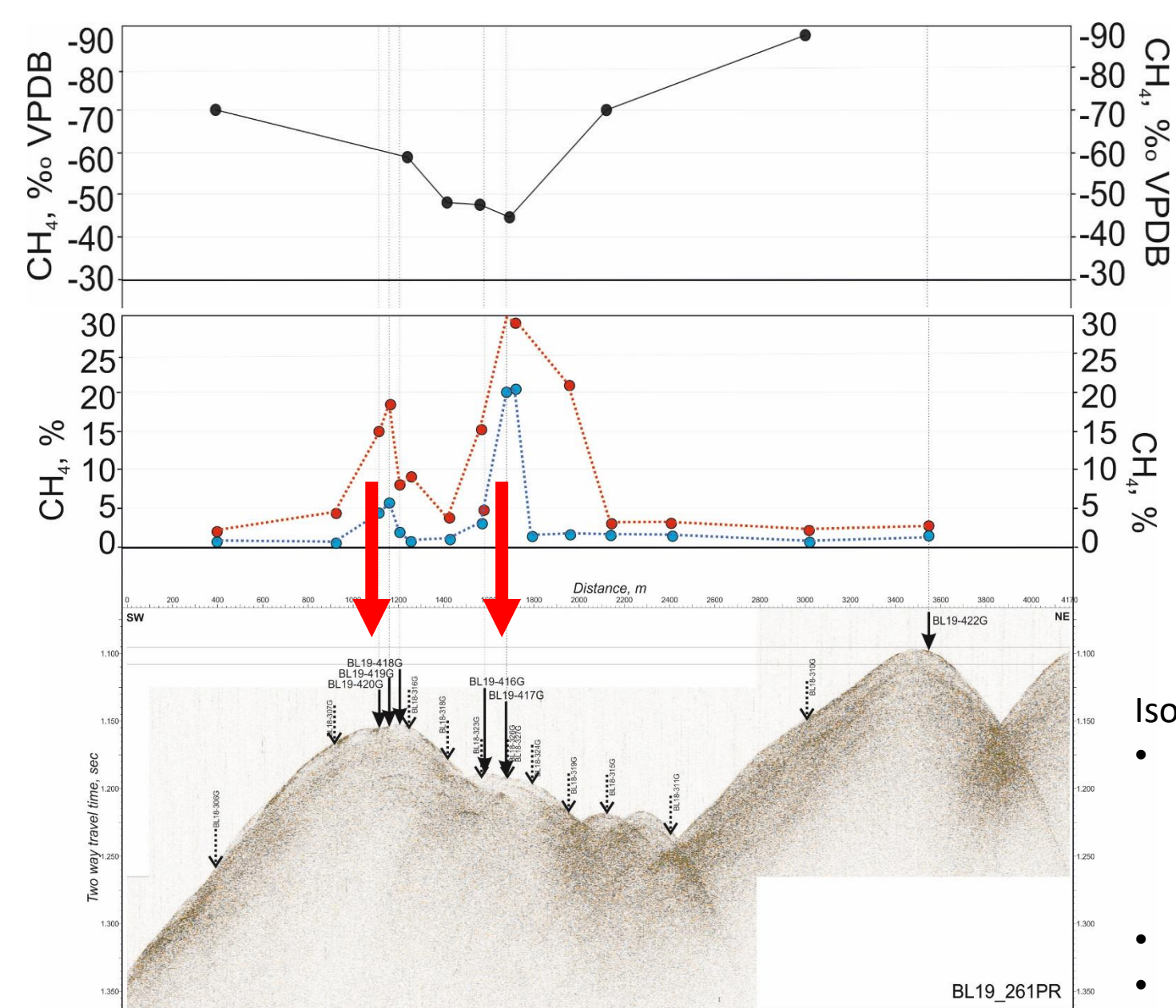


Map of the study area. The orange line - location of the geochemical profile, the red circle - zone with the highest concentration of methane in the sediments.

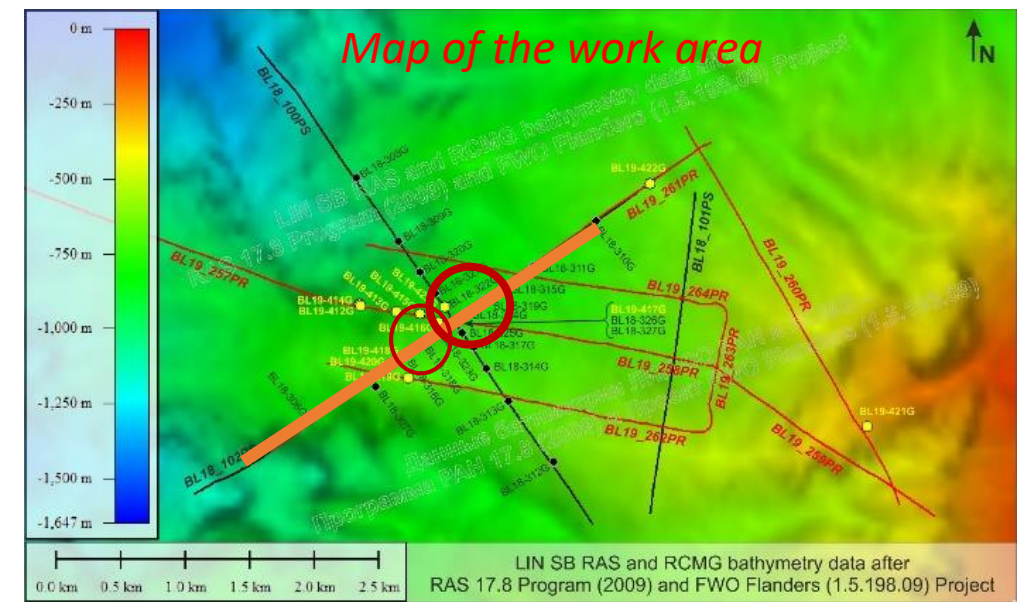
focused gas seeps «Gorevoy Utes»



Map of the study area. The orange line - location of the geochemical profile, the red circle - zone with the highest concentration of methane in the sediments.



- real concentration at 100 cm
- real concentration at 200 cm
- carbon isotope composition of methane



Isotopic studies:

- lateral redistribution of thermogenic methane together with enhanced bacterial methane generation in surrounding sediments.
- Periphery: $\delta^{13}\text{C}_{\text{CH}_4}$ - from -70.98 ‰ to -88.46 ‰,
- Center: $\delta^{13}\text{C}_{\text{CH}_4}$ is heavier (up to -41.00 ‰).

conclusions

- The migration affects all the studied parameters: content and isotopic composition of methane and homologues, increasing in TOC content, the increase in the fraction of saturated alkanes in the extracts, distribution of normal alkanes, composition of biomarkers.
- Geochemical data revealed that the source rocks for both hydrocarbon gases and oil are terrigenous and contain predominant humic organic matter components (kerogen type III).
- Results of geochemical studies are incorporated into an integrated model of source-to-surface fluid migration to explain the observed peculiarities of the Gorevoy Utes seepage area.



Thank you for attention!
