Preparation for a pilot project of CO2 geological storage in the Czech Republic

norway grants

Activity 2

Building a 3D static geological model of the storage site and storage complex

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Norway Grants

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IRIS Stavanger, NO

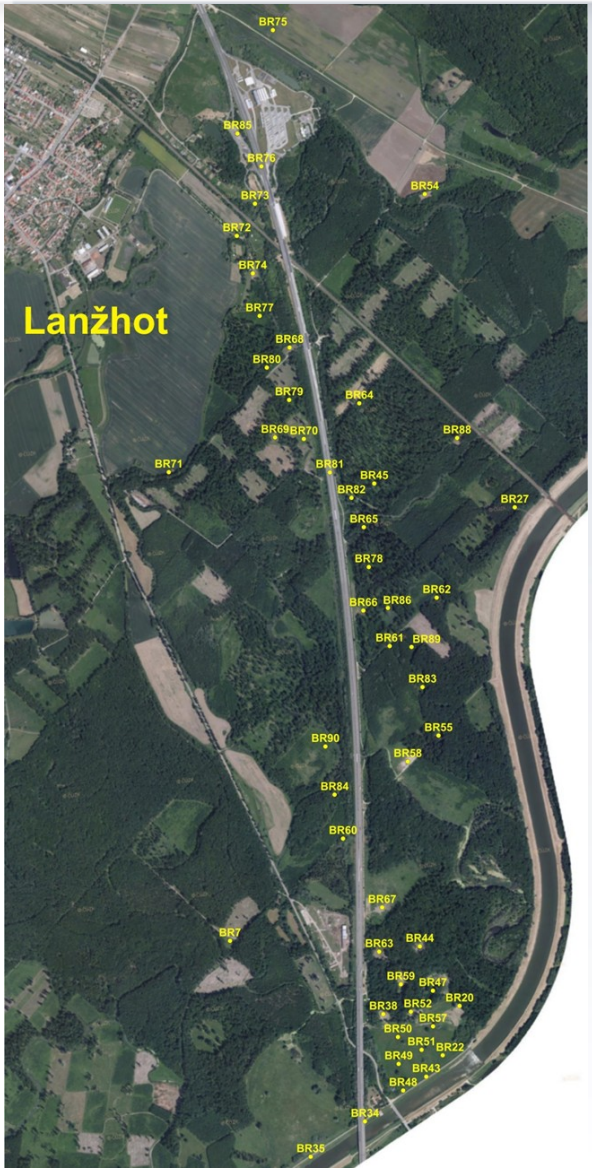
Acknowledgements: Shlumberger for providing the Academic license of the Petrel software

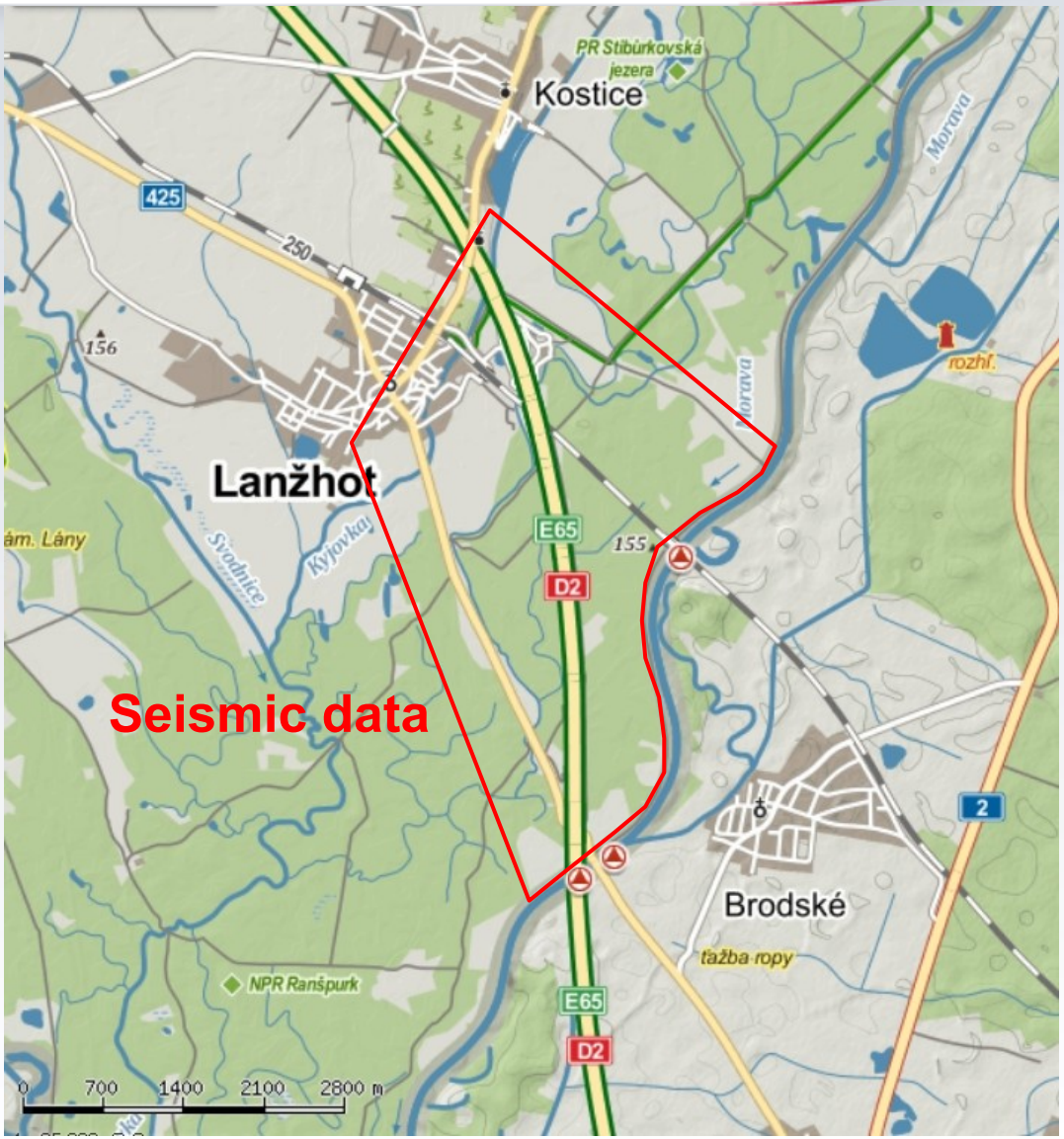
Co-operation in research and development of Carbon Capture and Storage technologies, Czech-Norwegian Seminar
Oslo, 12 October, 2016

Principle steps in building the 3D Model

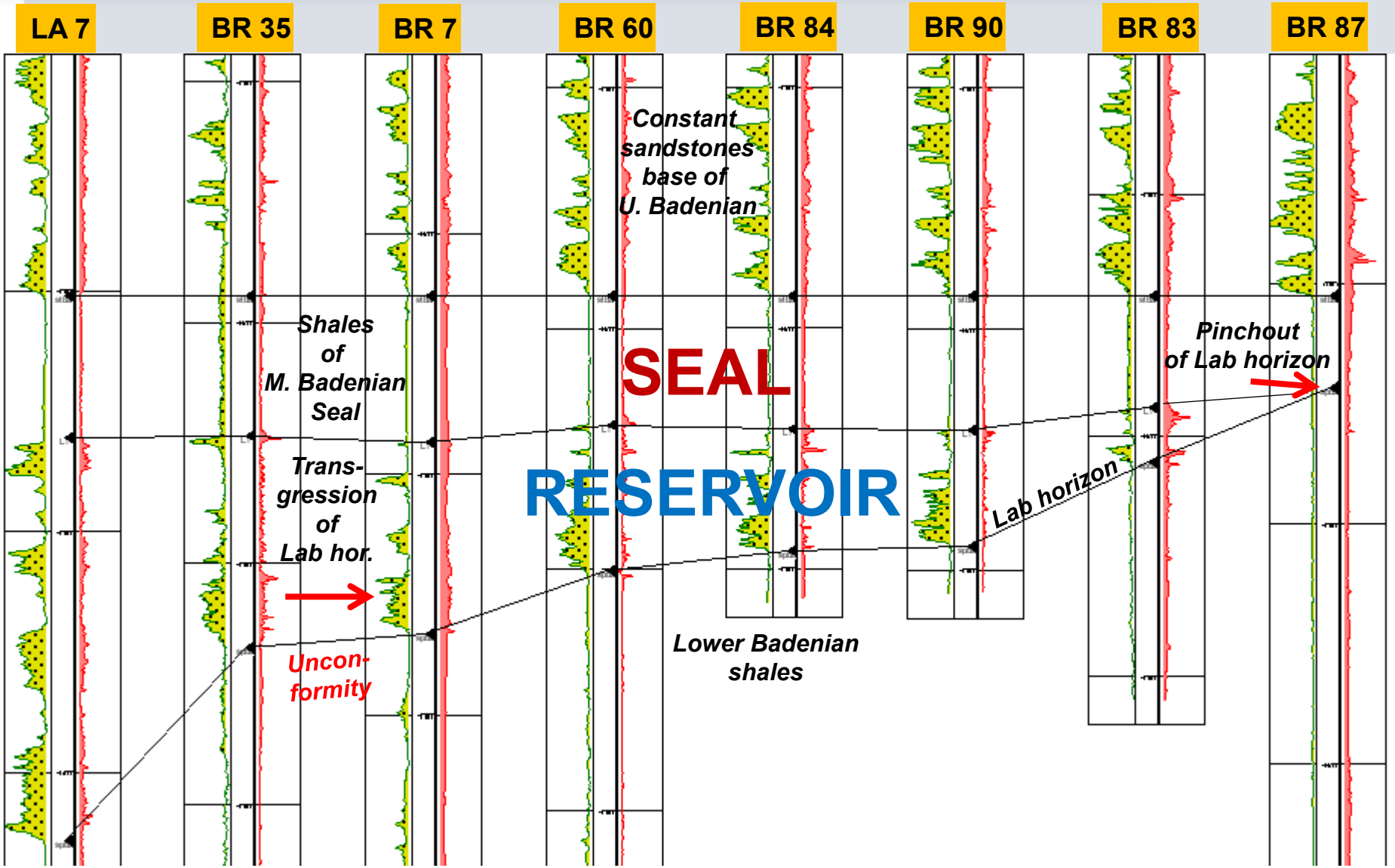
1. **Revised well logs and seismic data**
2. **Reservoir, seal, and faults**
3. **Preparation of data for Dynamic Modeling**
   - Well tests and pressure data
   - Production history from individual wells
4. **Data for Risk Analysis**
   - Well completion after abandonment
   - Perforations, casings and cement plugs
5. **Proposal of injection and monitoring wells**

LBr-1 CO_2-Storage Complex
Well locations and 3D seismics

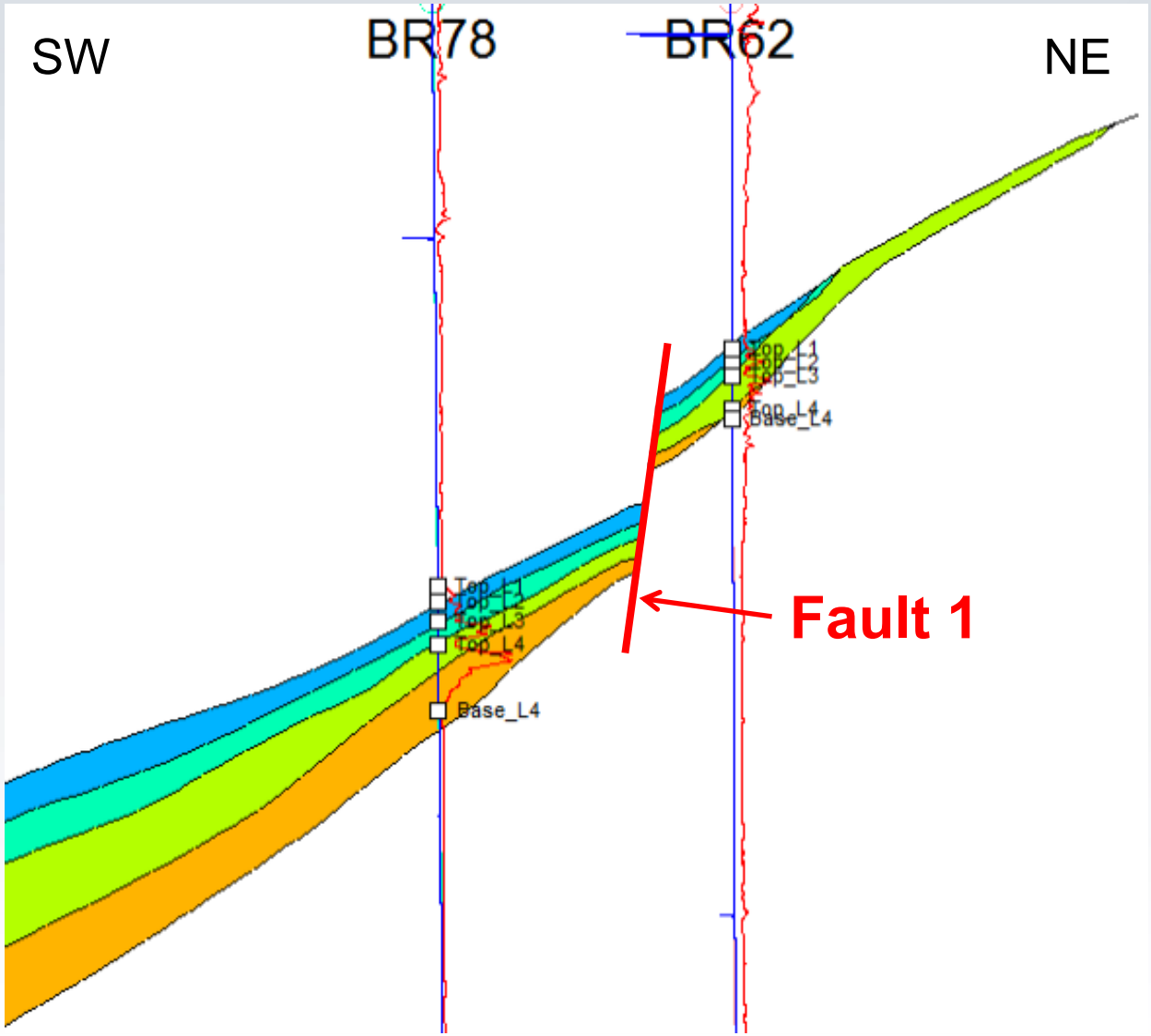




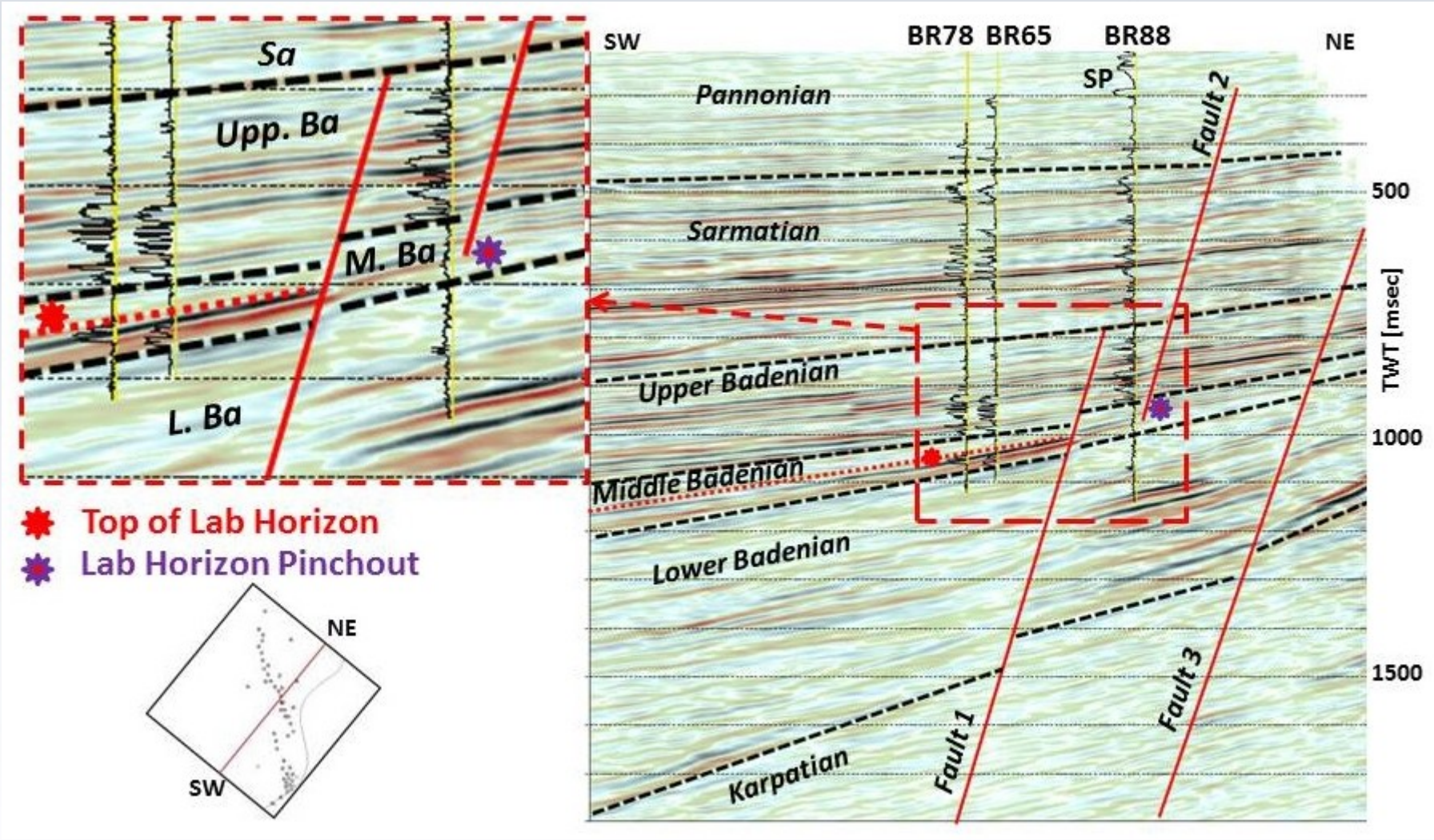
Litofacies analysis of well logs



Partial layers of the Lab reservoir

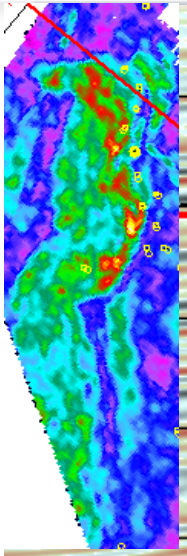


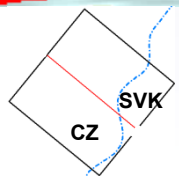
Integration of seismics and well log data



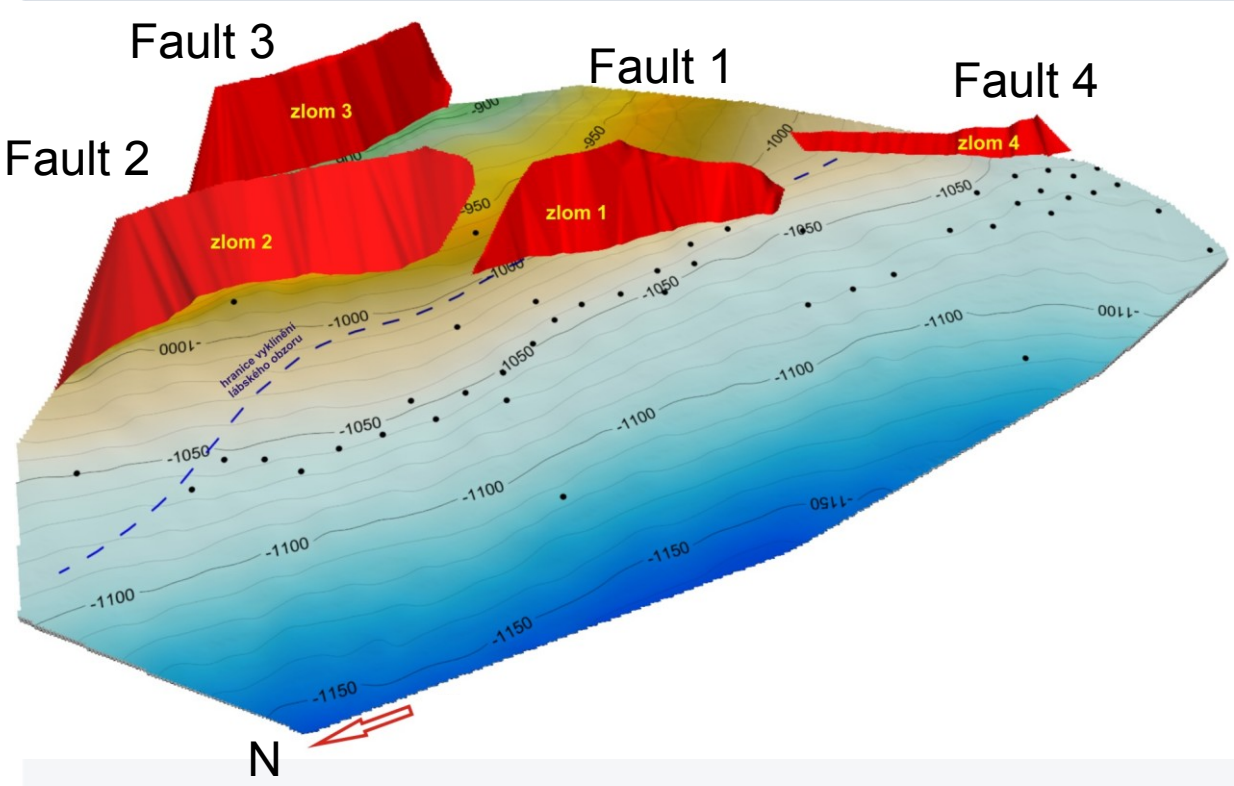
Seismic Stratigraphy + Well logs

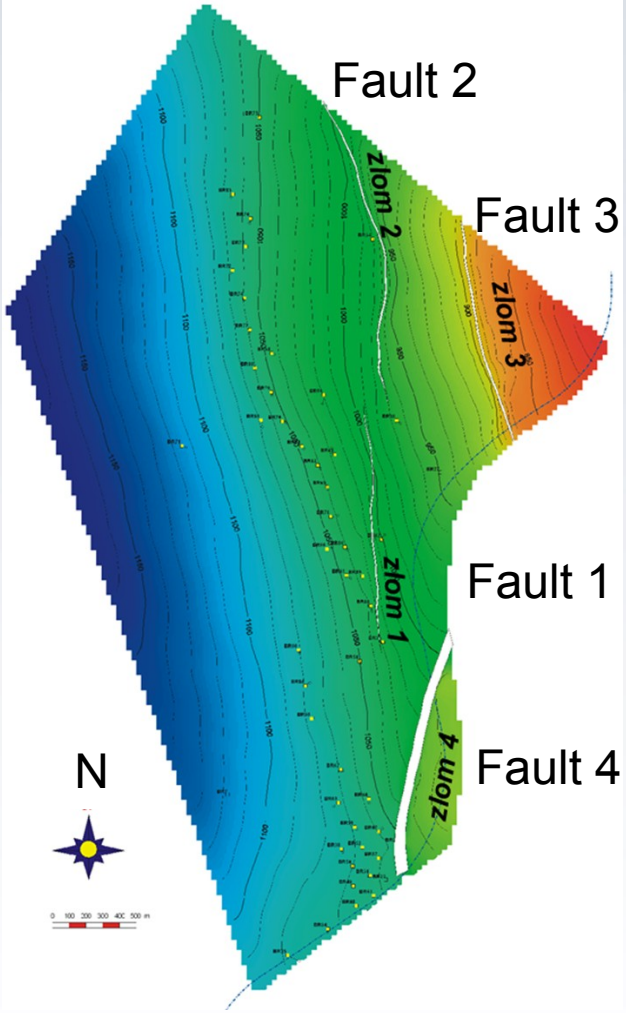
Map of the Sarm. channel





Mapping the surfaces and faults in time and depth domains

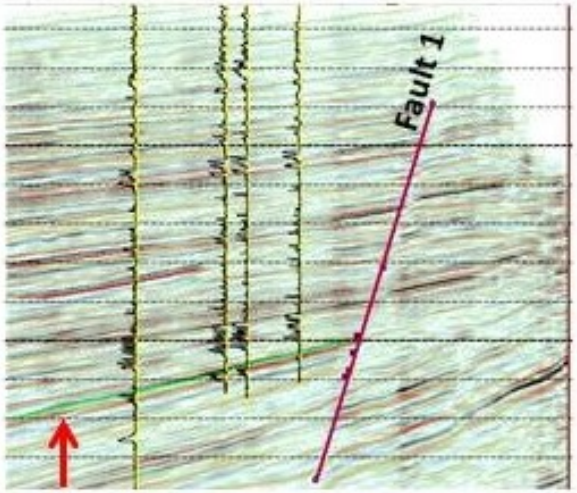




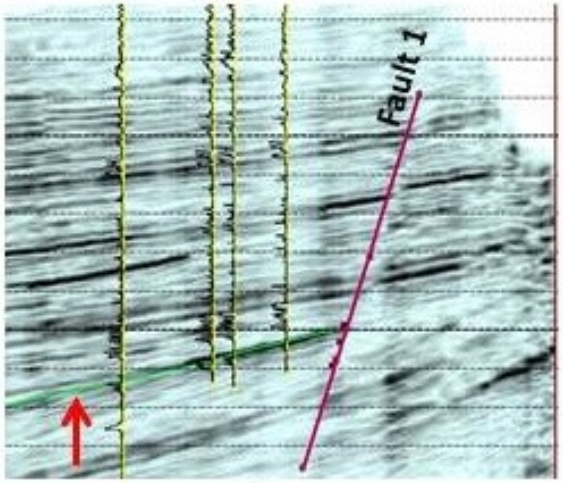
Eastern pinchout of the Lab reservoir

Seismic attribute analysis

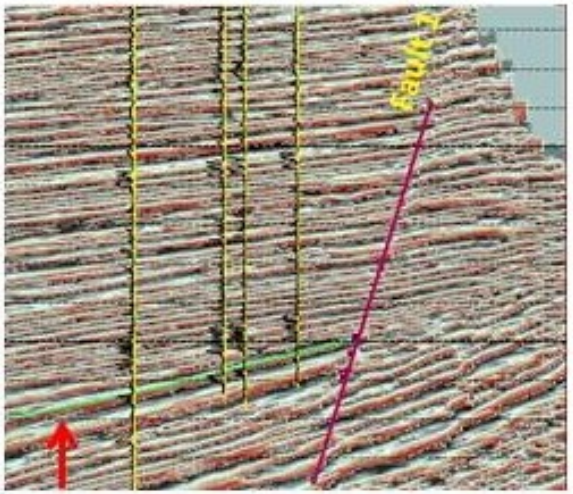
Pre Stack Time Migration - NoRAP



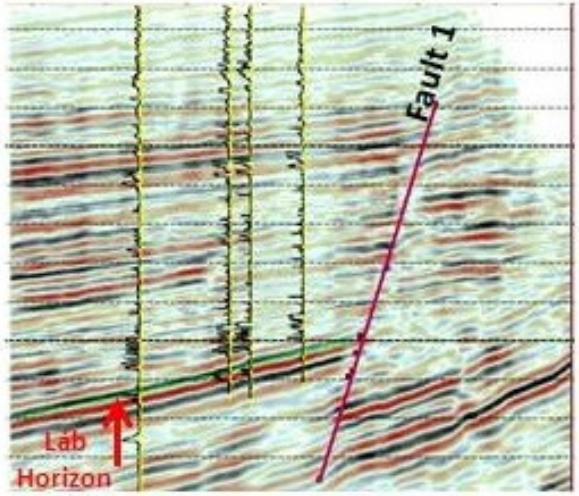
Instantaneous Amplitude



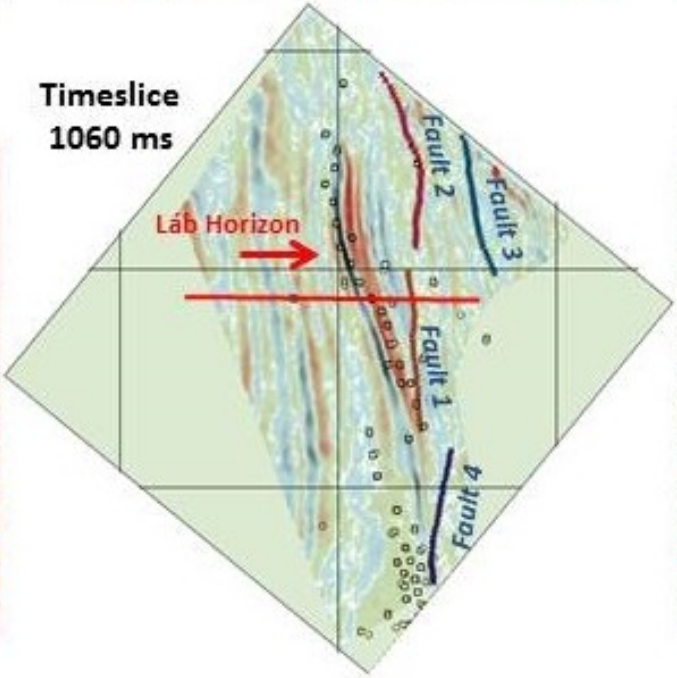
Instantaneous Phase



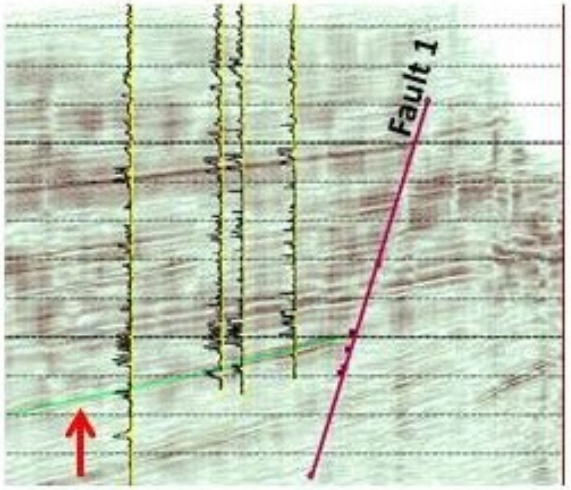
Bandpass Filter 4-8-16-32



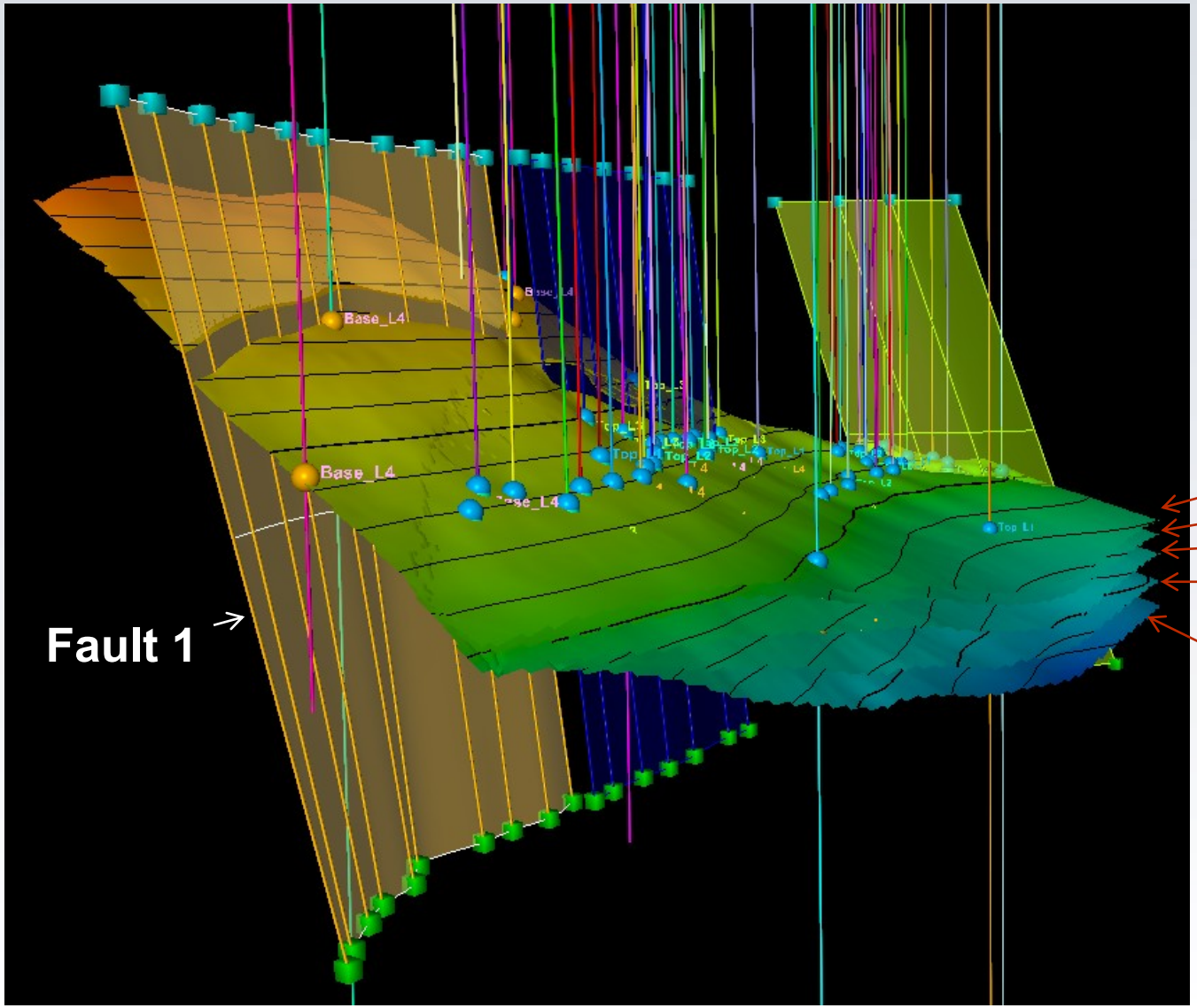
Timeslice
1060 ms



Bandpass Filter 16-32-64-128



3D Model in Petrel of the CO_2 Storage Complex



4 tops of the partial layers of the Lab reservoir

L1

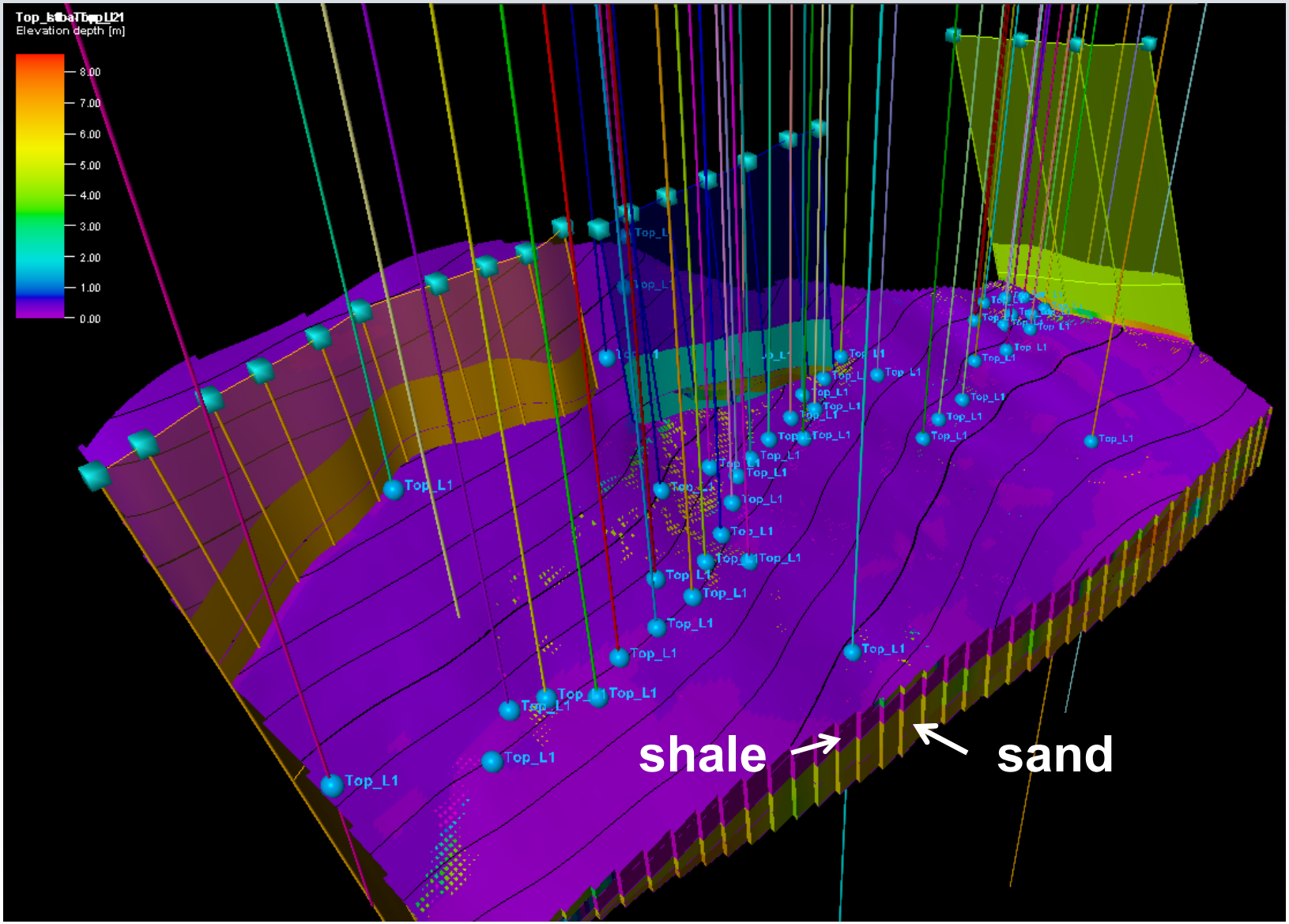
L2

L3

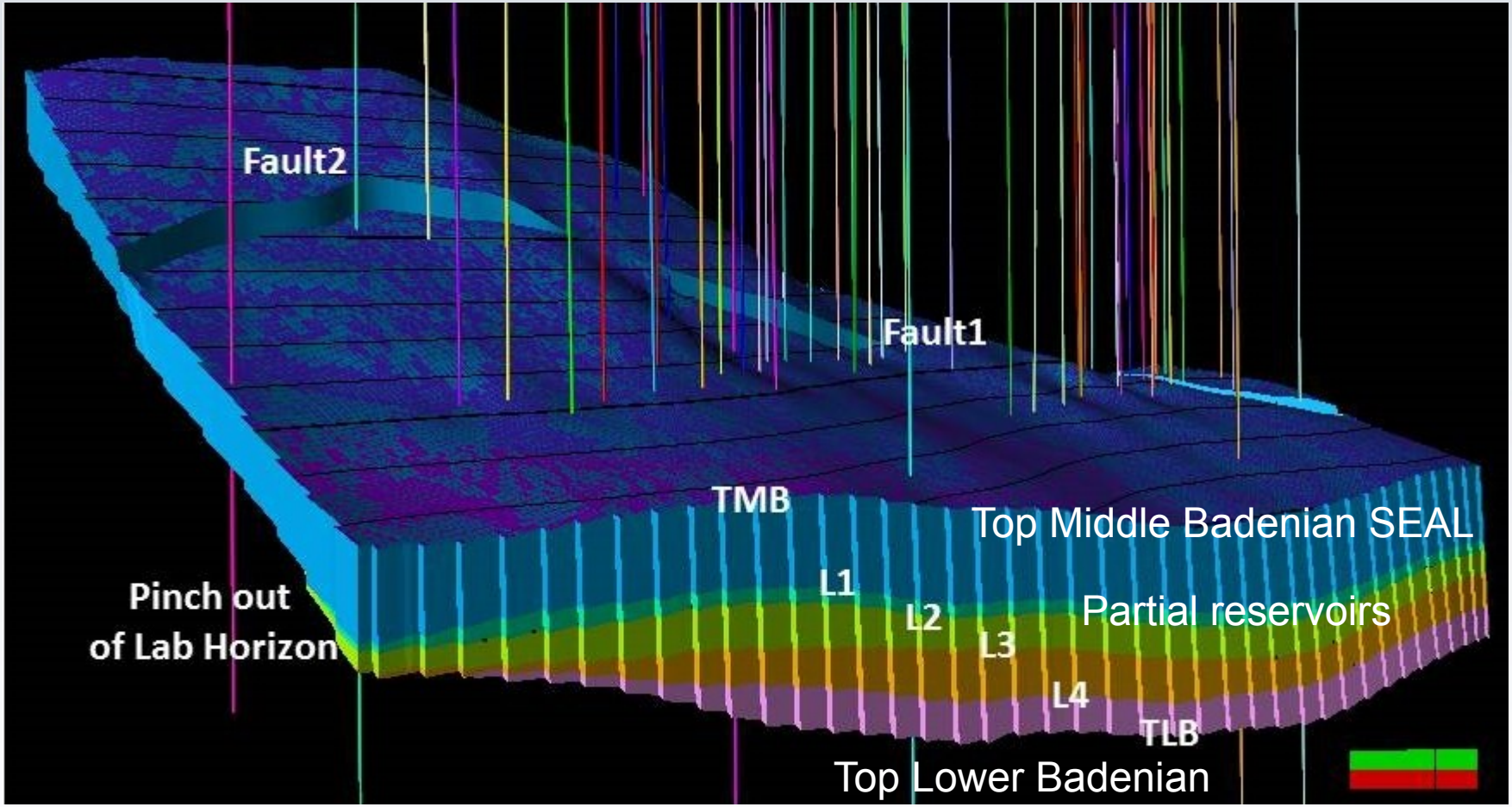
L4

Base of the Lab reservoir

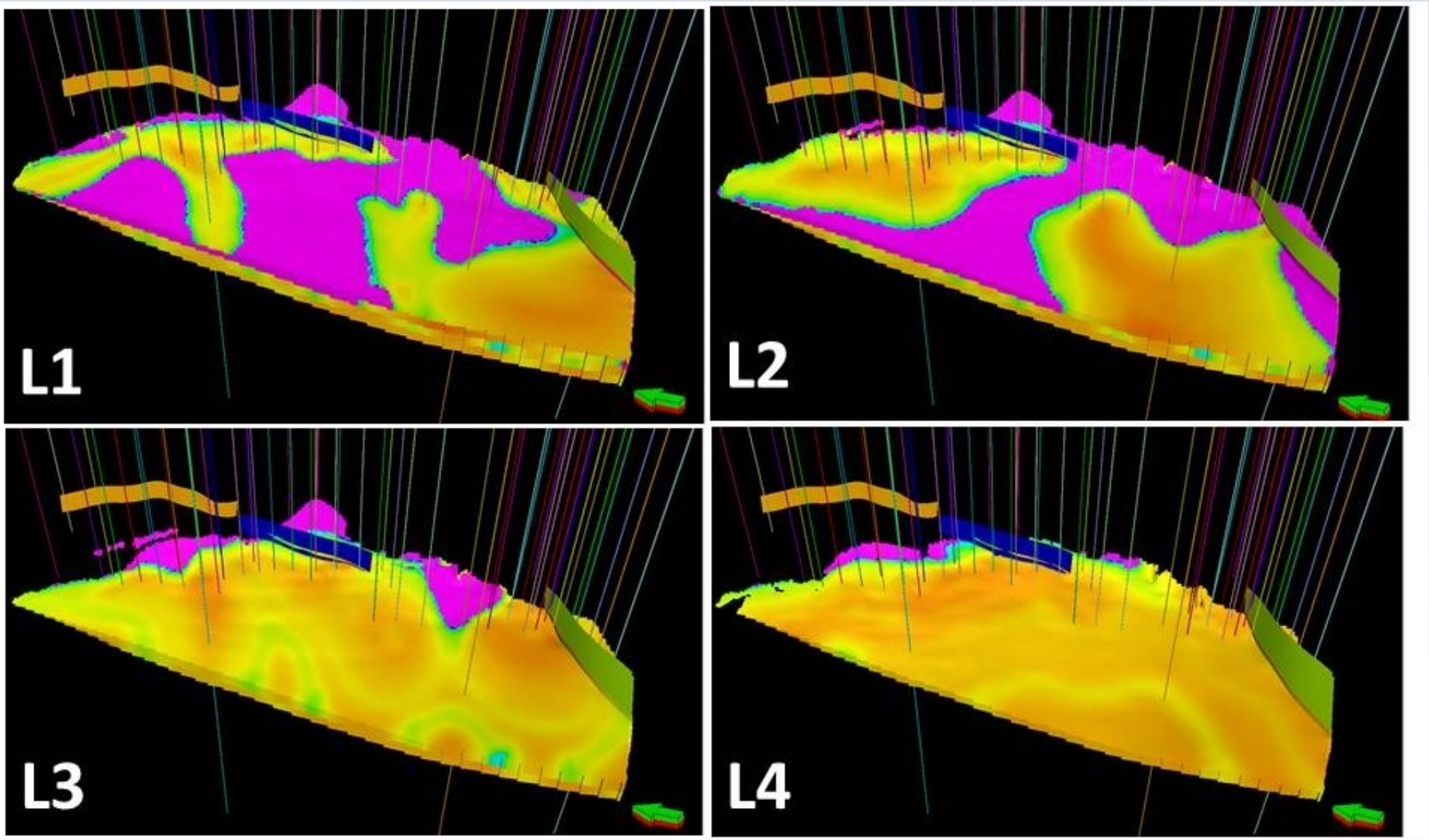
3D Model of LBr-1 viewed from NW
Colors show lithologies



3D LBr-1 Model viewed from NW intervals with properties

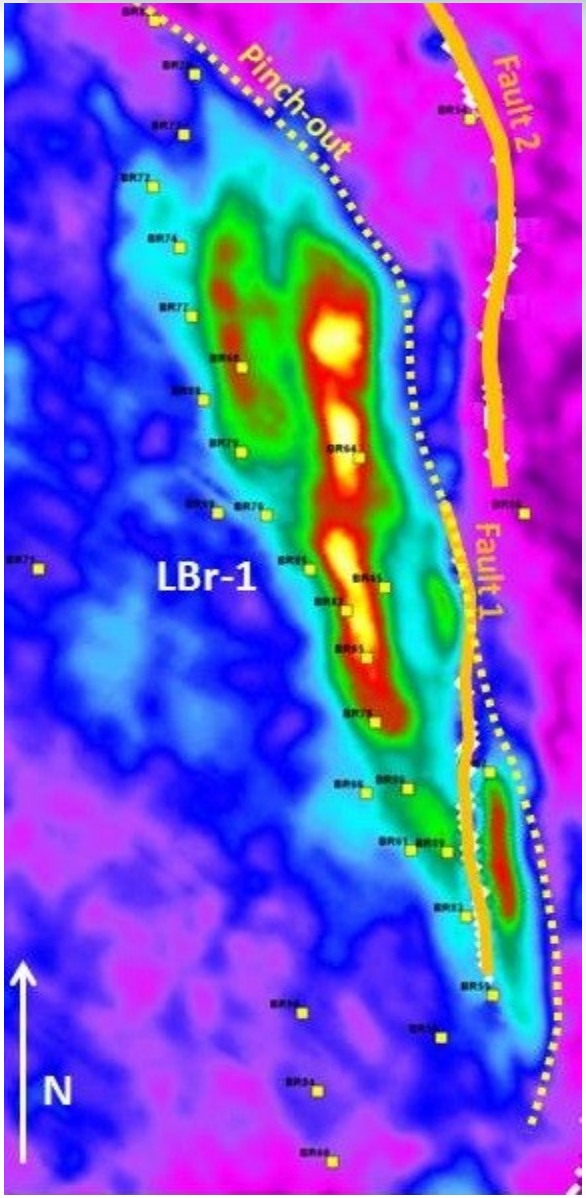


3D Model of LBr-1



Partial layers of the Lab reservoir with permeability

Average absolute amplitude of the Lab horizon

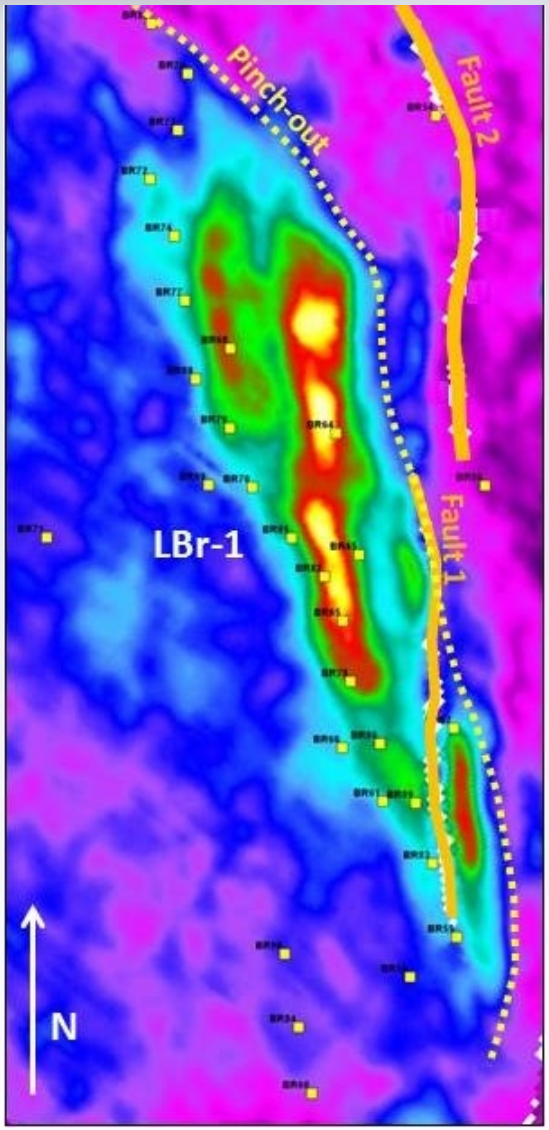


Application of seismic attribute analysis made it possible to visualize more details in the architecture of the storage complex.

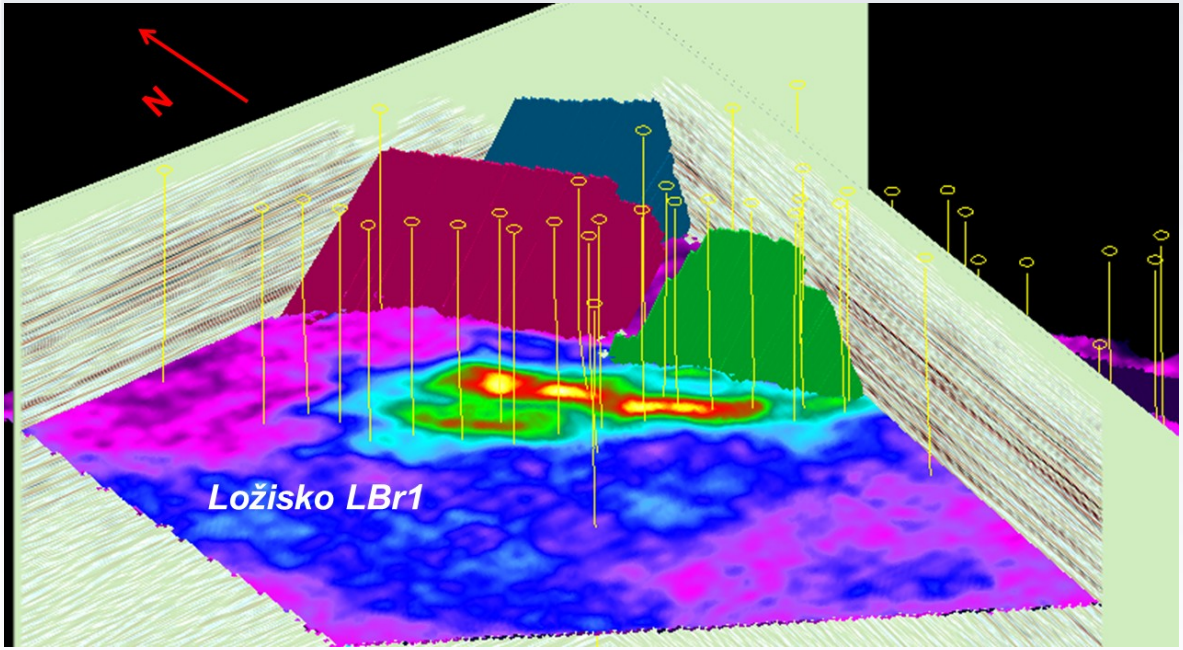
The average absolute amplitude shows the **residual hydrocarbon saturation** of the reservoir = probable **initial extent** of the oil and gas field.

Analýza seismických atributů

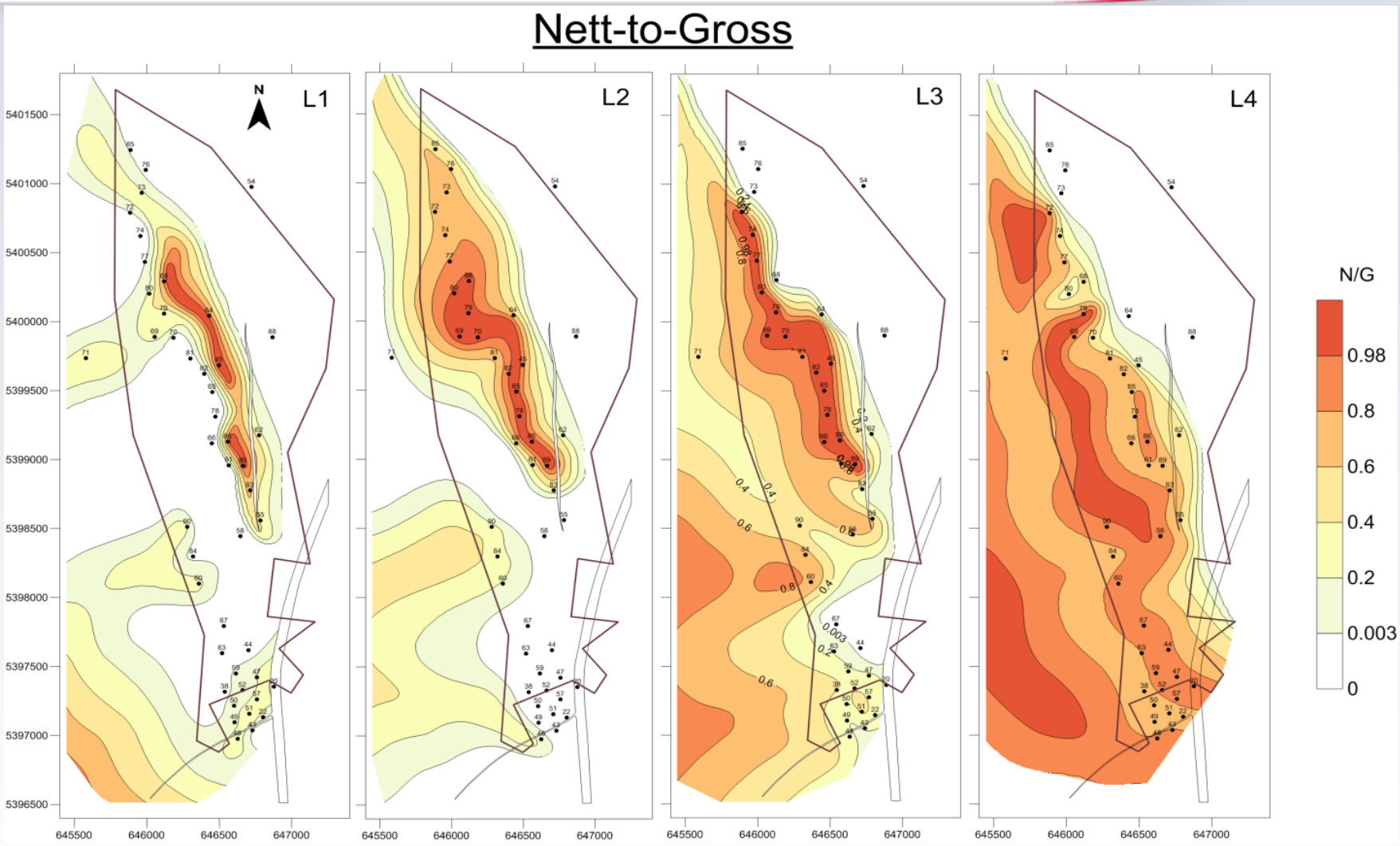
Povrch lábského obzorus atributem průměrná absolutní amplituda



3D pohled na povrch lábského obzoru s atributem průměrná absolutní amplituda

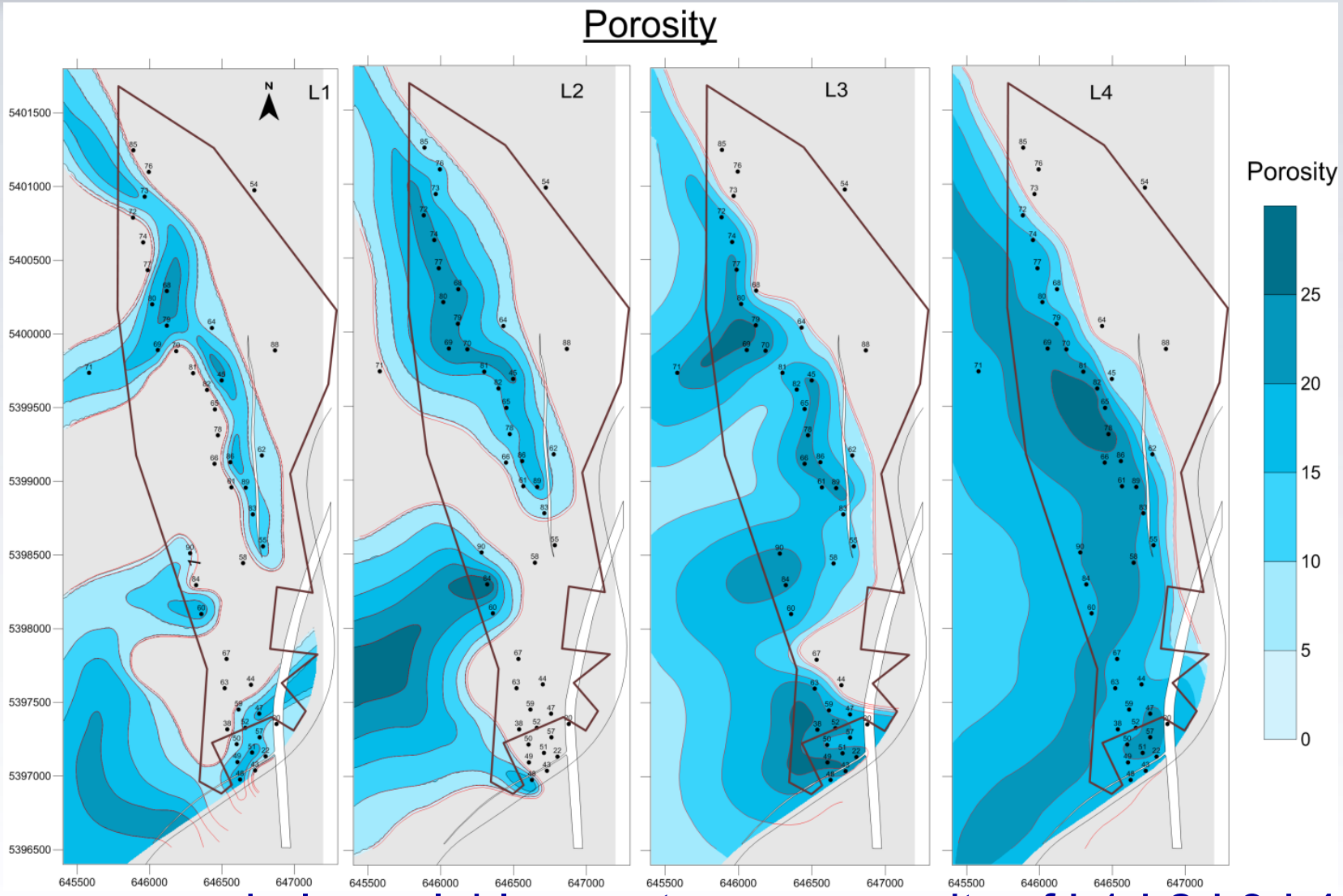


Net-to-Gross maps in the four partial horizons of the Lab reservoir



N/G = sand thickness / reservoir layer thickness

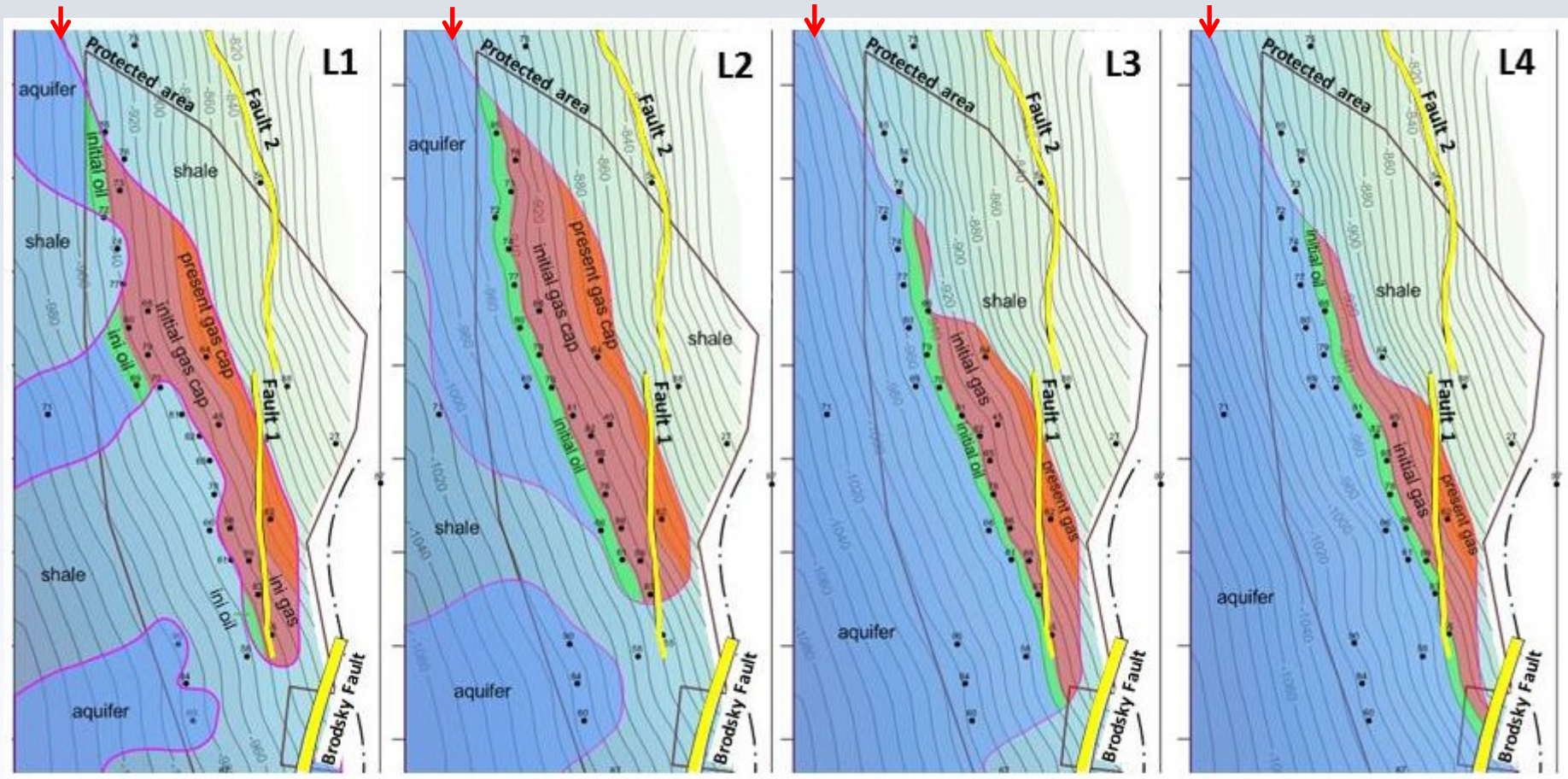
Porosity of the partial reservoir layers



Grey area = shale seal, blue contours = porosity of L1-L2-L3-L4

Tops (SSL) of the partial reservoir layers with Gas Cap – Oil zone – Aquifer

Possible spill point



Production data suggest partial communication among L1-L2-L3-L4

3D Model results – comparison the new and the archival reserves estimation

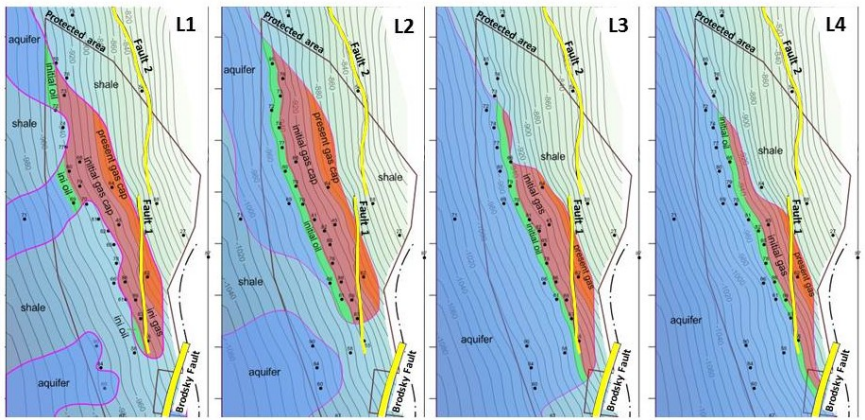
Oil and Gas reserves estimated using the new 3D model

OIL in place	GAS in place	Recoverable OIL	Recoverable GAS
thous. sm^3	mil. sm^3	thous. sm^3	mil. sm^3
290	97	73	77.6

Oil and Gas reserves based on archival report (Šele 1960)

OIL in place	GAS in place	Recoverable OIL	Recoverable GAS
thous. sm^3	mil. sm^3	thous. sm^3	mil. sm3
305	84	61.1	75.4

Cumulative production of Oil and Gas

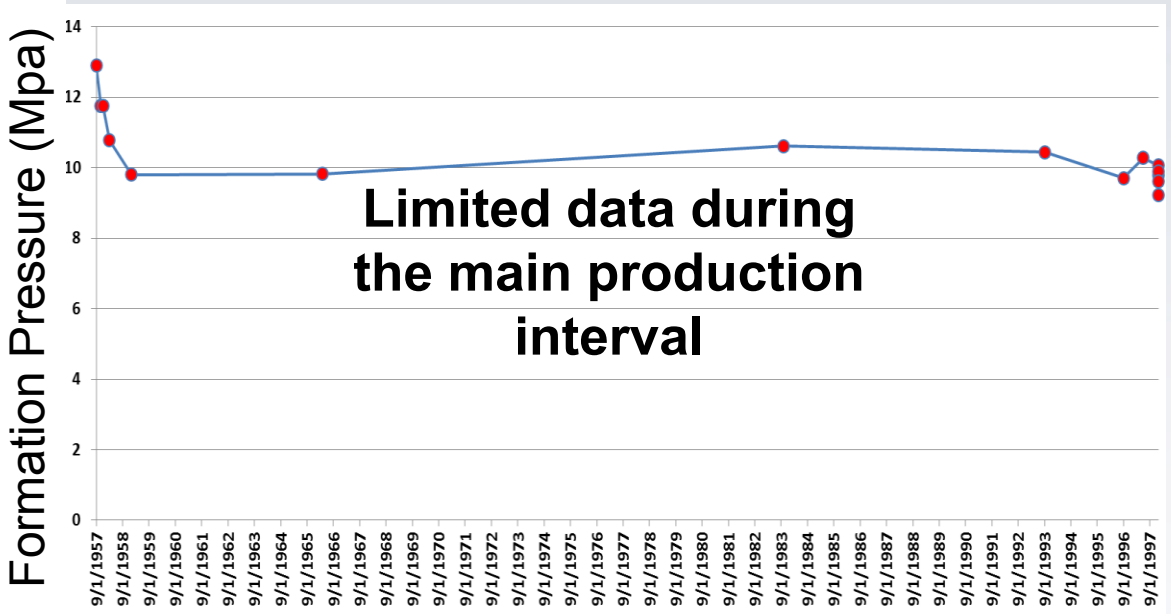


Archival report (Káňa 1998)

Cumulative OIL	Cumulative GAS
thous. sm^3	mil. sm^3
61.9	68.7

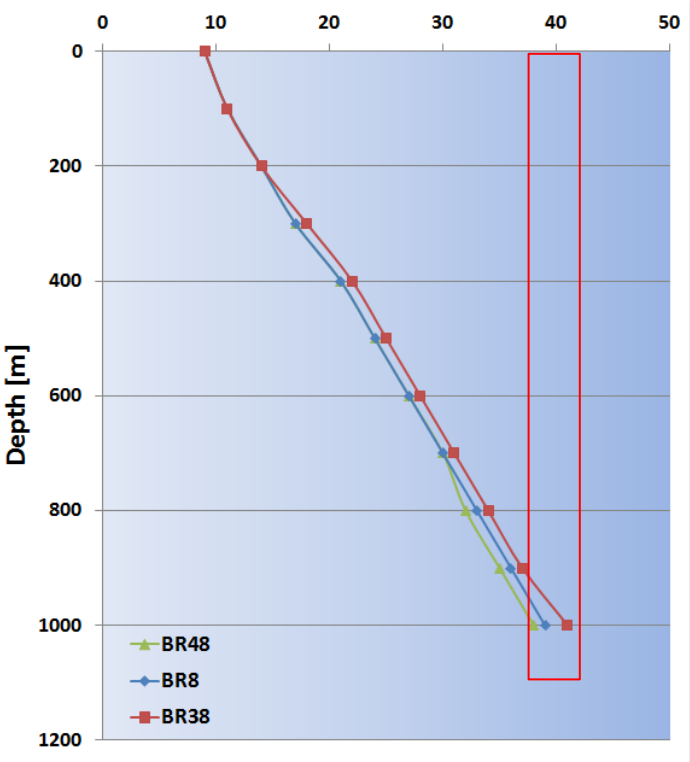
Add on properties
Pressure and Temperature

Formation pressure evolution throughout the production history in LBr-1

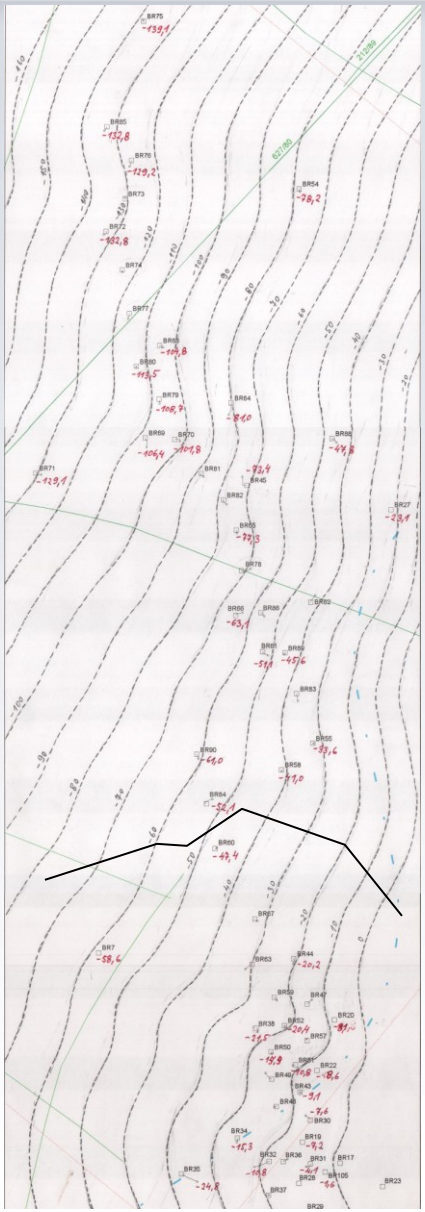


Time: Sep 1957 – Sep 1997

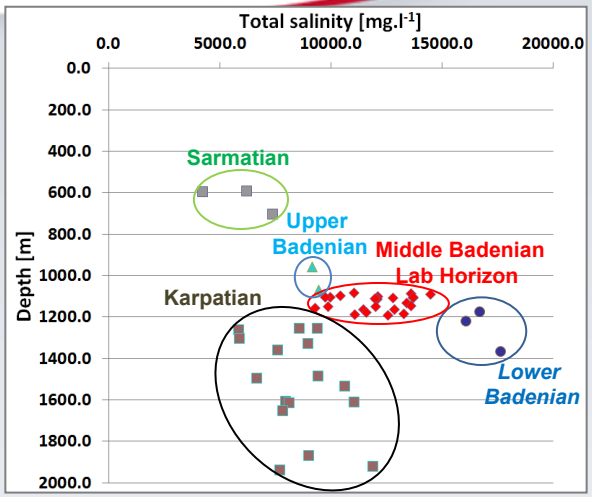
Steady State Temperature (C) with measured depth (m) based on measurements in wells in the LBr1

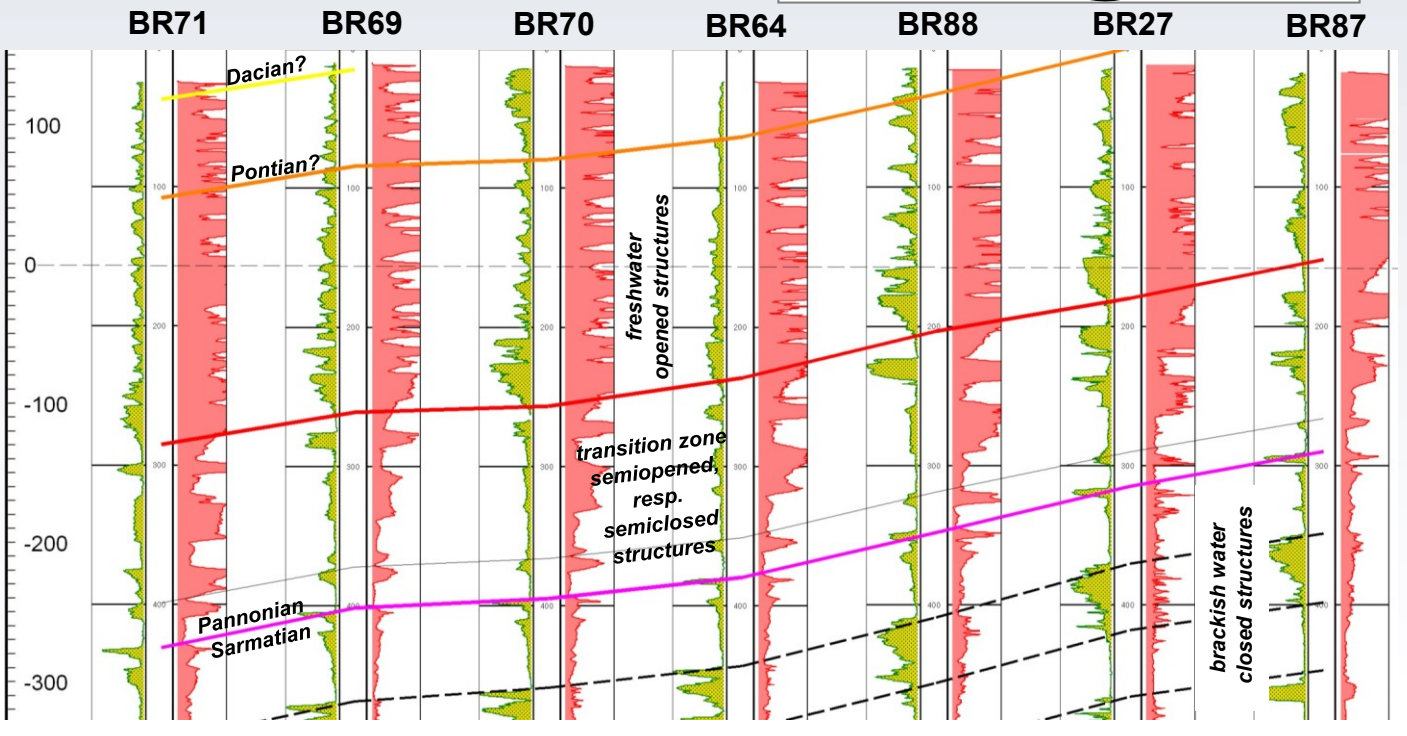


Hydrogeochemical Model of saline and freshwater zones

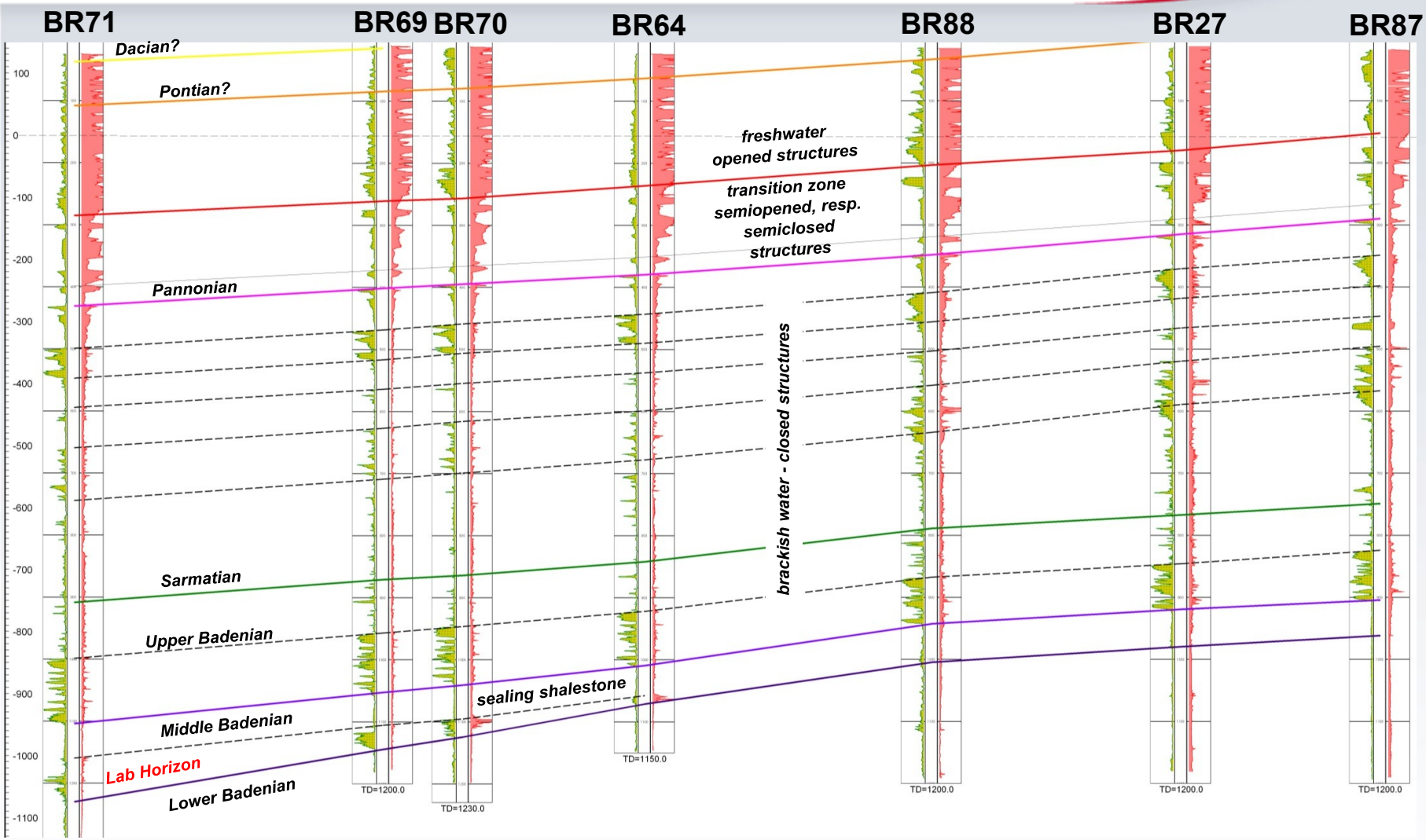


Map of the brines – freshwater transition zone





Hydrogeochemical zones with brines and freshwater in the LBr-1 overburden

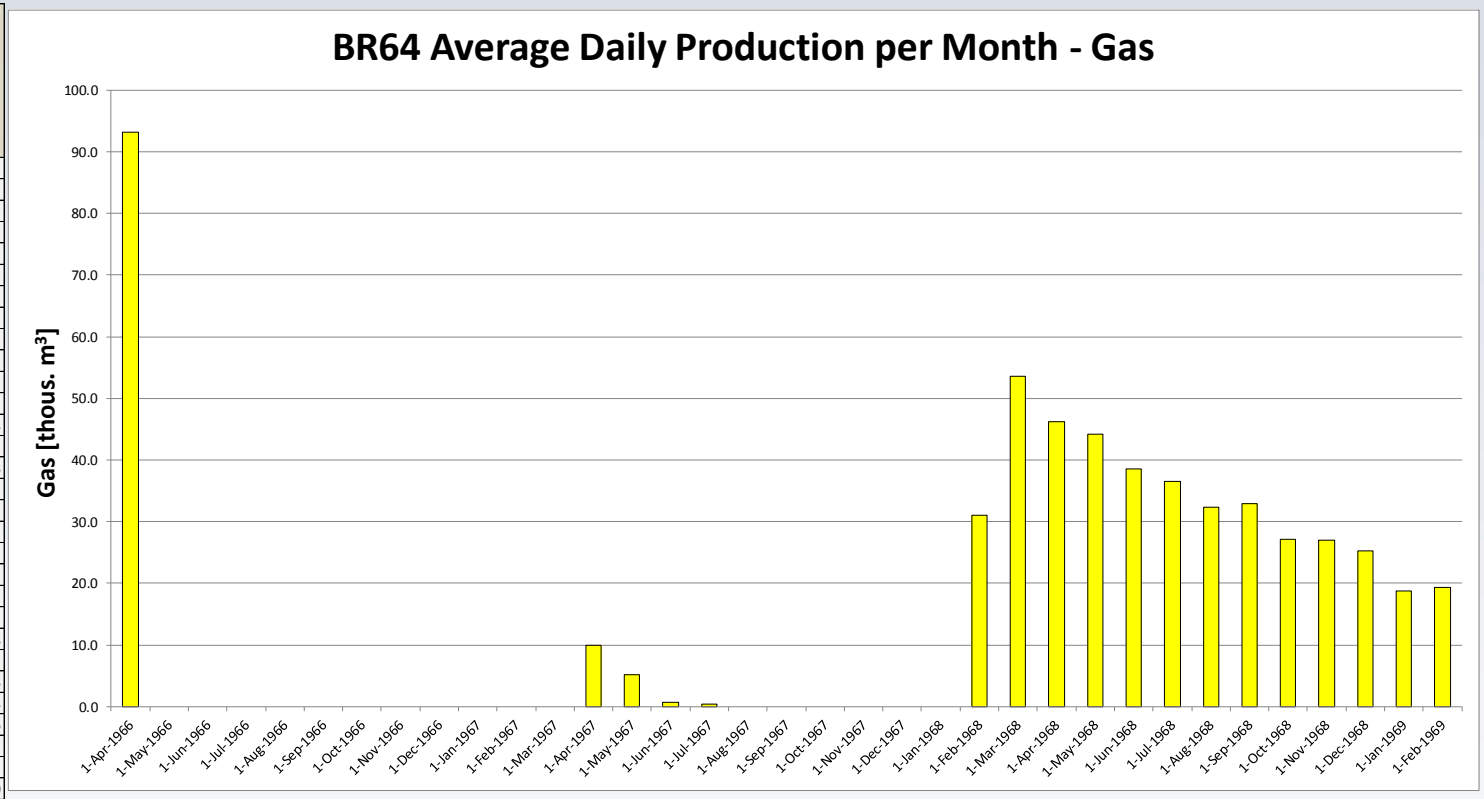


Total salinity: freshwater – to 1 000 mg.l^{-1}, transition zone – from 1 000 to 3 000 mg.l^{-1}, brackish water – over 3 000 mg.l^{-1}

Data for Dynamic modeling and History Matching

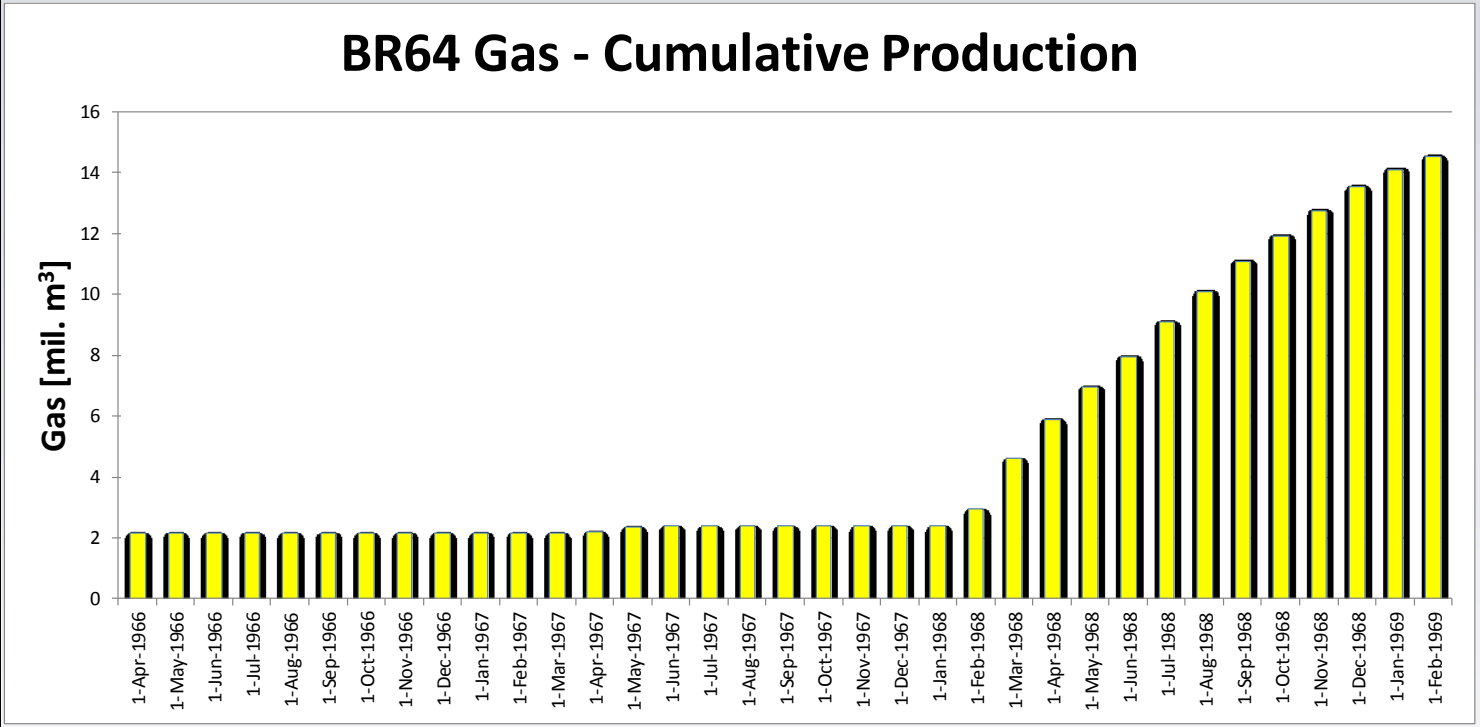
Production, pressure and test data - individual wells

Well	Date	Average Gas Daily Production per Month [thous. m^3]	Number of Production Days
BR64	1-Apr-1966	93182.2	23
BR64	1-May-1966		
BR64	1-Jun-1966		
BR64	1-Jul-1966		
BR64	1-Aug-1966		
BR64	1-Sep-1966		
BR64	1-Oct-1966		
BR64	1-Nov-1966		
BR64	1-Dec-1966		
BR64	1-Jan-1967		
BR64	1-Feb-1967		
BR64	1-Mar-1967		
BR64	1-Apr-1967	9875.0	4
BR64	1-May-1967	5171.0	31
BR64	1-Jun-1967	621.4	28
BR64	1-Jul-1967	458.3	12
BR64	1-Aug-1967		
BR64	1-Sep-1967		
BR64	1-Oct-1967		
BR64	1-Nov-1967		
BR64	1-Dec-1967		
BR64	1-Jan-1968		
BR64	1-Feb-1968	30994.4	18
BR64	1-Mar-1968	53625.8	31
BR64	1-Apr-1968	46185.7	28
BR64	1-May-1968	44233.3	24
BR64	1-Jun-1968	38546.2	26
BR64	1-Jul-1968	36480.6	31
BR64	1-Aug-1968	32367.7	31
BR64	1-Sep-1968	32976.7	30
BR64	1-Oct-1968	27193.5	31
BR64	1-Nov-1968	27006.7	30
BR64	1-Dec-1968	25306.5	31
BR64	1-Jan-1969	18800.0	31
BR64	1-Feb-1969	19371.4	21



Production data – Br-64 GAS

Well	Date	Gas - Cummulative Production [m3]
BR64	1-Apr-1966	2143191
BR64	1-May-1966	2143191
BR64	1-Jun-1966	2143191
BR64	1-Jul-1966	2143191
BR64	1-Aug-1966	2143191
BR64	1-Sep-1966	2143191
BR64	1-Oct-1966	2143191
BR64	1-Nov-1966	2143191
BR64	1-Dec-1966	2143191
BR64	1-Jan-1967	2143191
BR64	1-Feb-1967	2143191
BR64	1-Mar-1967	2143191
BR64	1-Apr-1967	2182691
BR64	1-May-1967	2342991
BR64	1-Jun-1967	2360391
BR64	1-Jul-1967	2365891
BR64	1-Aug-1967	2365891
BR64	1-Sep-1967	2365891
BR64	1-Oct-1967	2365891
BR64	1-Nov-1967	2365891
BR64	1-Dec-1967	2365891
BR64	1-Jan-1968	2365891
BR64	1-Feb-1968	2923791
BR64	1-Mar-1968	4586191
BR64	1-Apr-1968	5879391
BR64	1-May-1968	6940991
BR64	1-Jun-1968	7943191
BR64	1-Jul-1968	9074091
BR64	1-Aug-1968	10077491
BR64	1-Sep-1968	11066791
BR64	1-Oct-1968	11909791
BR64	1-Nov-1968	12719991
BR64	1-Dec-1968	13504491
BR64	1-Jan-1969	14087291
BR64	1-Feb-1969	14494091

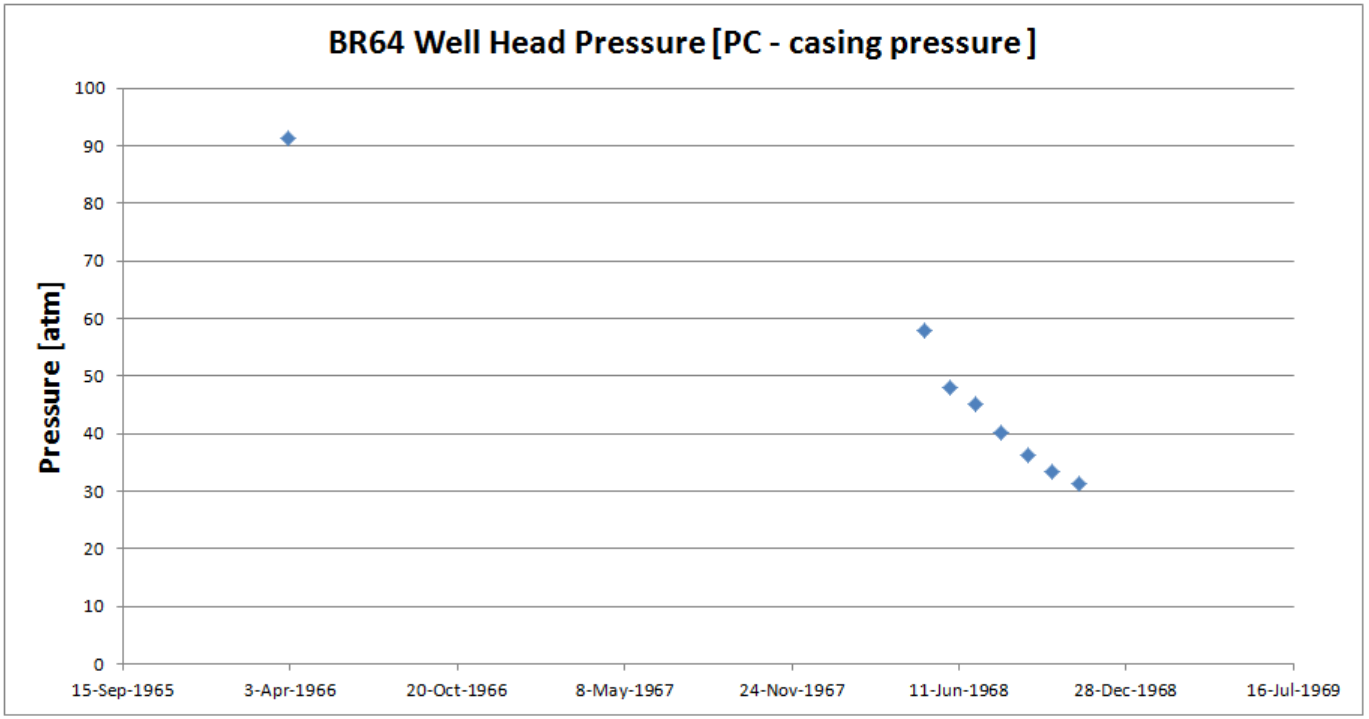


Pressure - individual well data with time

Well	Date	Well Head Pressure [PC - casing pressure] [atm]
BR64	1-Apr-1966	91.23
BR64	1-May-1966	
BR64	1-Jun-1966	
BR64	1-Jul-1966	
BR64	1-Aug-1966	
BR64	1-Sep-1966	
BR64	1-Oct-1966	
BR64	1-Nov-1966	
BR64	1-Dec-1966	
BR64	1-Jan-1967	
BR64	1-Feb-1967	
BR64	1-Mar-1967	
BR64	1-Apr-1967	
BR64	1-May-1967	
BR64	1-Jun-1967	
BR64	1-Jul-1967	
BR64	1-Aug-1967	
BR64	1-Sep-1967	
BR64	1-Oct-1967	
BR64	1-Nov-1967	
BR64	1-Dec-1967	
BR64	1-Jan-1968	
BR64	1-Feb-1968	
BR64	1-Mar-1968	
BR64	1-Apr-1968	
BR64	1-May-1968	57.89
BR64	1-Jun-1968	48.08
BR64	1-Jul-1968	45.14
BR64	1-Aug-1968	40.24
BR64	1-Sep-1968	36.31
BR64	1-Oct-1968	33.37
BR64	1-Nov-1968	31.41
BR64	1-Dec-1968	
BR64	1-Jan-1969	
BR64	1-Feb-1969	

Perforation depth 1066-1070 m, 11 Nov 1957

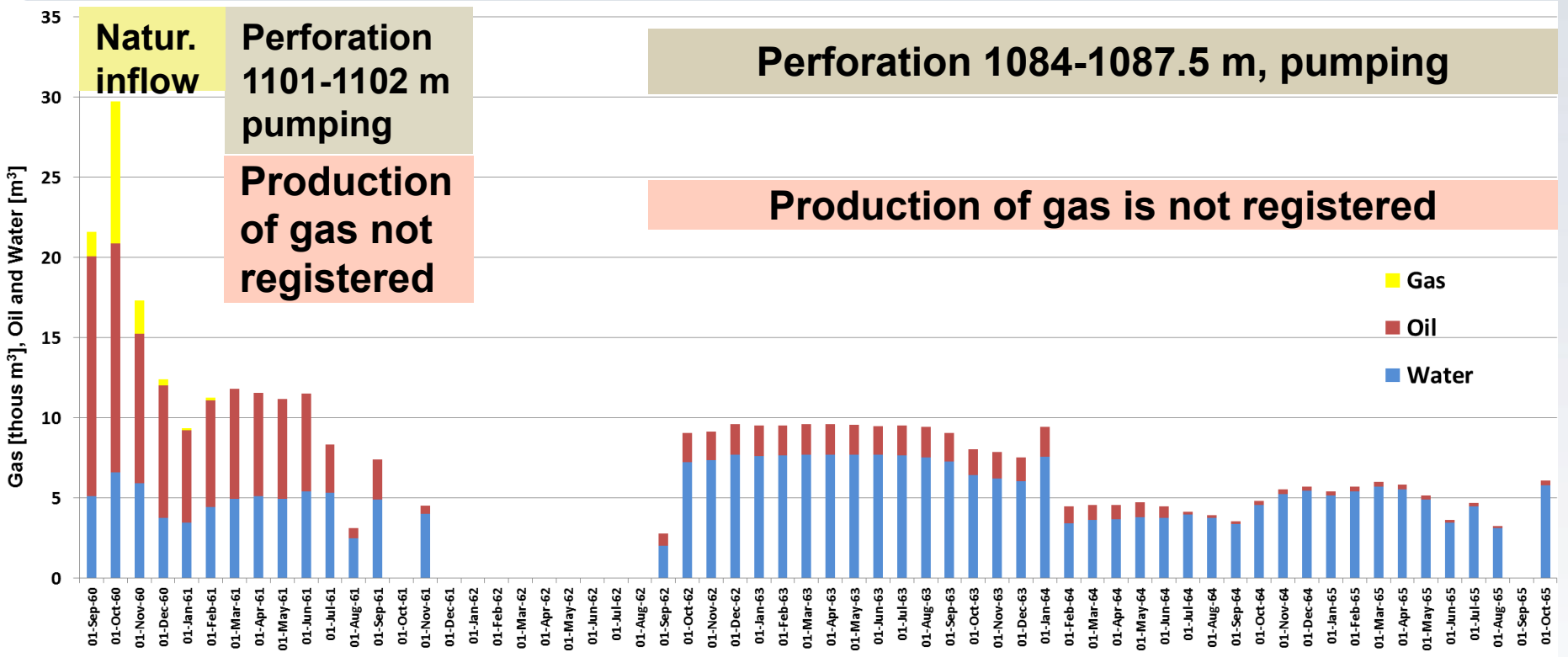
Casing pressure 110 atm, Tubing pressure 120 atm



15 Sep 1957

16 Jul 1969

Average daily production per month - well Br-89

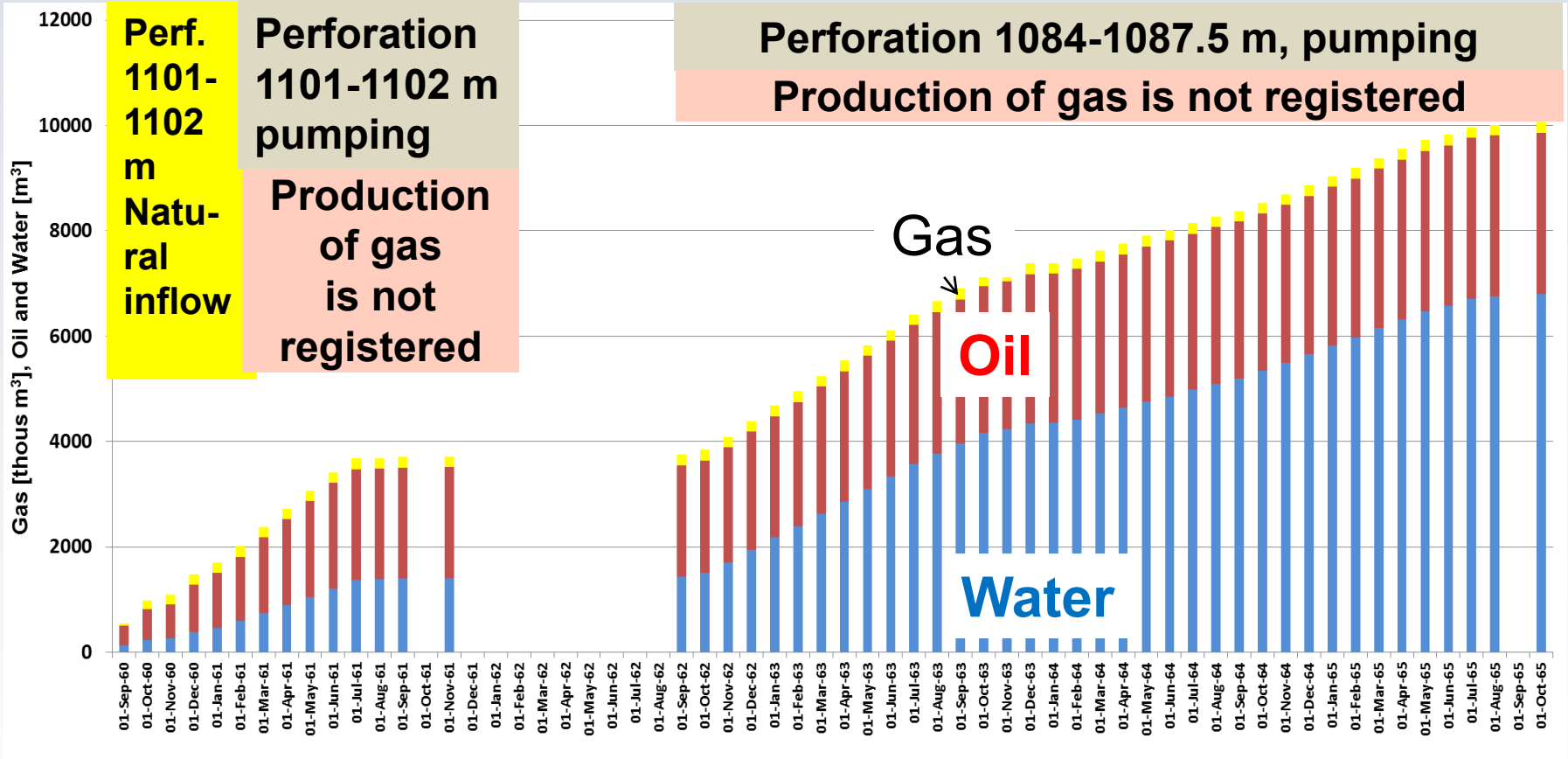


Sep 1960

Perforation 1101-1102 m natural inflow

Oct 1965

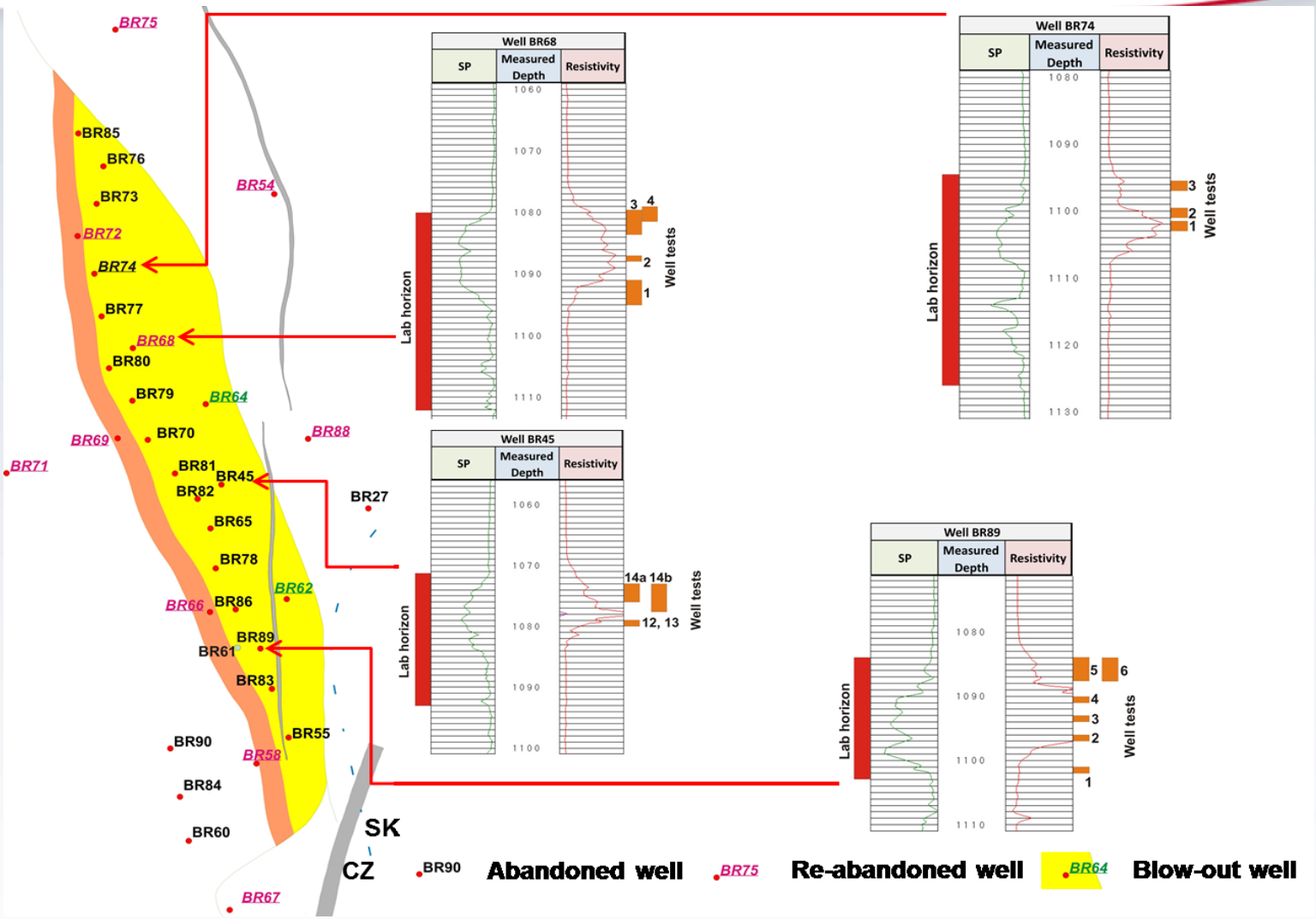
Cummulative production well BR 89



Sep 1960

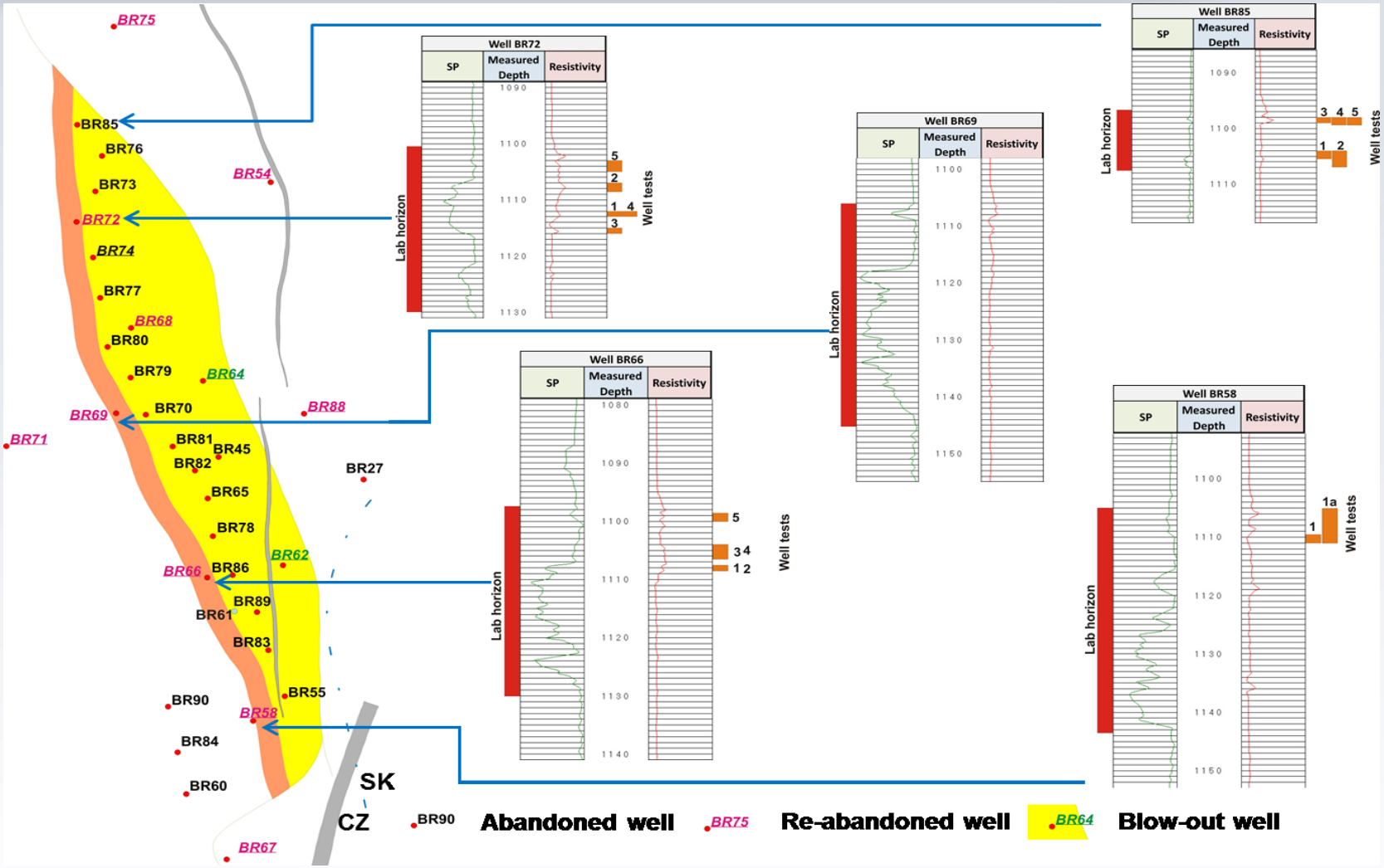
Oct 1965

Proposal for injection and monitoring



Návrh vtlačných (injektážních) vrtů **Proposed injection wells**

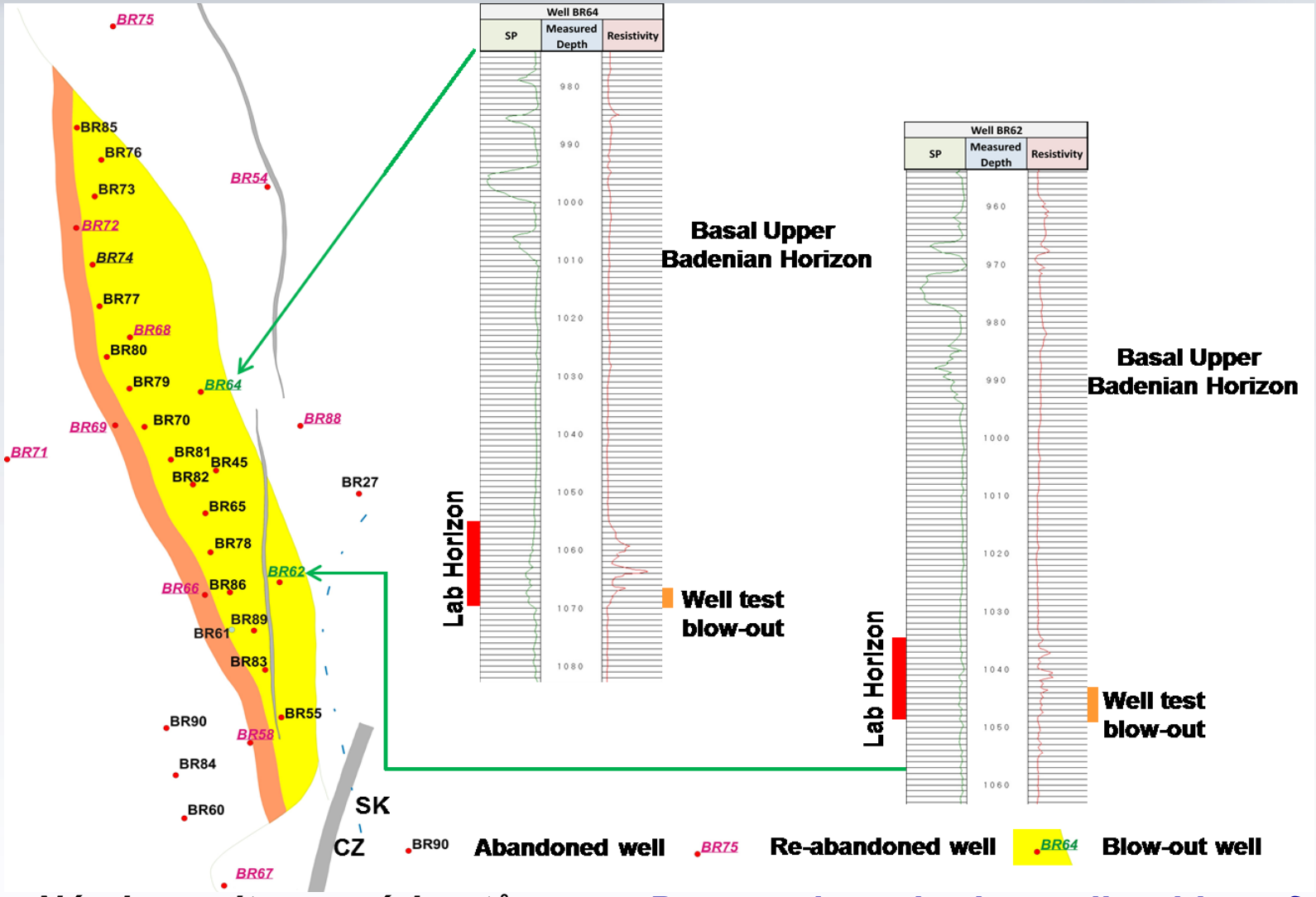
Proposal for injection and monitoring at **reservoir** level



Návrh monitorovacích vrtů na úrovni lábského obzoru

Proposed monitoring wells at the Láb reservoir level

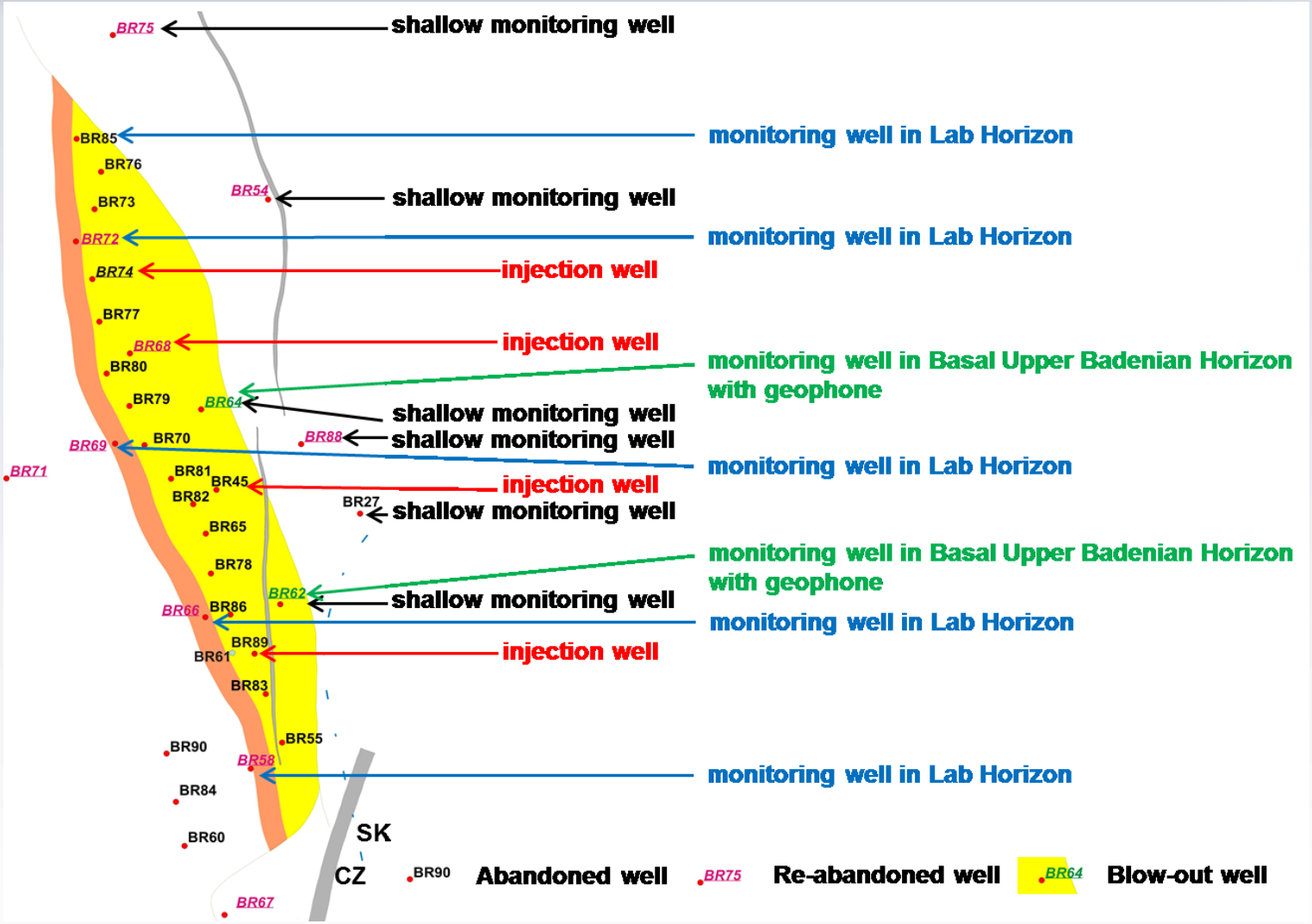
Proposal for injection and monitoring above the seal



Návrh monitorovacích vrtů v bazálním obzoru svrchního badenu

Proposed monitoring wells with perforation in the Basal sand of the Upper Badenian

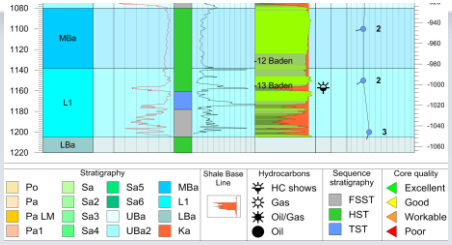
Proposal for injection and monitoring

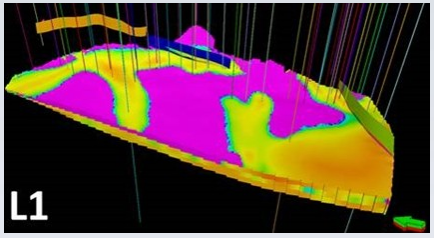


Komplexní návrh vtlačných, hlubokých a mělkých monitorovacích vrtů

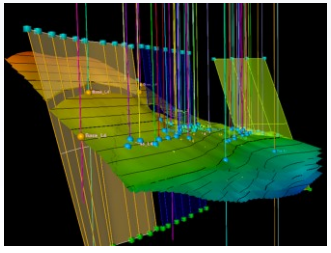
Proposed system of injection and deep & shallow monitoring wells

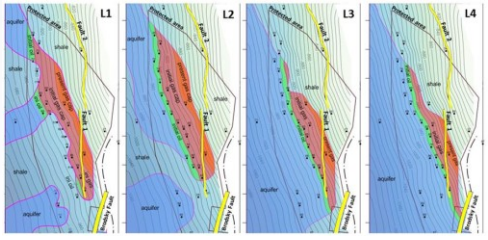
Conclusions

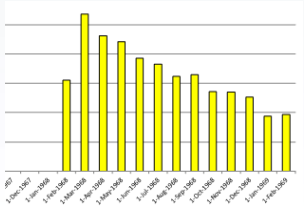


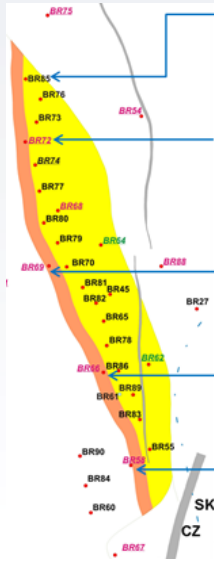


1. New stratigraphy
2. 3D Reservoir & seal properties
3. Database on gas pressure & Production history from individual wells for Dynamic Modeling
4. Well completion after abandonment in GIS for Risk Analysis
5. Proposal of injection and monitoring wells









Thank you for your attention