# Structure of the East European Craton and its contact with Alpides

- cooperation with Institute of Geophysics NASU, Ukraine
(GEORIFT 2013 and RomUkrSeis experiments)

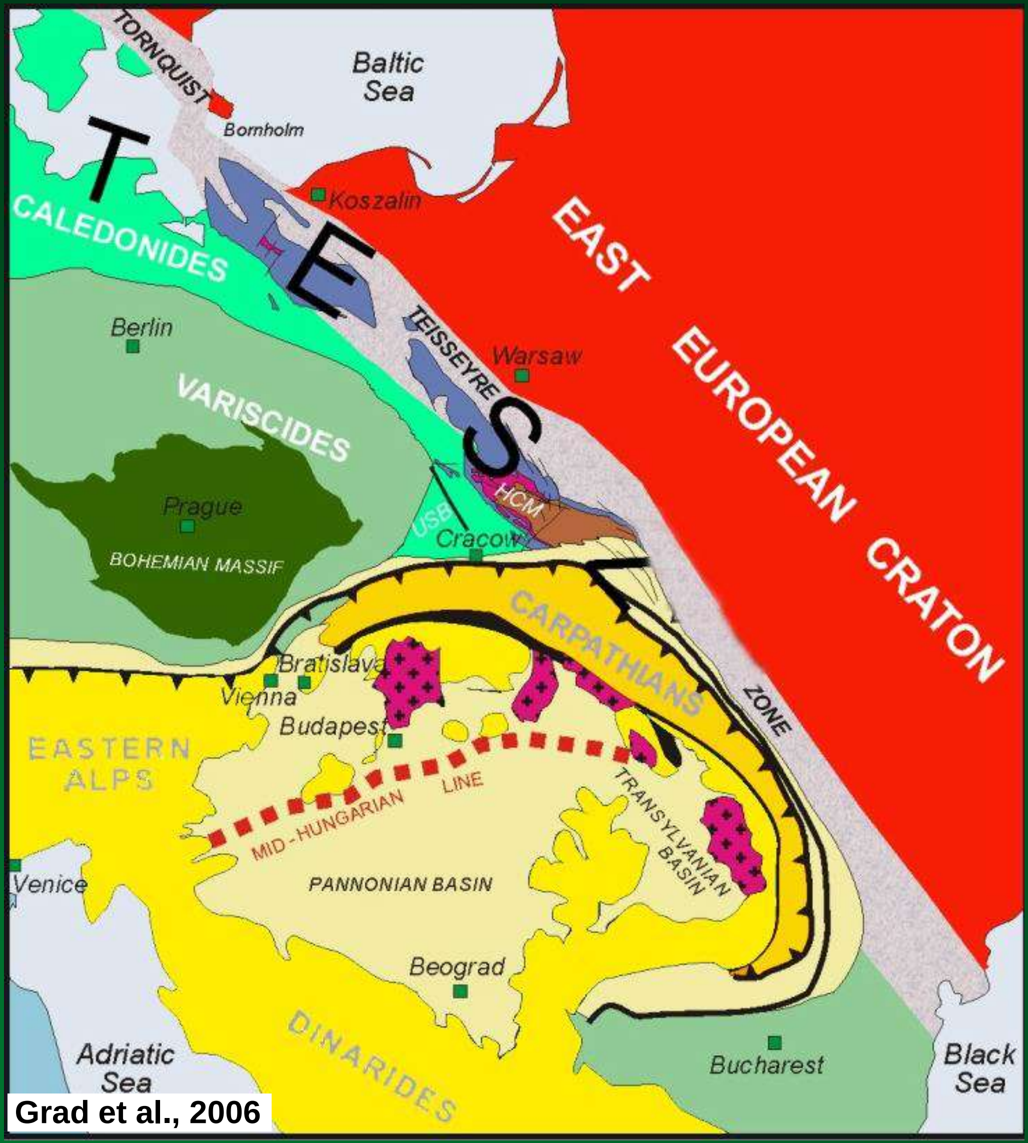

***Piotr Środa***

*and*

*Department of Seismic Lithospheric Research, IGF PAS*


**IGF PAN, 2019**

# TECTONIC MAP OF CENTRAL EUROPE




Grad et al., 2006

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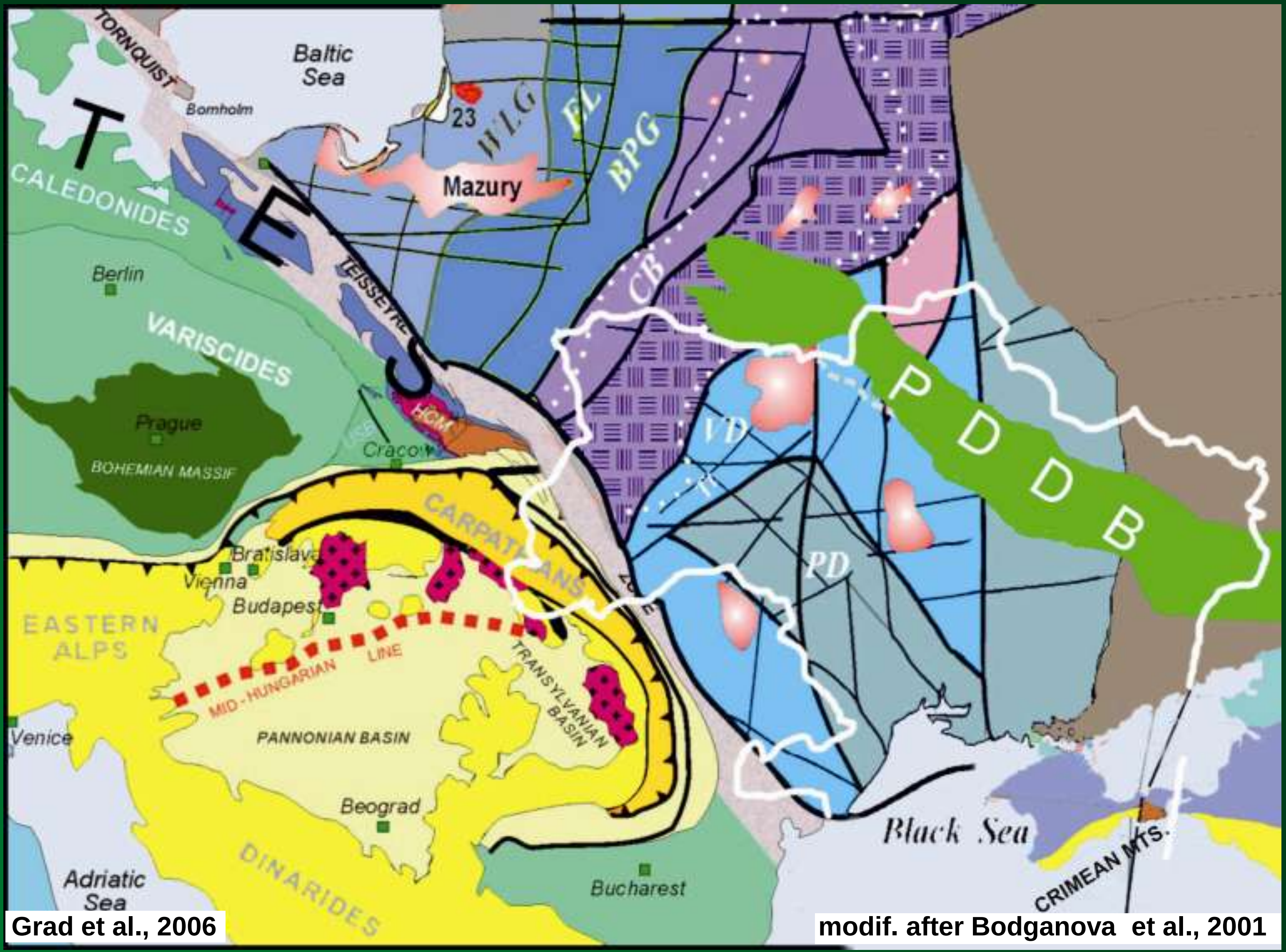

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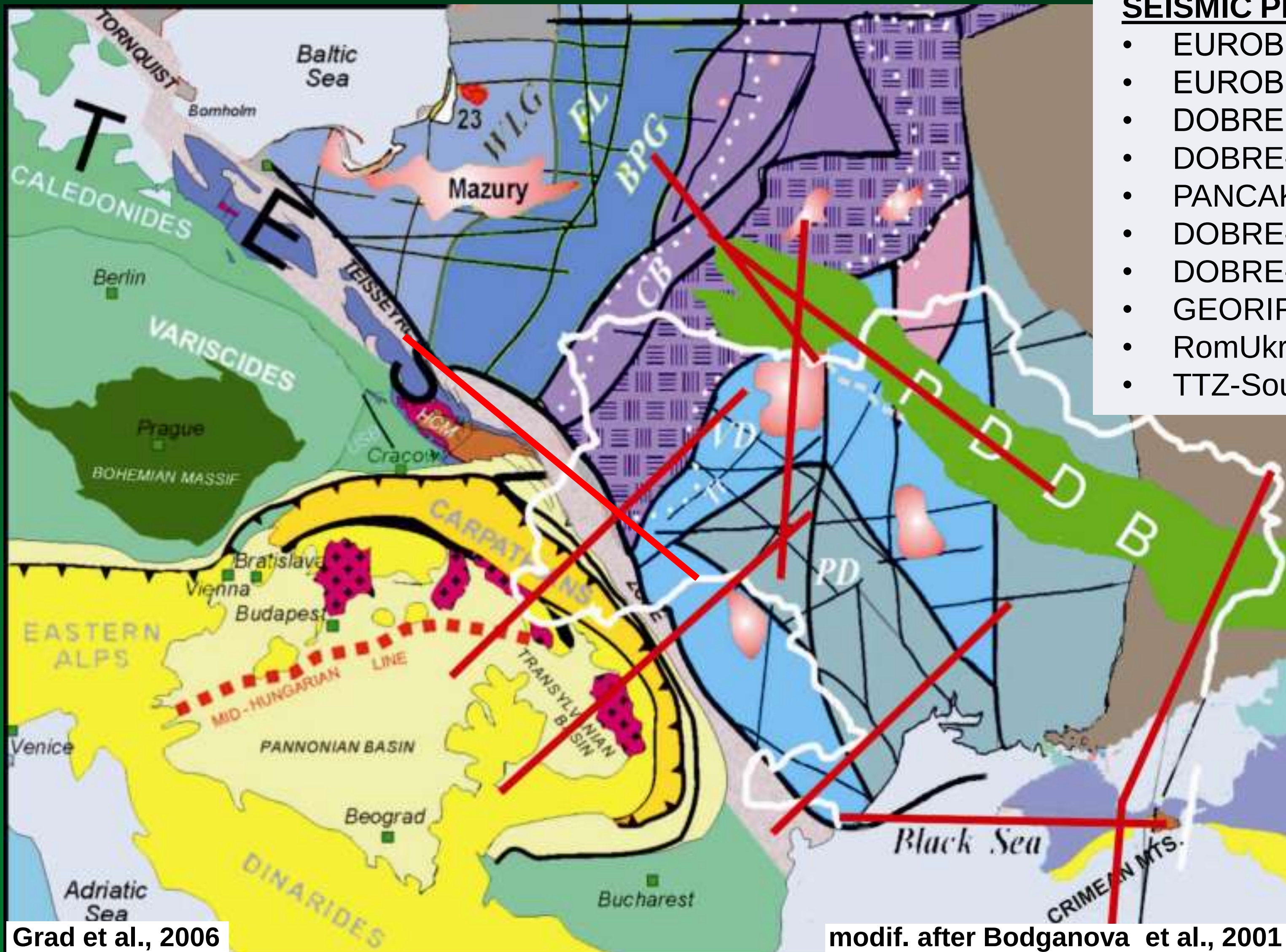


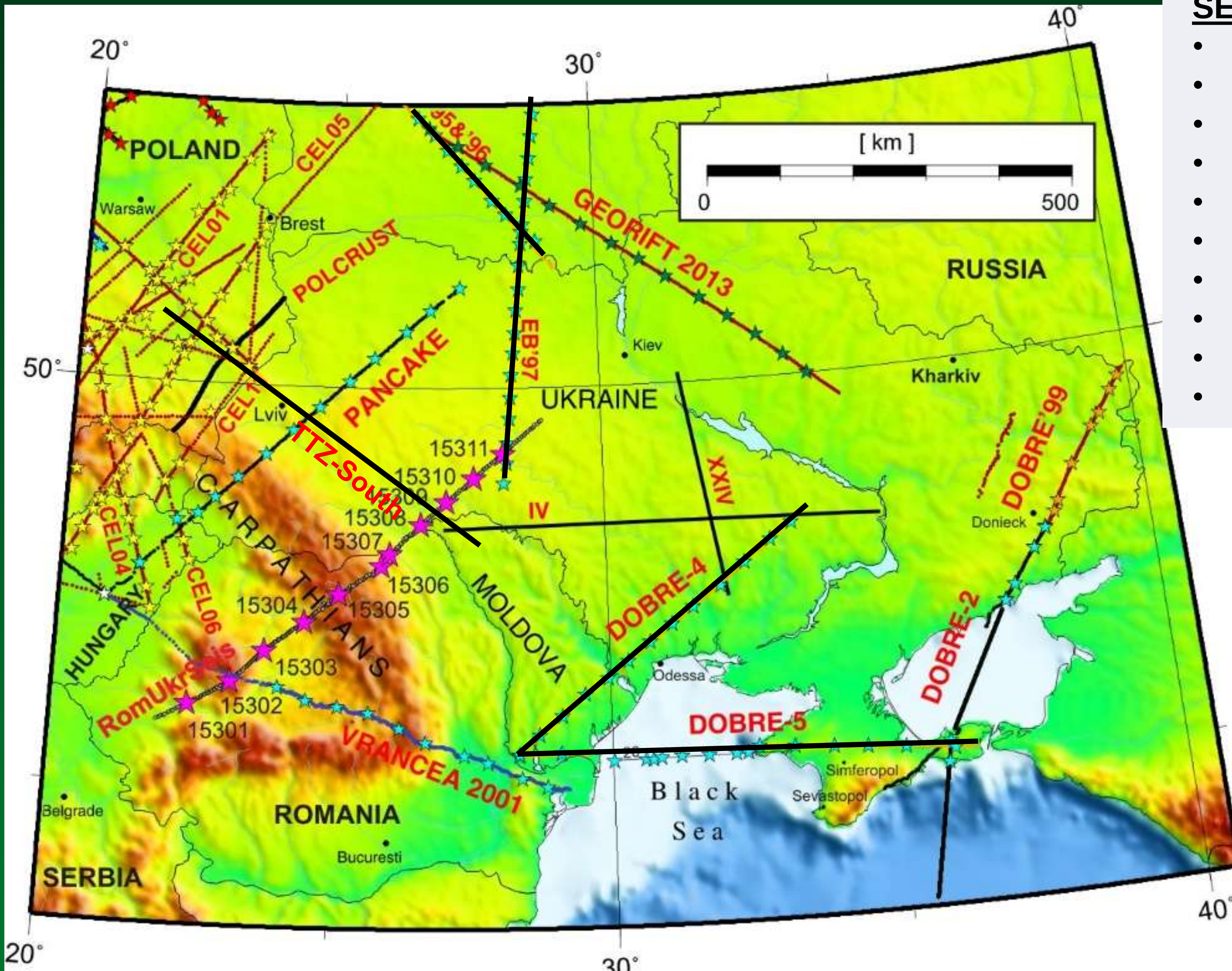

Grad et al., 2006

modif. after Bodganova et al., 2001

**SEISMIC PROFILES:**

- EUROBRIDGE '96
- EUROBRIDGE '97
- DOBRE '99
- DOBRE-2
- PANCAKE
- DOBRE-4
- DOBRE-5
- GEORIFT 2013
- RomUkrSeis 2014
- TTZ-South

# WIDE-ANGLE SEISMIC PROFILES IN SW PART OF THE EEC

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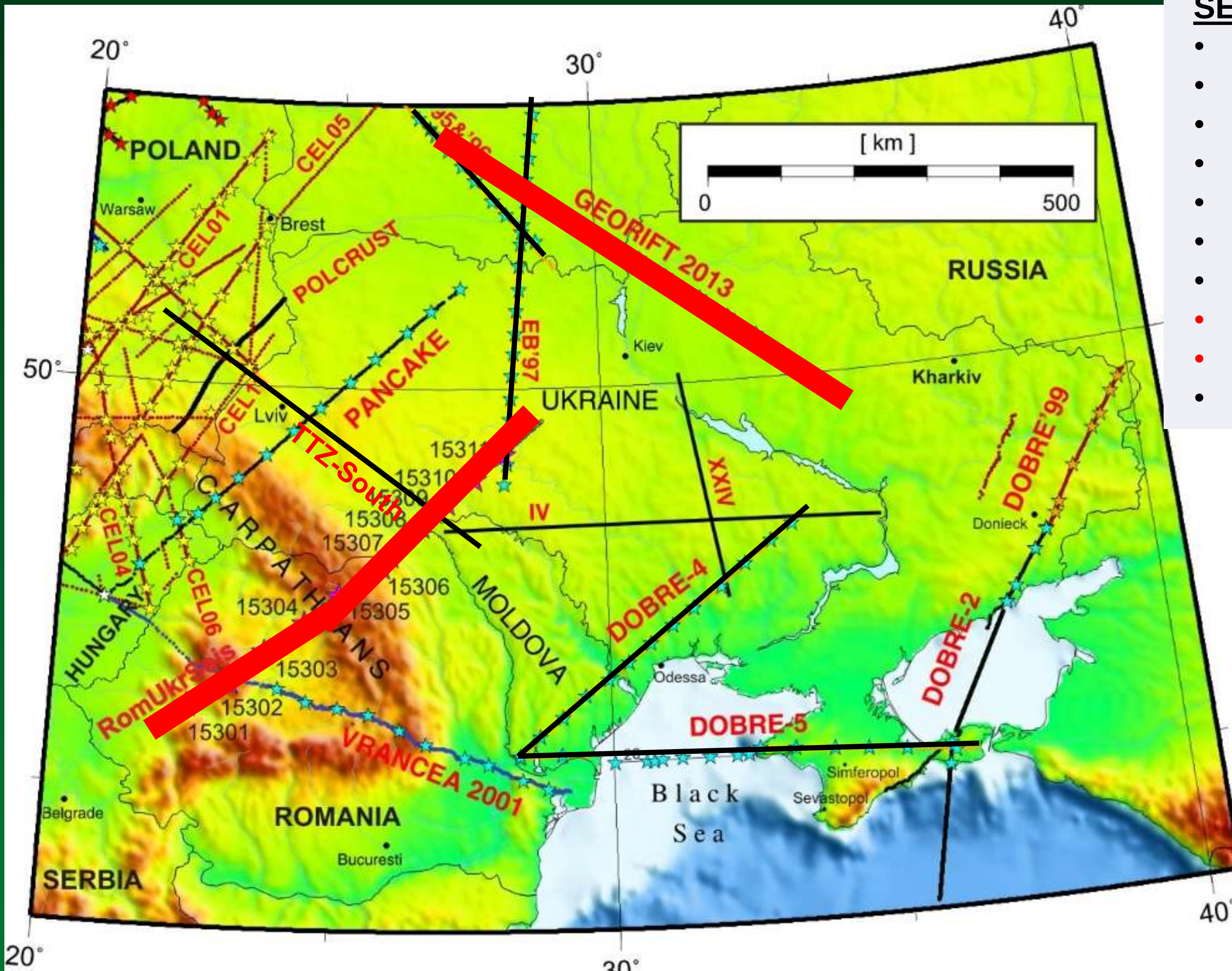
# WIDE-ANGLE SEISMIC PROFILES IN SW PART OF THE EEC

**Recent profiles (at various interpretation stage) presented:**

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- **GEORIFT 2013**
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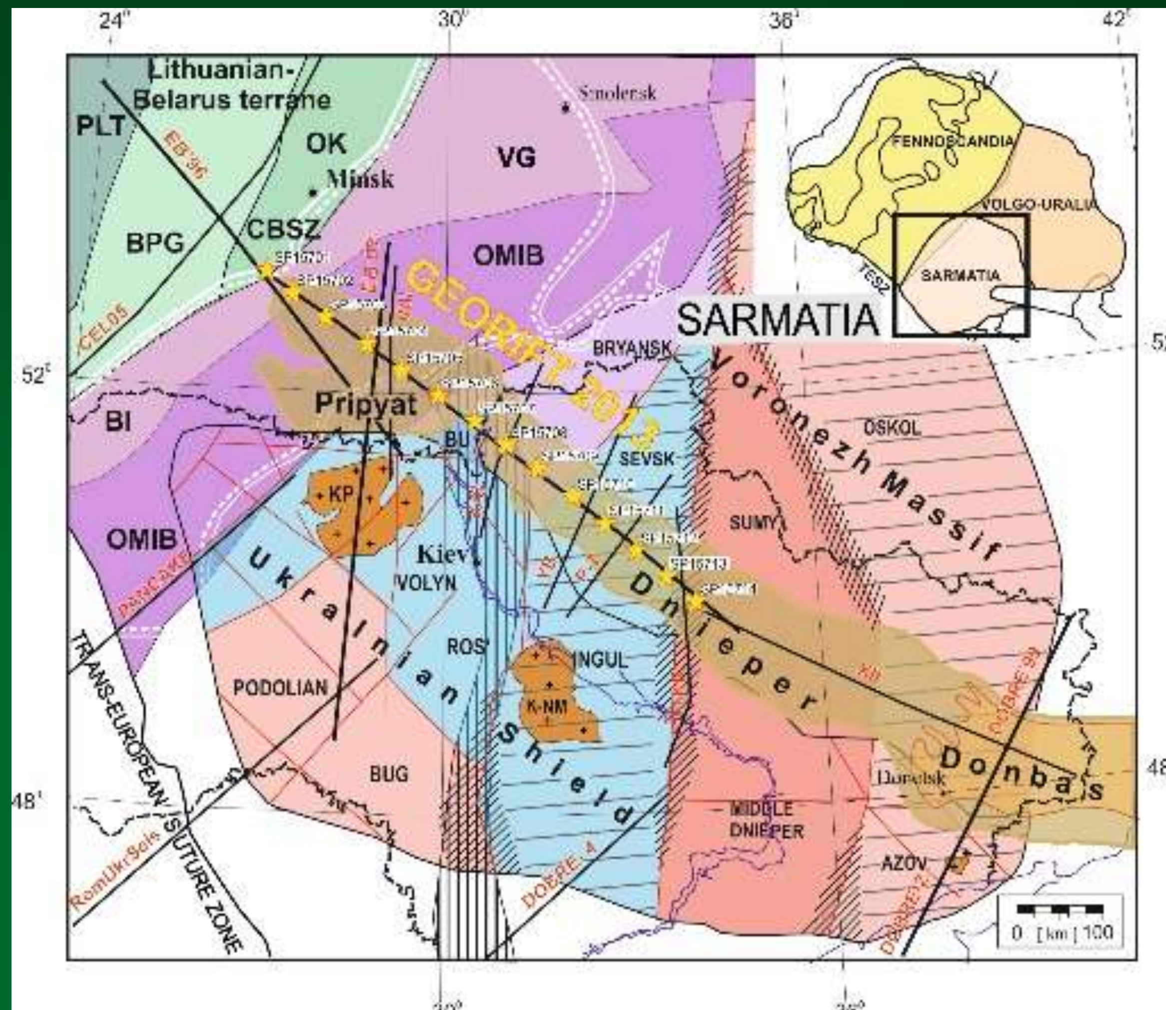
# GEORIFT 2013 seismic profile

**Lithospheric structure along Pripyat-Dnieper-Donets Basin (Belarus and Ukraine)**

**Contributing countries:**

- Ukraine
- Belarus
- Poland
- Finland
- Denmark

- 670 km profile length
- 14 shot points
- 309 1-C seismic recorders



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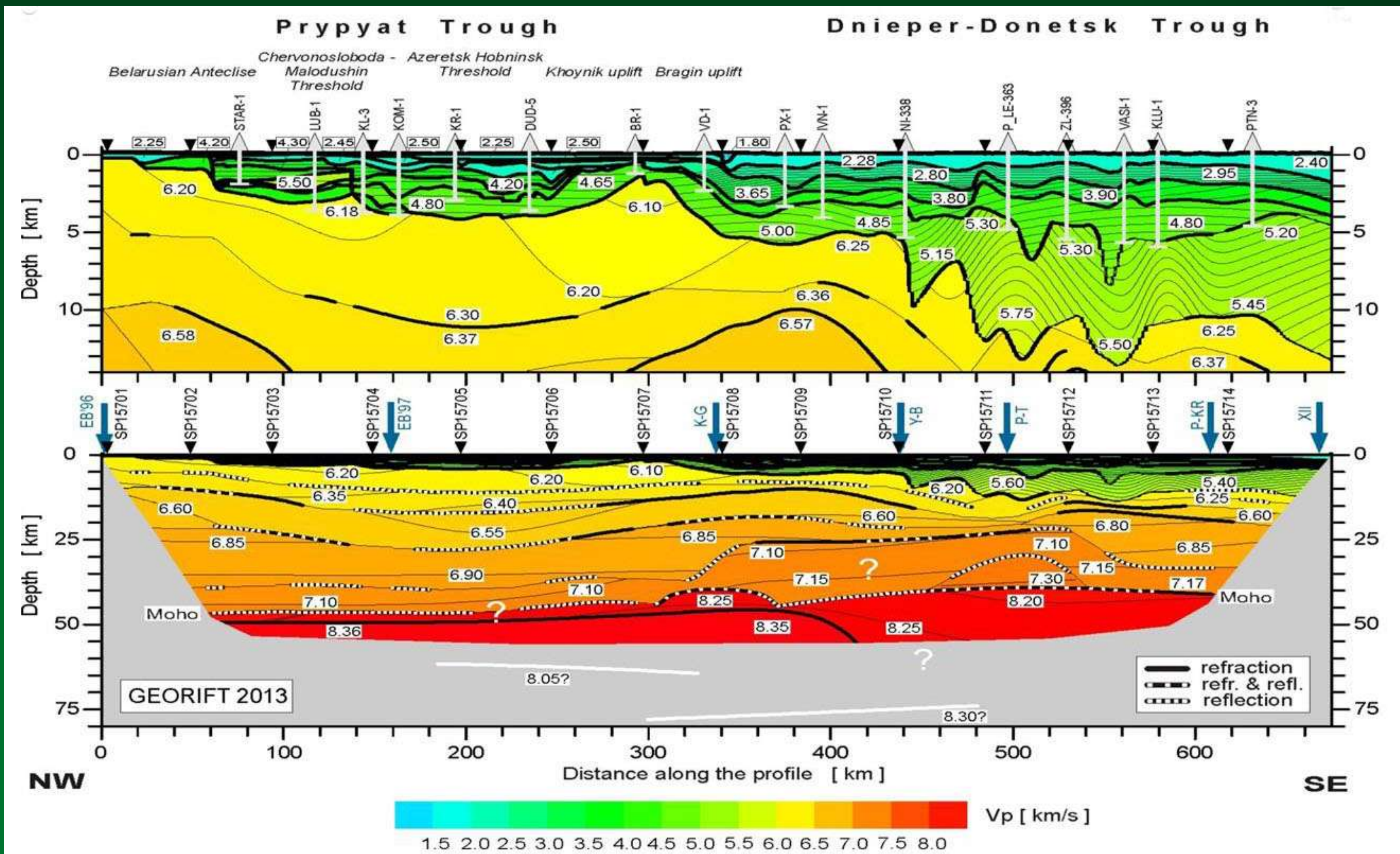
**Publication in GJI, 2018:**

Lithospheric structure along wide-angle seismic profile GEORIFT 2013 in Pripyat-Dnieper-Donets Basin (Belarus and Ukraine) – **Geophysical Journal International**, 2018, 212 (3), 1932–1962.



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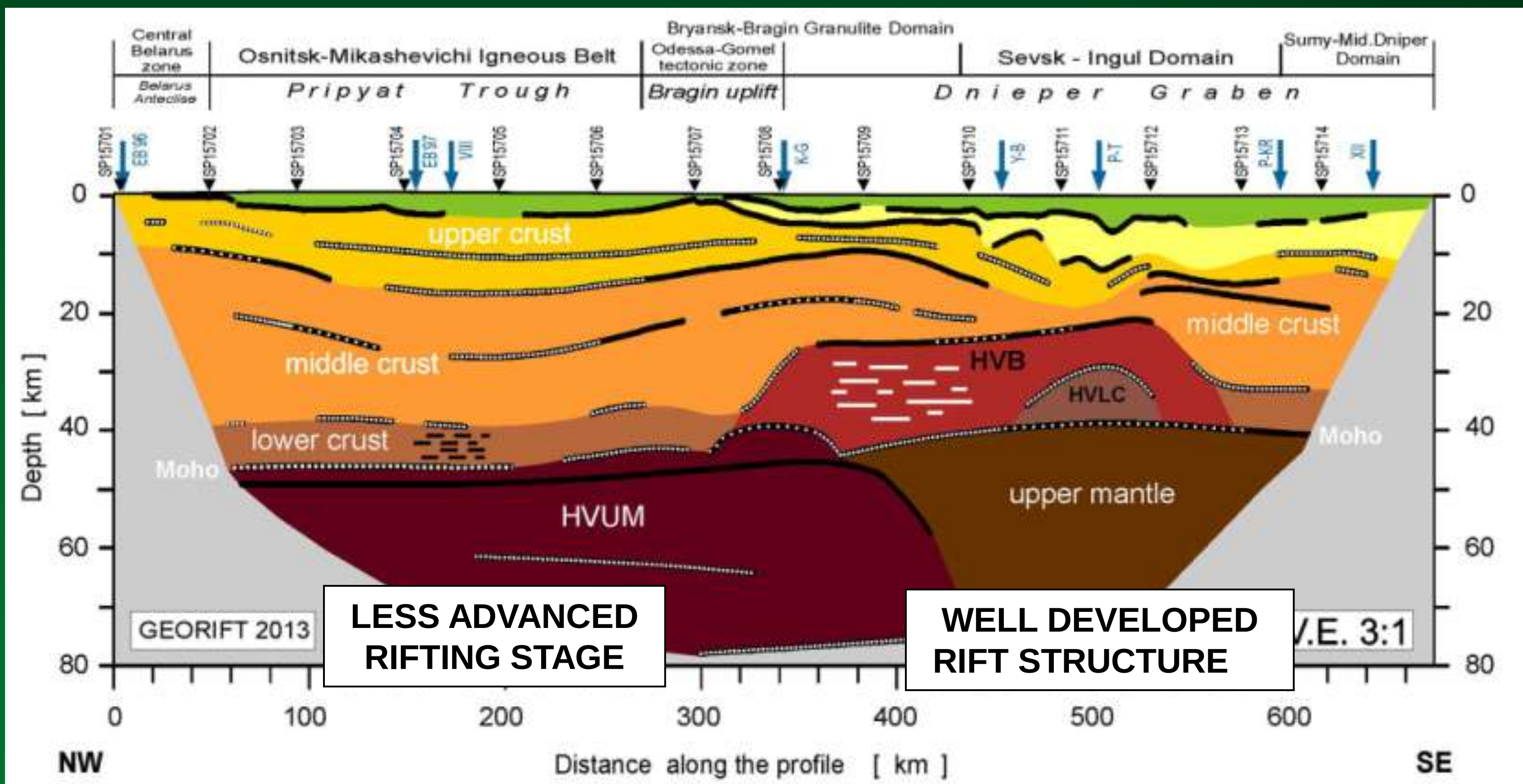
Lithospheric structure along wide-angle seismic profile GEORIFT 2013 in Pripyat-Dnieper-Donets Basin (Belarus and Ukraine) – **Geophysical Journal International**, 2018, 212 (3), 1932–1962.

## TECTONIC INTERPRETATION



# RomUkrSeis 2014 seismic profile

**Lithospheric structure across Apuseni mountains, Eastern Carpathians and EEC**

**(Manuscript in preparation)**

**Contributing countries:**

Ukraine - IG NASU, Kiev

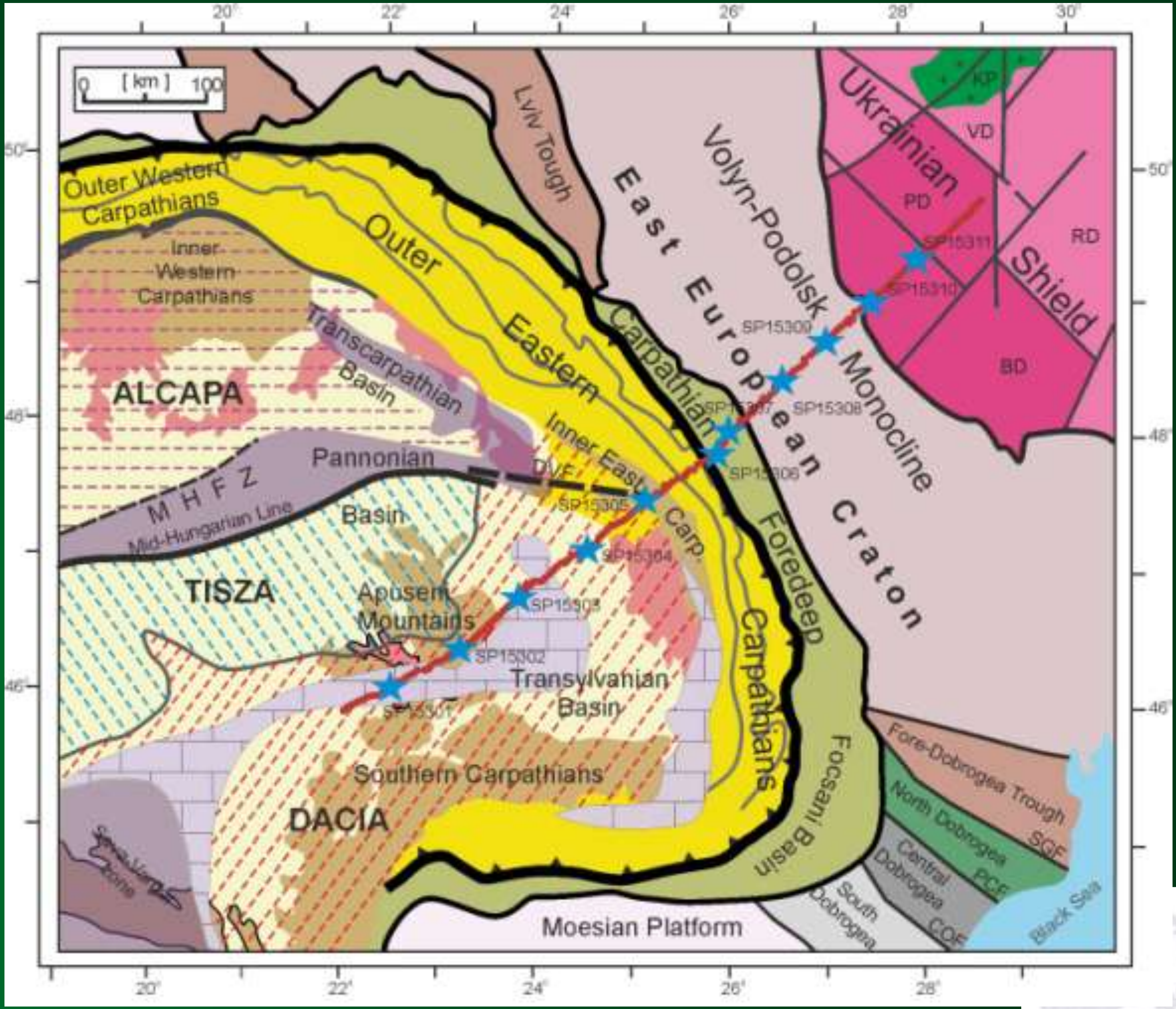
Romania - Univ. Of Bucharest

Poland - IGF PAN, Warsaw

UK, Scotland - Univ. of Aberdeen

Germany - GFZ Potsdam

- **675 km profile length**
- **11 shot points**
- **350 1-C seismic recorders**



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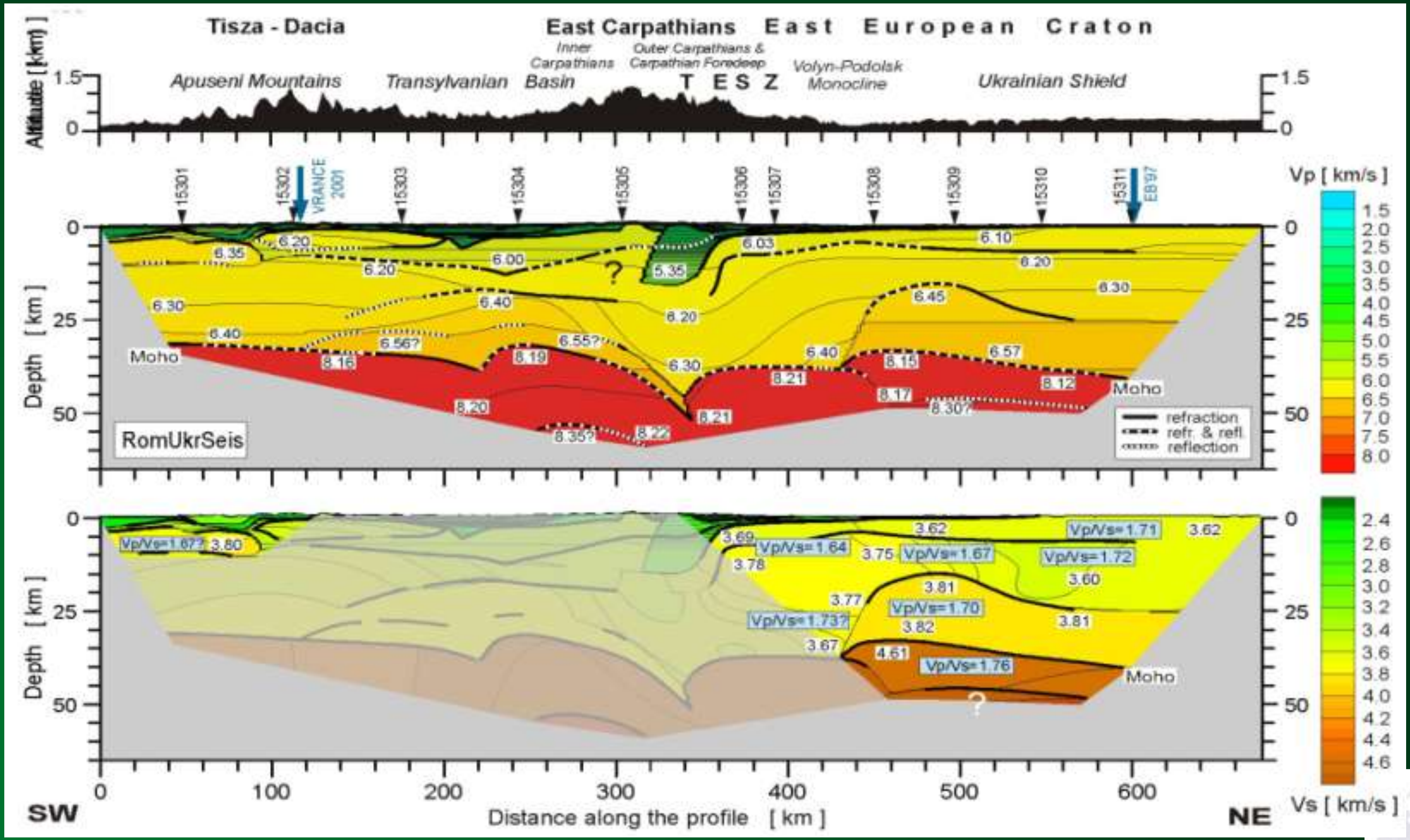
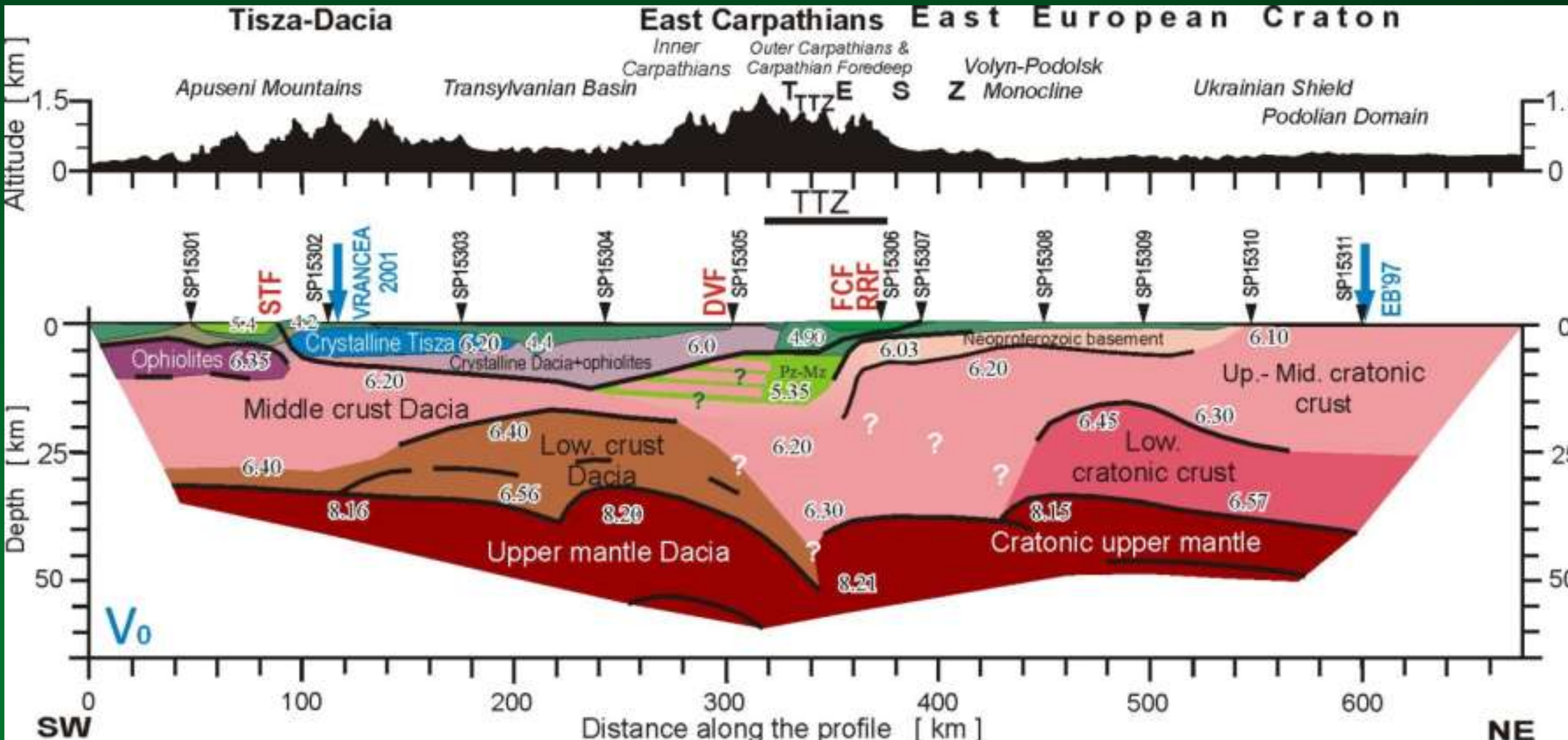


# RomUkrSeis 2014 seismic profile

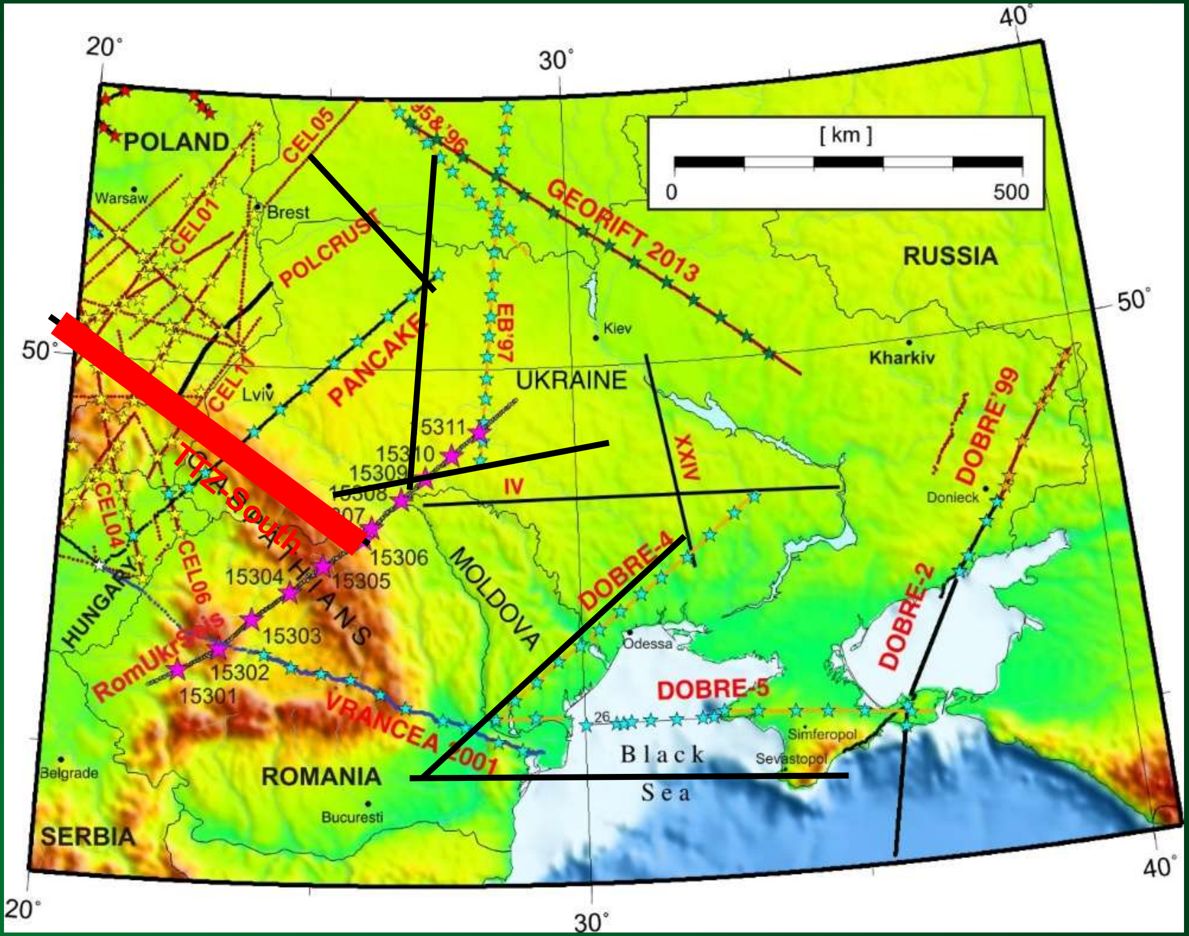
**Lithospheric structure across Apuseni mountains, Eastern Carpathians and EEC**

**(Manuscript in preparation)**

- Thick (~15 km) (meta)sedimentary wedge beneath E Carpathians
- Localized Moho depth anomaly beneath E Carpathians
- Anomalously low Vp (~6.3) in lower crust of EEC margin



# Thank you for attention




# Thank you for attention

# Deep Seismic Project TTZ-South

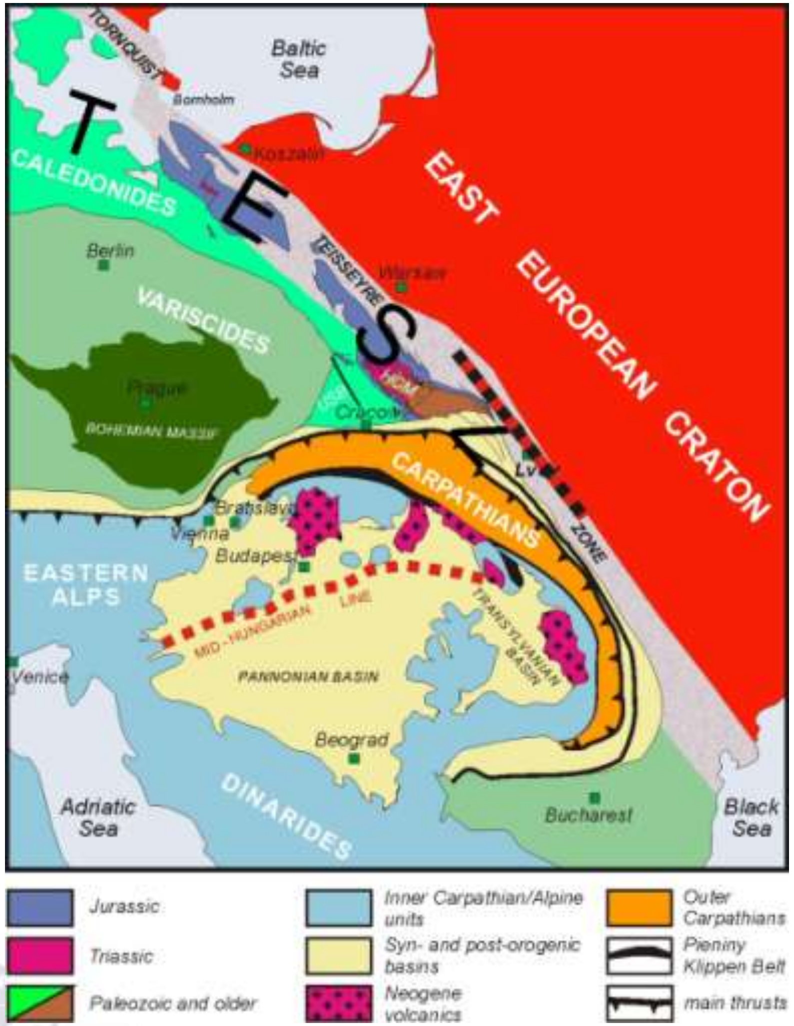
Statutory topic: **NSL1**

Department of Lithospheric Research

GFZ Helmholtz-Zentrum Potsdam

National Science Centre Poland

Institute of Geophysics Polish Academy of Sciences




# Project objectives of TTZ-South

- Determination of the structure along along the Teisseyre-Tornquist Zone (TTZ) in the region of southeastern Poland and western Ukraine

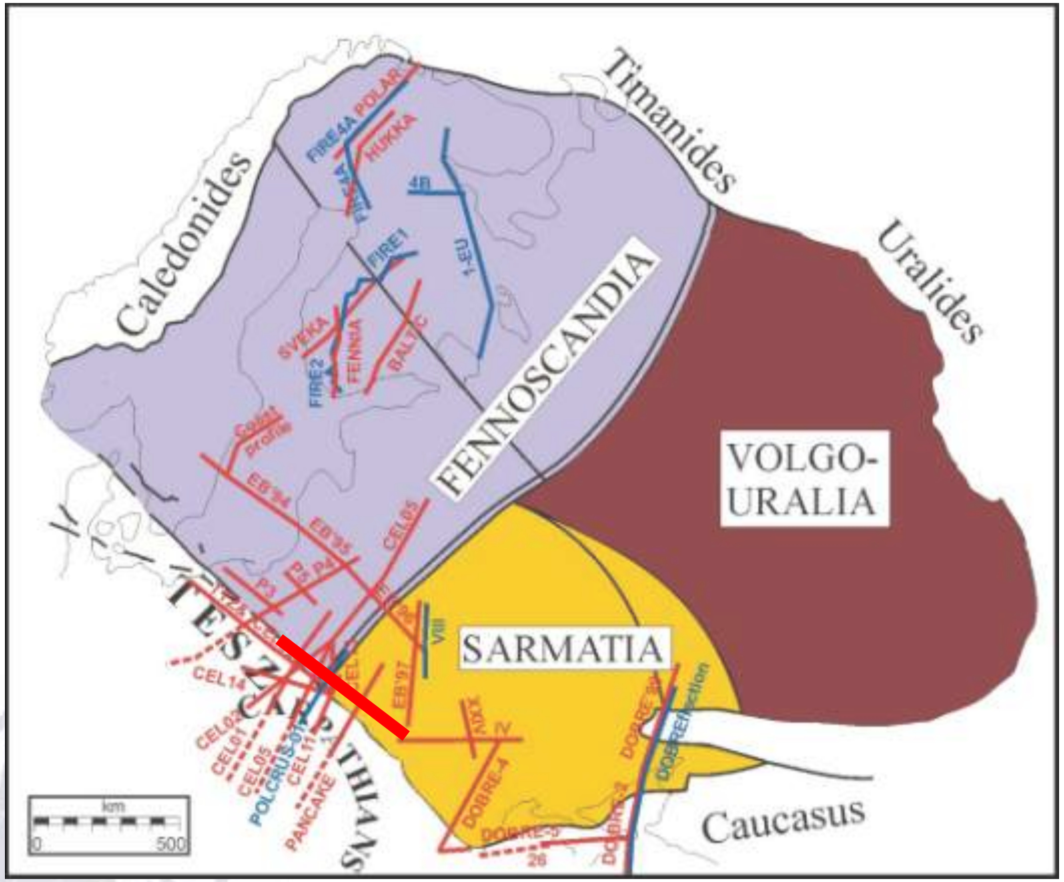
- Understanding of geodynamical processes which shaped the present structure of the lithosphere in this region of Central Europe

- Seismic profile TTZ-South crosses the region of high importance which is the contact between the three large geological systems of Europe:

  - East European Craton
  - Palaeozoic Platform
  - Alpine orogen (represented by Carpathians mountains).

**Fig.** 1. Location of the profile on the background of tectonic map of the Central Europe (Grad et al. 2006, JGR 111).
USB – upper Silesian block; HCM – Holly Cross Mountains;
TESZ – Trans-European Suture Zone. Stars represent shot points; dots - recording stations.

- TTZ-South profile crosses boundary of two main units of the EEC – Fennoscandia and Sarmatia.
- Previous seismic investigations were performed along Polish part of the TTZ (transect TTZ - CEL03) and profile TTZ-South it's an extension.



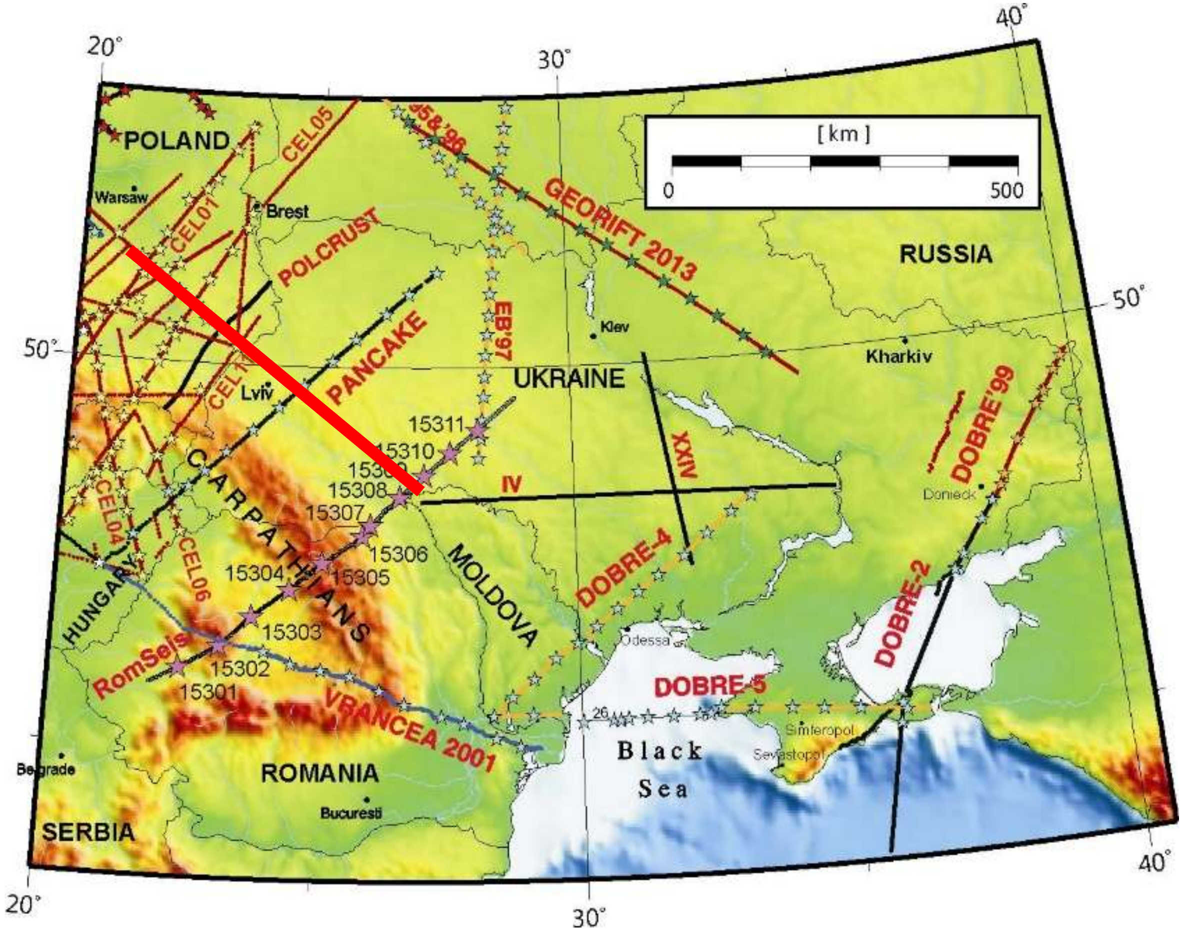




**Fig. 3.** Wide angle refraction & reflection deep seismic profiles in the project area.

**Fig. 2**. Major Paleproterozoic tectonic domains in the Baltic Sea area (Bogdanowa et.al. 2015 modified)

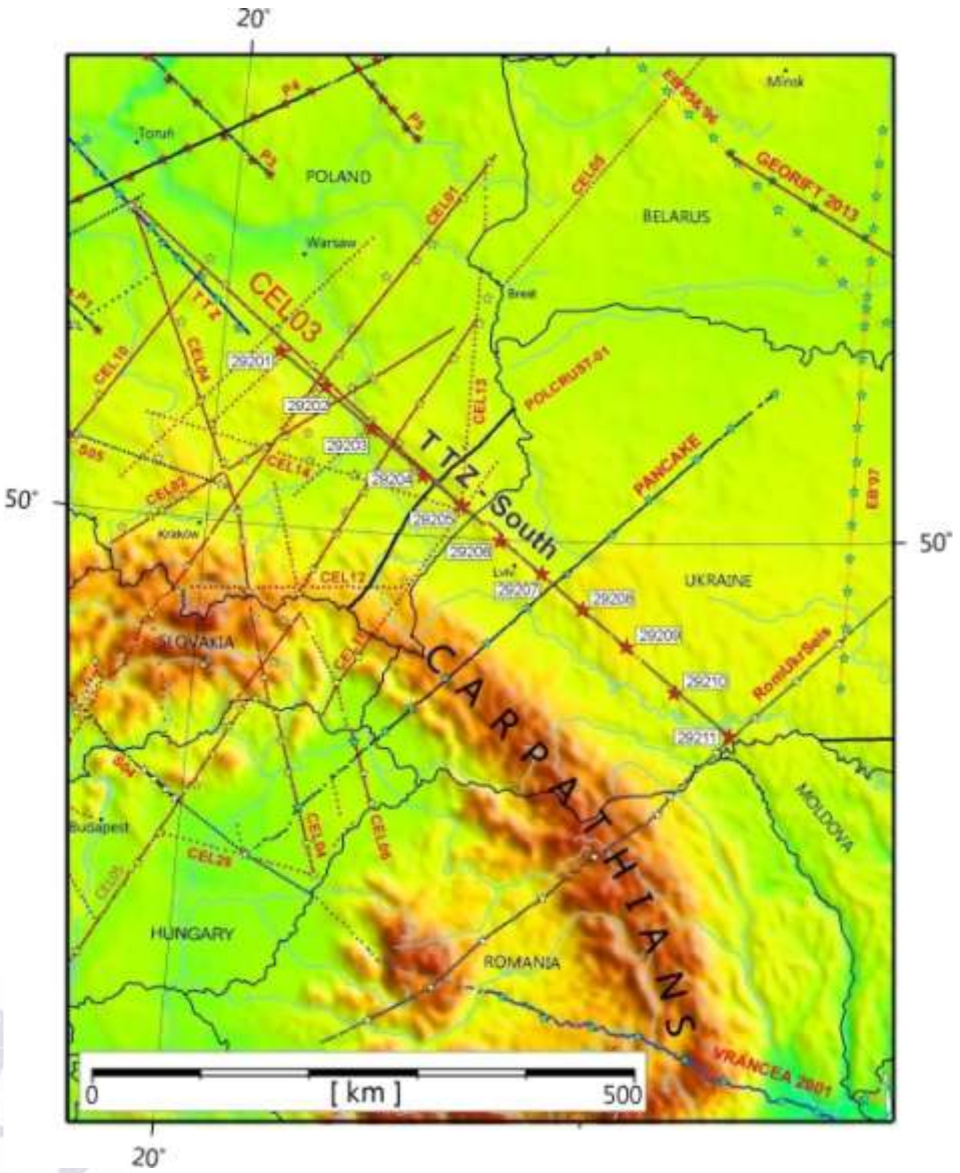



**Fig. 4.** Location of the composite of the TTZ-South profile and previous refraction seismic profiles in the study area. Stars represent shot points; dots - recording stations.

Institute of Geophysics
Polish Academy of Sciences

# Project TTZ-South

Cooperation with Institute of Geophysics National Academy of Sciences of Ukraine and GFZ Potsdam.

**Project preparation : >** 1.5 year

**Field measurements :** 7-14 September 2018

**Numer of shot points :** 11

Poland - 5

Ukraine - 6

**Number of field seismic stations :** ~320

**Profile length :** 545 km

Poland : ~240 km (overlaping the CEL03 Profile)

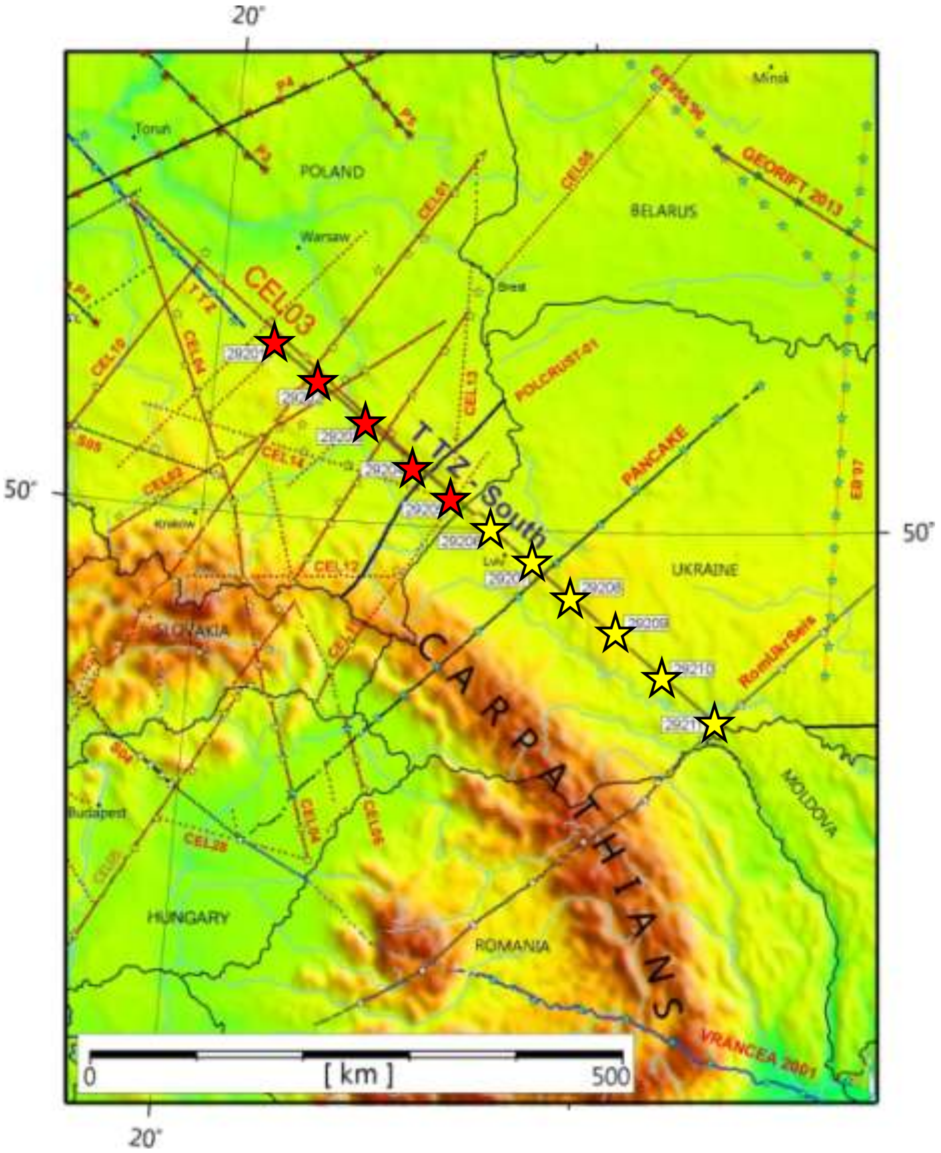
Ukraine : ~ 305 km

**Funds :** NCN Harmonia 8

**Contractors :** Geofizyka Toruń Sp. z o.o. & Ukrgeofizika

# Shot points

Seismic energy was generated in eleven shot points using explosives (600-1000 kg TNT) placed in 20-30 m deep holes, deployed every 45-60 km along the profile.

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Polish Academy of Sciences

# Field measurements

**7 - 14 September 2018**

The deployment of seismic recorders have been carried out by the teams of the Department of Seismic Research of the Lithosphere of the Institute of Geophysics PAS and the Institute of Geophysics of the National Academy of Sciences of Ukraine

Besides our own seismic stations additional 150 recorders were borrowed from the GeoForschungsZentrum (GFZ) Potsdam equipment pool and deployed by Ukrainian teams.

Seismic registrations were conducted by in total ~300 field seismic stations deployed along the profile every 2.5-3.5 km.

Photos from the field base camp located in Janów Lubelski.

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Polish Academy of Sciences

# Field measurements

The analysis of the experimental data obtained, carried out with proven, modern interpretation methods (2D modelling), will be the basis for studies of the structure of the Earth's crust and the upper mantle.

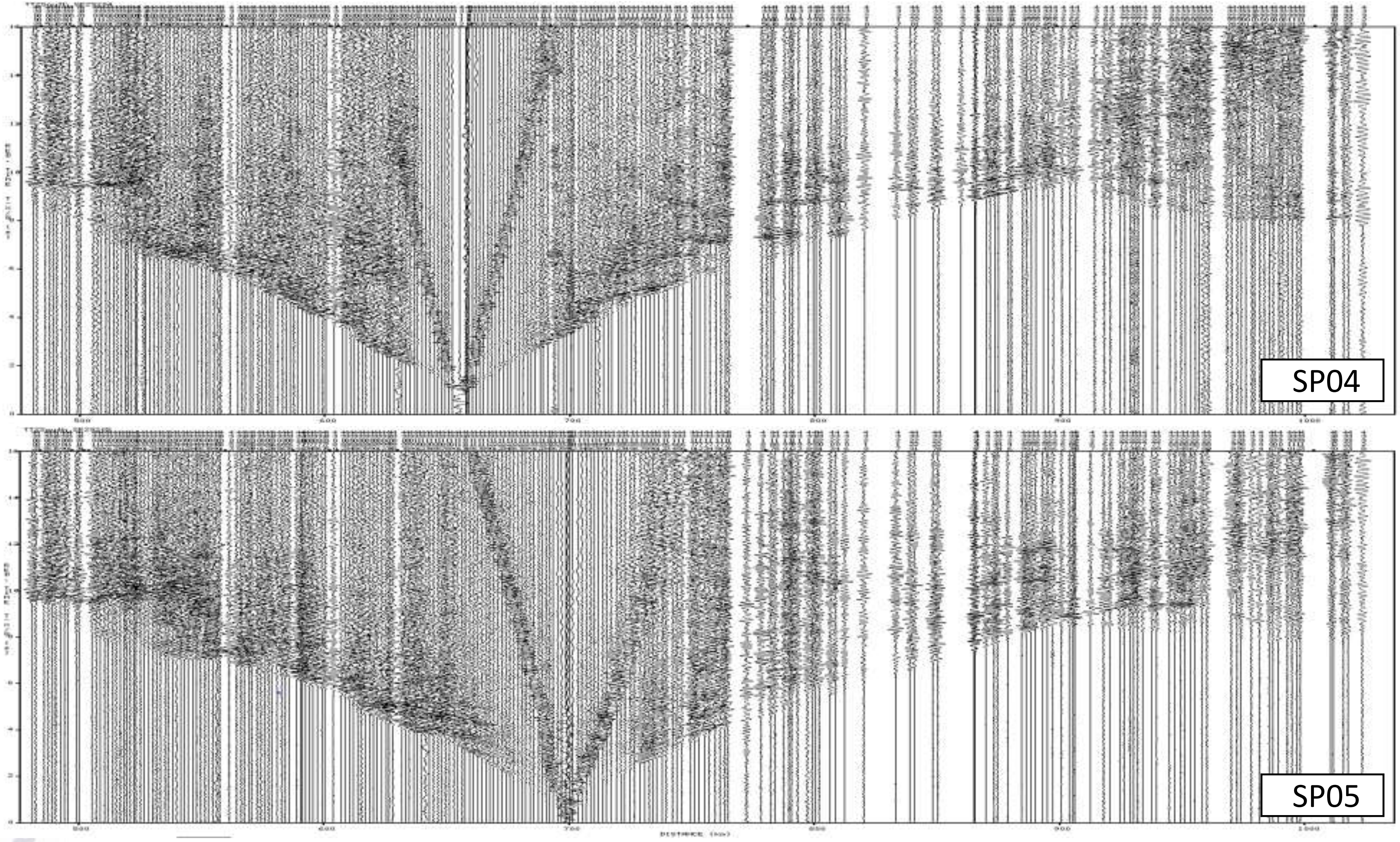



**Fig.5.** Seismic record sections on the profile TTZ-South - SP04 and SP05.

# Thank you for your attention

Institute of Geophysics
Polish Academy of Sciences

GFZ
Helmholtz-Zentrum
POTSDAM

National
Science
Centre
Poland

# Anisotropy of the upper mantle beneath Sudetes: passive seismic experiment AniMaLS


***Piotr Środa, Monika Bociarska, Julia Rewers***

and working group:

***M. Grad[(2)], J. Grzyb[(1)], T. Janik[(1)], M. Polkowski[(2)], J. Puziewicz[(4)],
T. Skrzynik[(1)], M. Wilde-Piórko[(3)], D. Wójcik[(1)]***

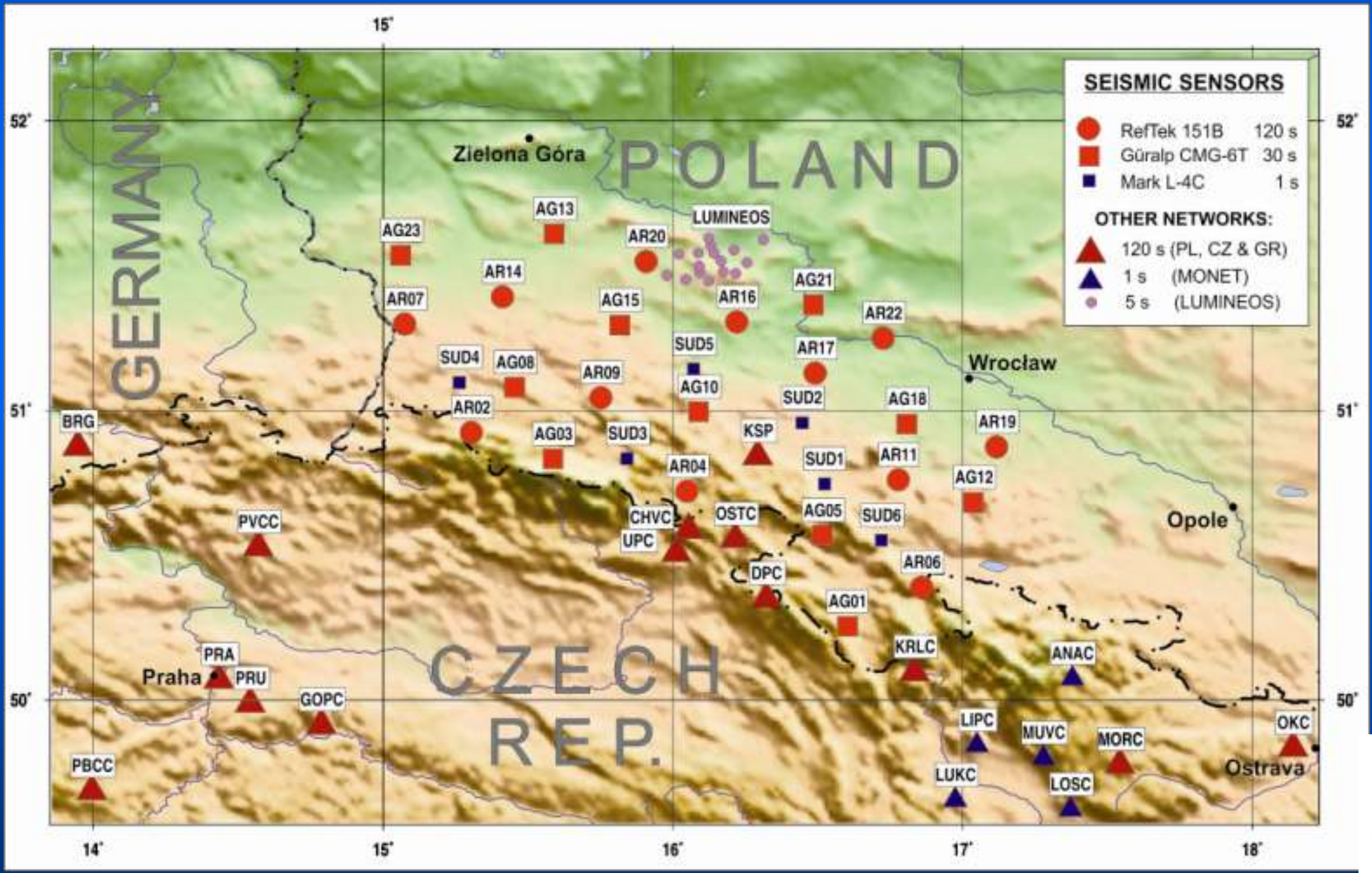
(1) – Institute of Geophysics, Polish Academy of Sciences; (2) – Institute of Geophysics, University of Warsaw
(3) – Institute of Geodesy and Cartography, Warsaw, (4) – Institute of Geological Sciences, University of Wrocław


**IGF PAN, 2019**

# Passive seismic experiment AniMaLS

## (Anisotropy of the Mantle beneath the Lower Silesia)

- **Data acquisition: continuous recording of regional and teleseismic events during > 2 years since 10.2017 (still underway);**
- **Data sources: 23 broadband + 6 SP seismometers (12 – IGF UW, 11+6 – IGF PAN), permanent stations of PL and CZ seismological networks (7 BB and 5 SP).**



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- Scientific objective (authors: Monika Wilde-Piórko and Warsaw University group):
  - modelling of structure and anisotropy varations in the Sudetes upper mantle based on analysis of seismograms of teleseismic events;
  - attempt to correlate the results with petrological studies of crystal preferred orientation (CPO) in upper mantle xenoliths from Lower Silesia;
  - regional studies of the crustal structure;

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  - attempt to correlate the results with petrological studies of crystal preferred orientation (CPO) in upper mantle xenoliths from Lower Silesia;
  - regional studies of the crustal structure;
- Research methods:
  - S-wave splitting method (SKS and SKKS phases);
  - receiver function method (RF decomposition into azimuthal harmonics);
  - teleseismic tomography;
  - other(?)
- Funding source: NCN grant OPUS-12 „Określenie anizotropii sejsmicznej litosfery na obszarze Dolnego Śląska”

# WHY ANISOTROPY?...

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**Seismic anisotropy:**

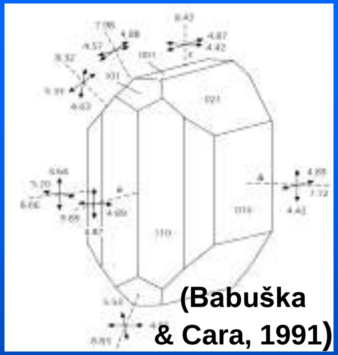
**dependence of seismic wave velocities on the direction of propagation or on shear-wave polarization.**

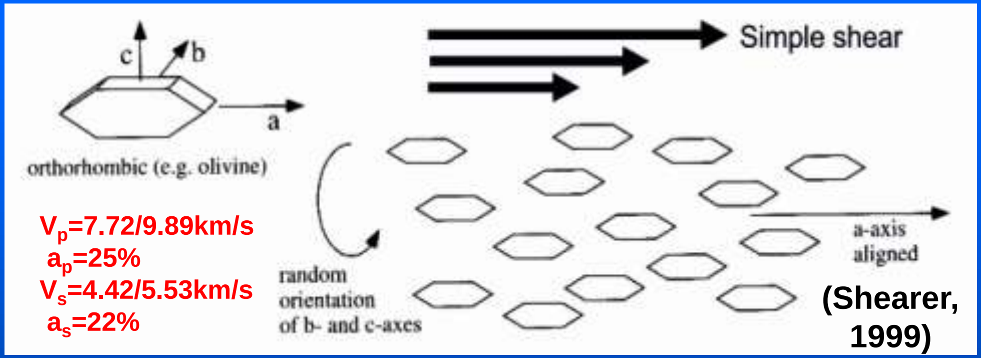
## 1. Seismic anisotropy is a widespread phenomenon

**Mechanism (mantle):**

- Olivine is a major constituent of the upper mantle
- Olivine crystals are seismically anisotropic
- Olivine crystals are coherently aligned by mantle flow and mantle deformations

→ **MANTLE ANISOTROPY**




## 2. Seismic anisotropy is a good marker of deformation processes, gives constraints on the tectonic evolution of the lithosphere.

# WHY SUDETES?...

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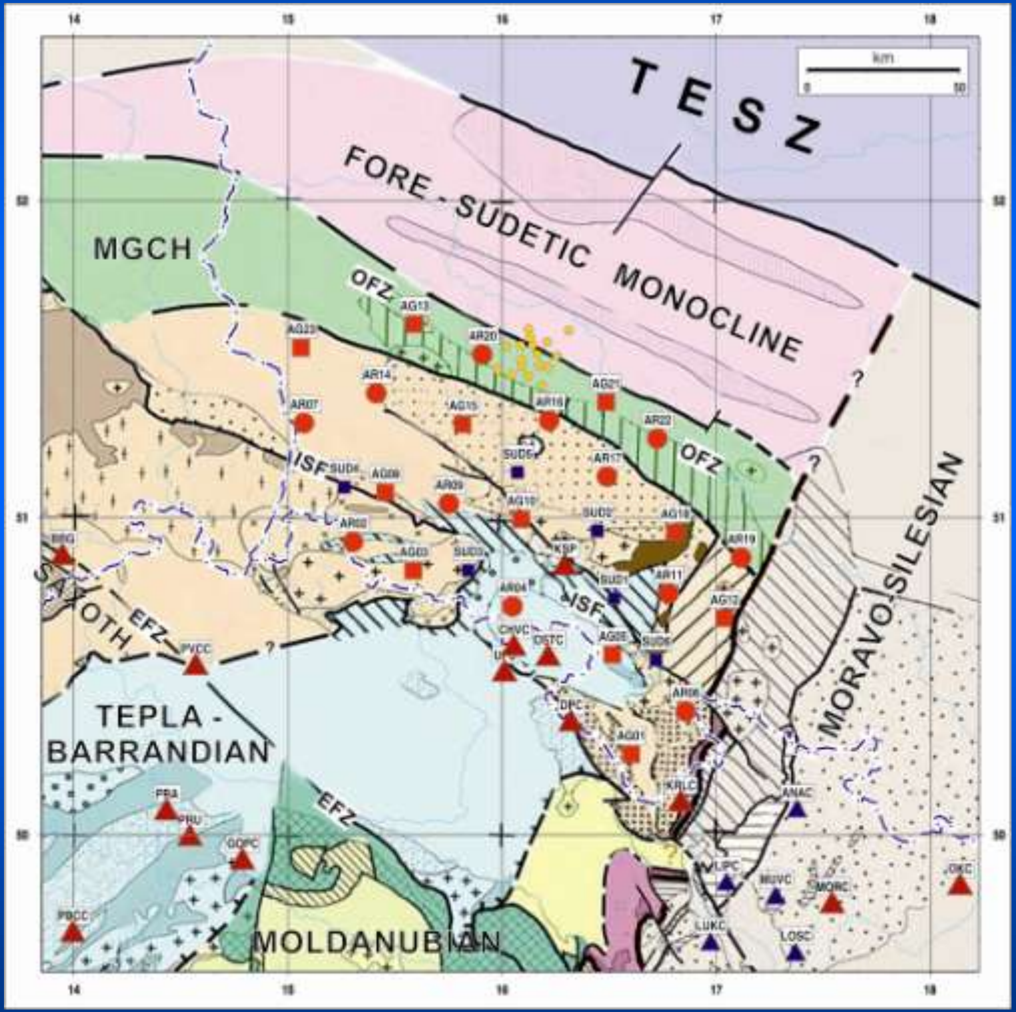
- **Tectonically interesting:** NE margin  of complex Variscan internides (Bohemian Massif);

- **Complex mozaic of contrasting blocks**
  **(cooling age: Proterozoic to Carboniferous)**

- **Consolidation time:**
  **Late Devonian – Early Carboniferous**

- **Structure controlled by 3 major fault zones:**
  - Elbe Fault Zone (EFZ),
  - Intra-Sudetic Fault (ISF),
  - Odra Fault Zone  (OFZ).




**(map modified after  Franke et al., 2017)**

# WHY SUDETES?...

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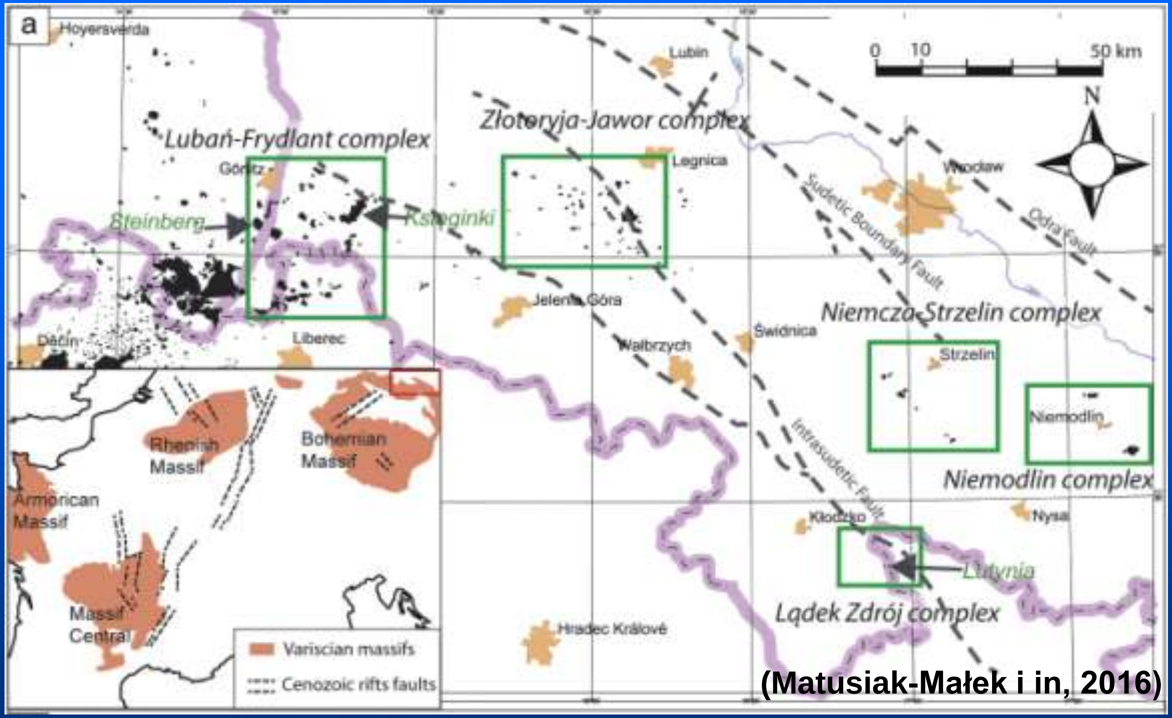
- **Tectonically interesting:** NE margin  of complex Variscan internides (Bohemian Massif);
- **Poorly known mantle properties** (unlike in other parts of the Bohemian Massif);
- **Complementary petrological data available** (studies of anisotropy in mantle xenoliths from Tertiary volcanics – prof. J. Puziewicz group, University of Wrocław).

**Mantle xenolith in basalt**

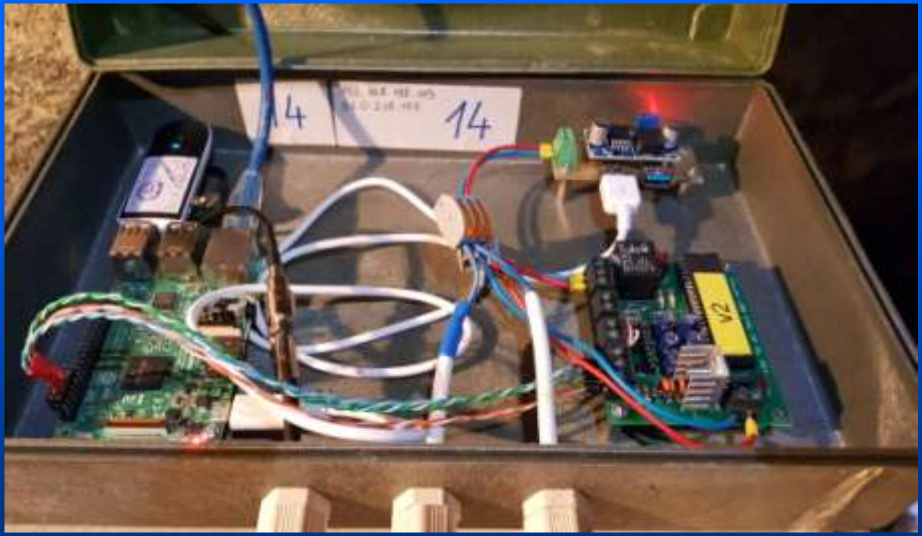
**Locations of Cainozoic volcanic rocks in Sudetes**




**(Matusiak-Małek i in, 2016)**

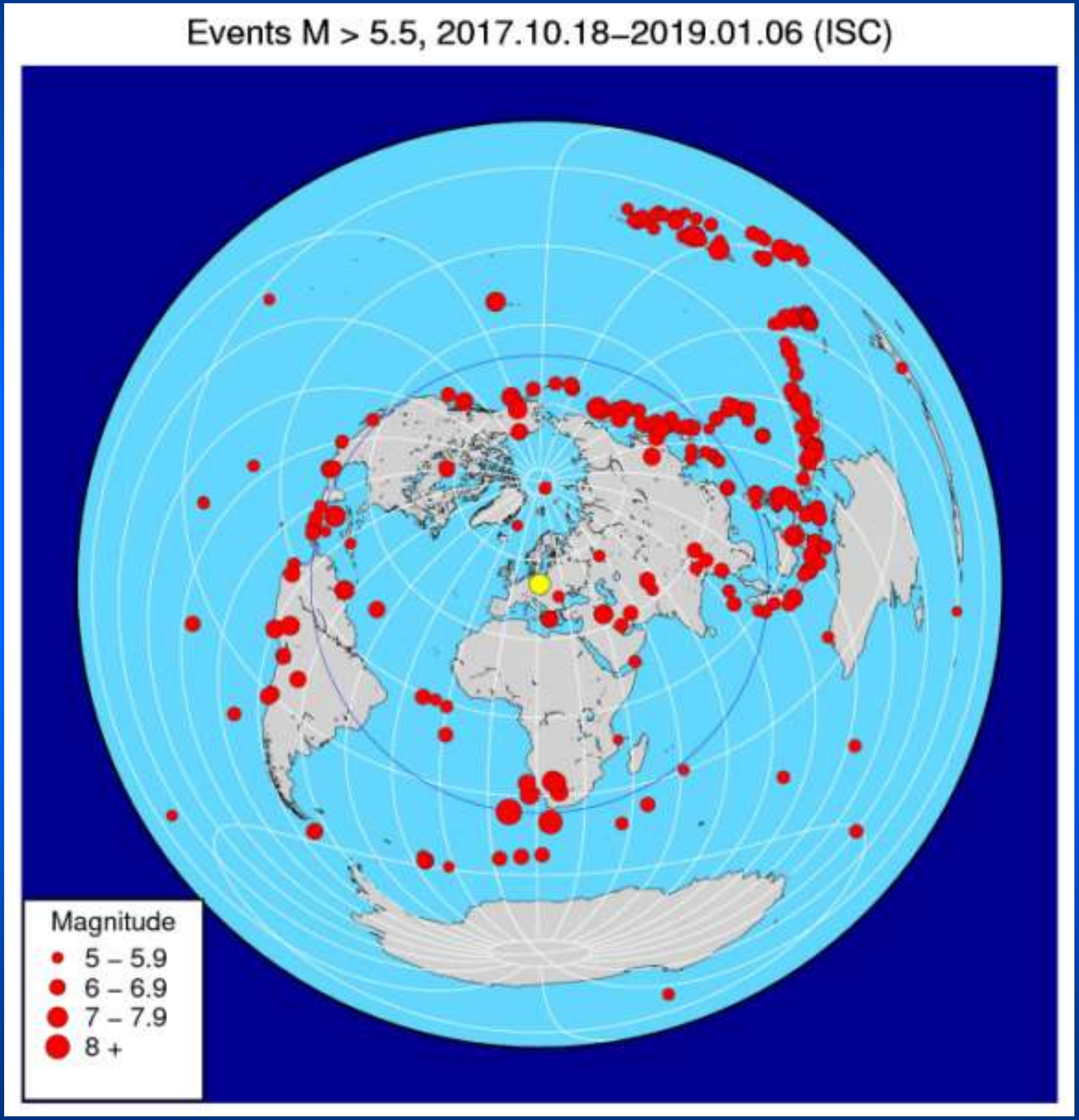
# SEISMIC MEASUREMENTS

**Locations: house basements, sheds, foresters houses, churches etc.**



# SEISMIC MEASUREMENTS

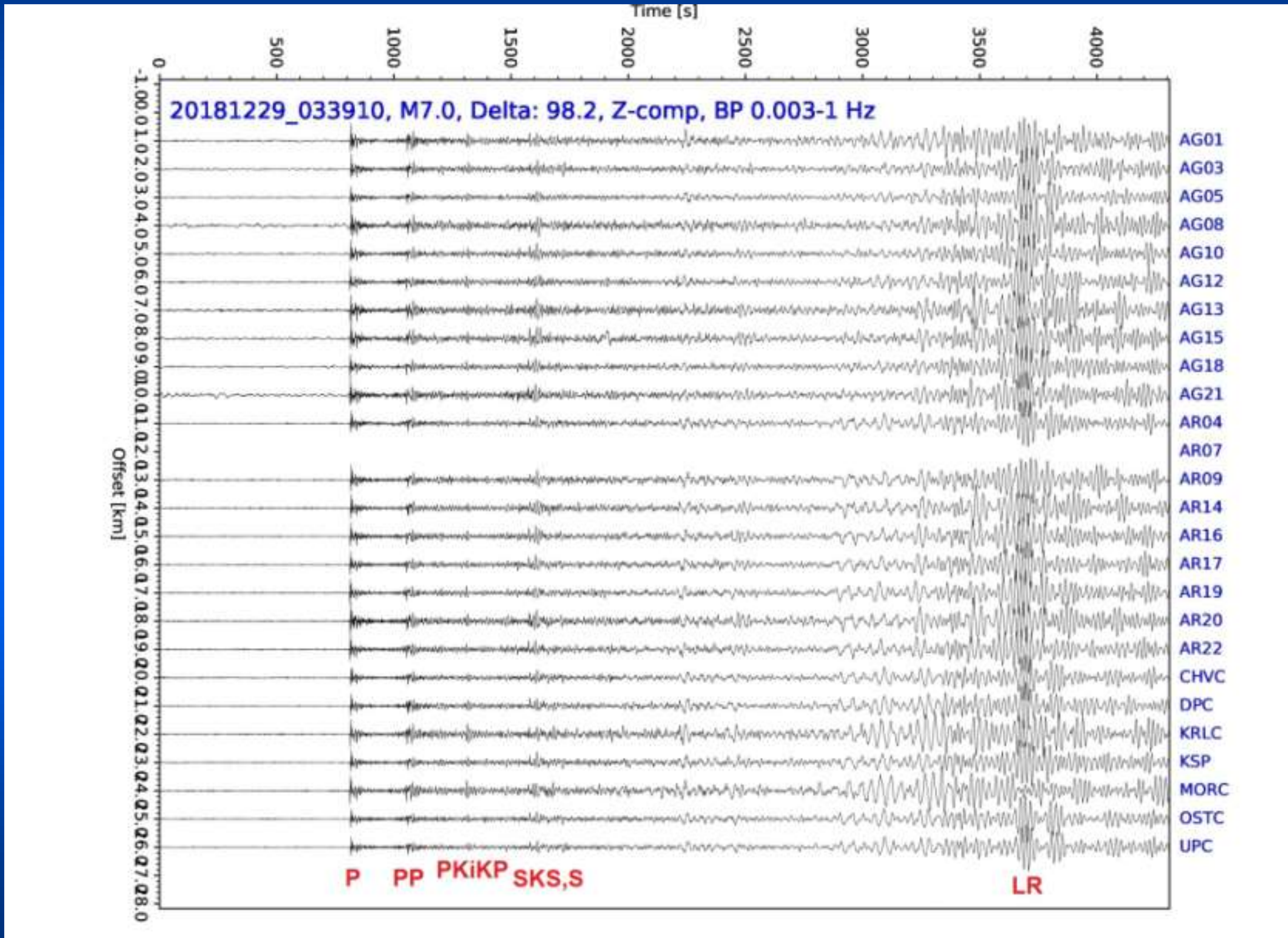
# SEISMIC EVENTS since 10.2017, M > 5.5




~ 400 events

# SEISMIC DATA EXAMPLE: Mindanao, M7.0 event

**Mindanao, 2018/12/29-03:39:09 Loc: 5.9240, 126.8040, depth=59km, M7.0 (NEIC), Δ=98°**



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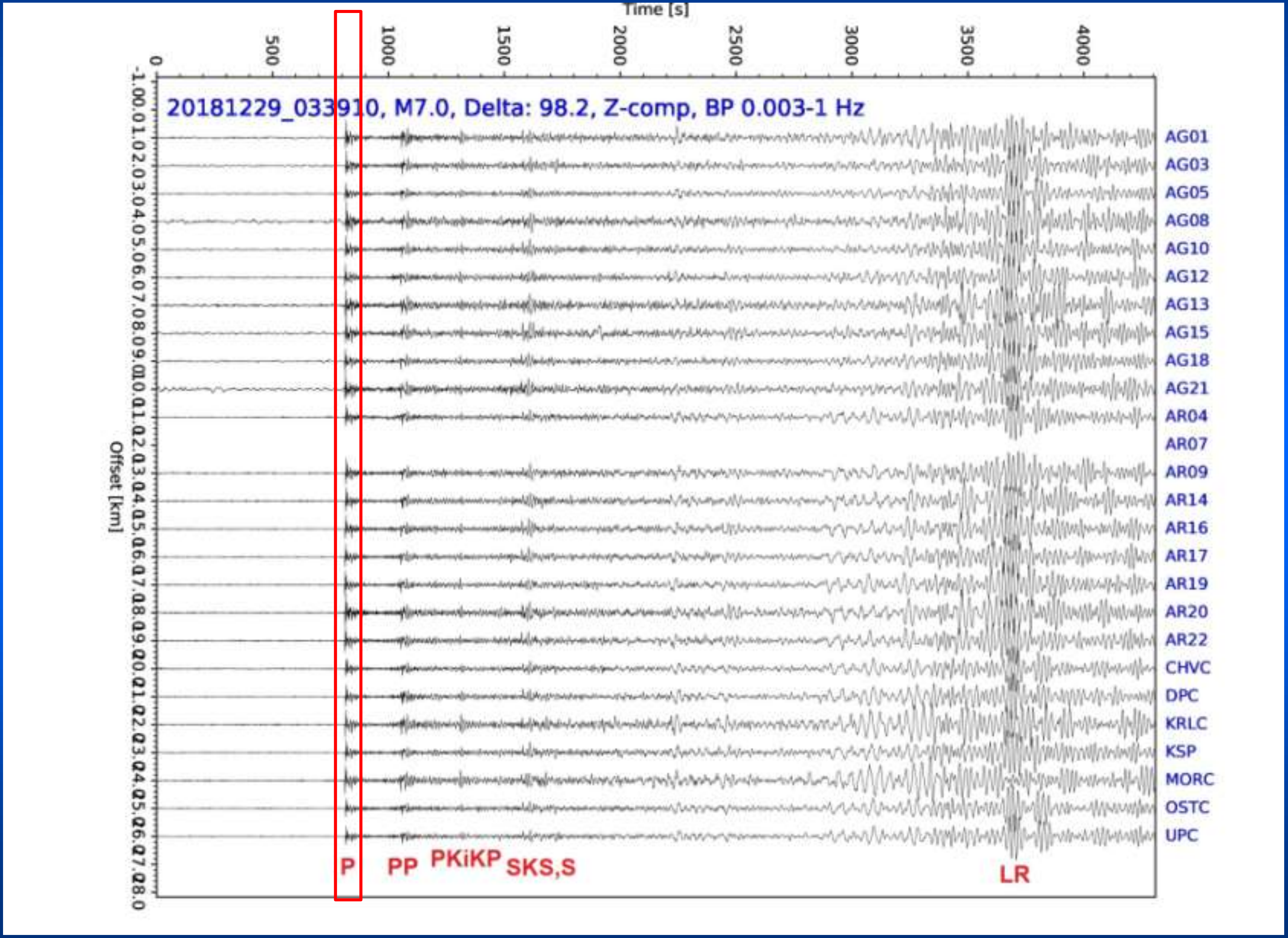

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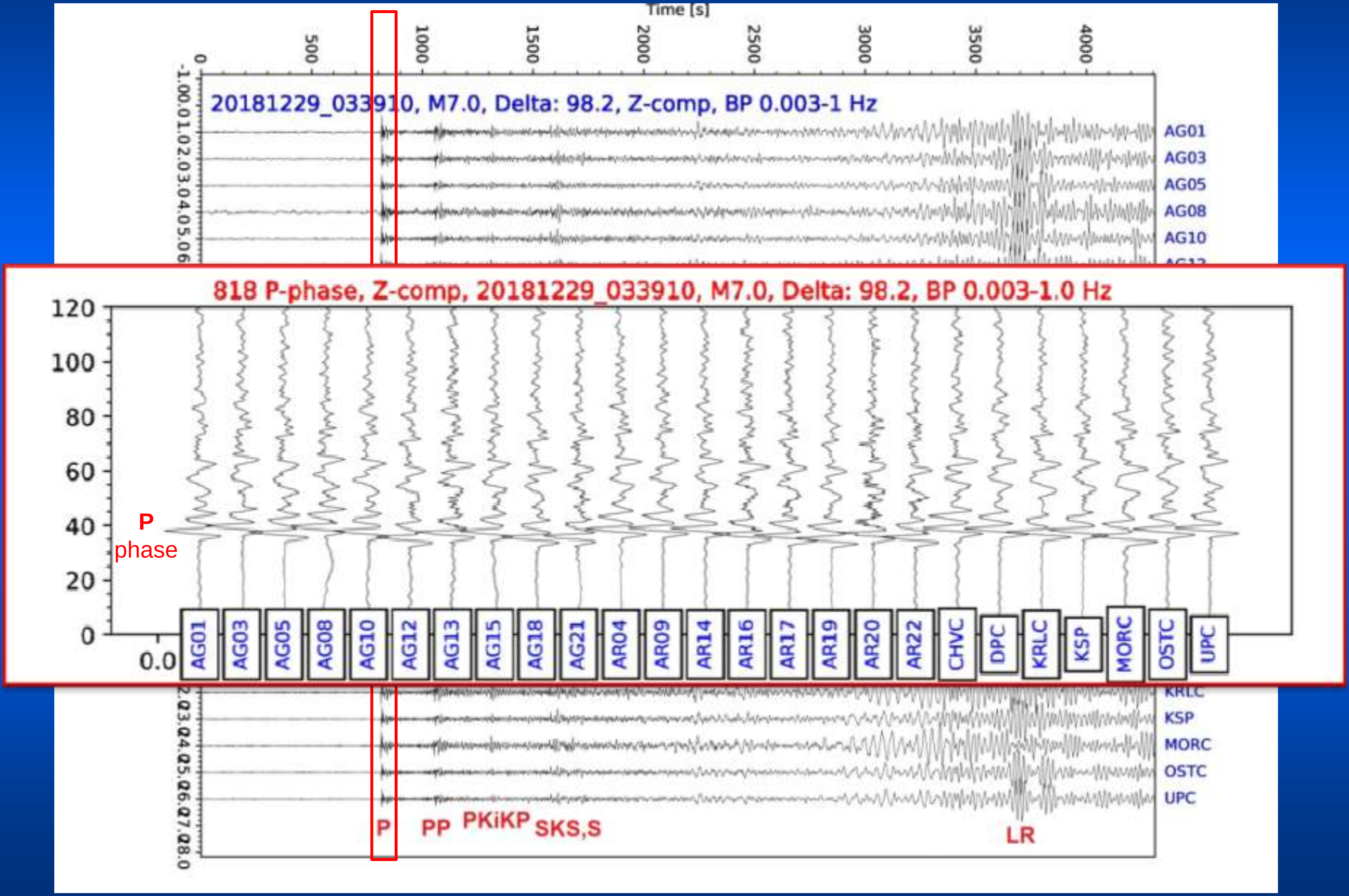

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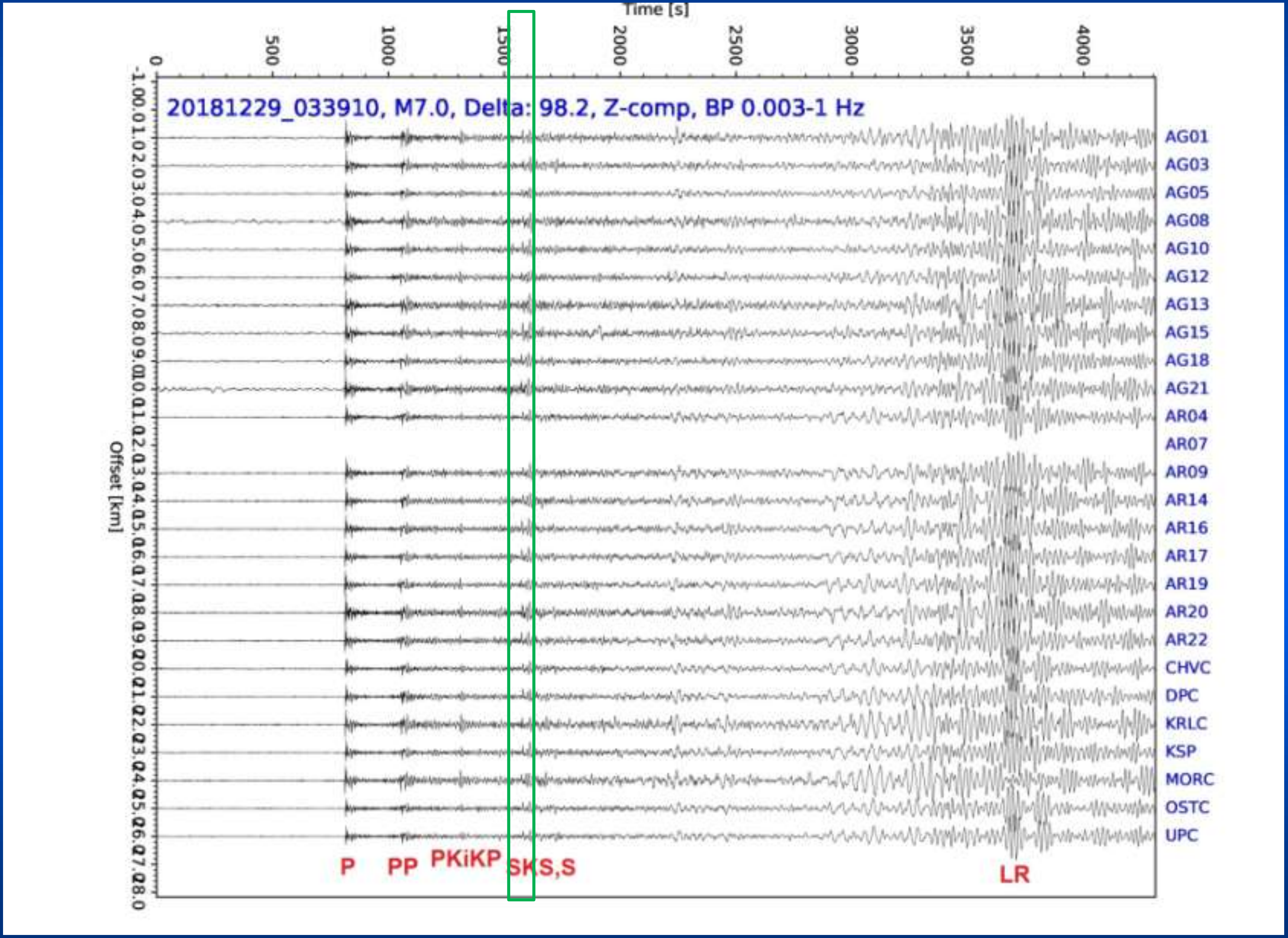

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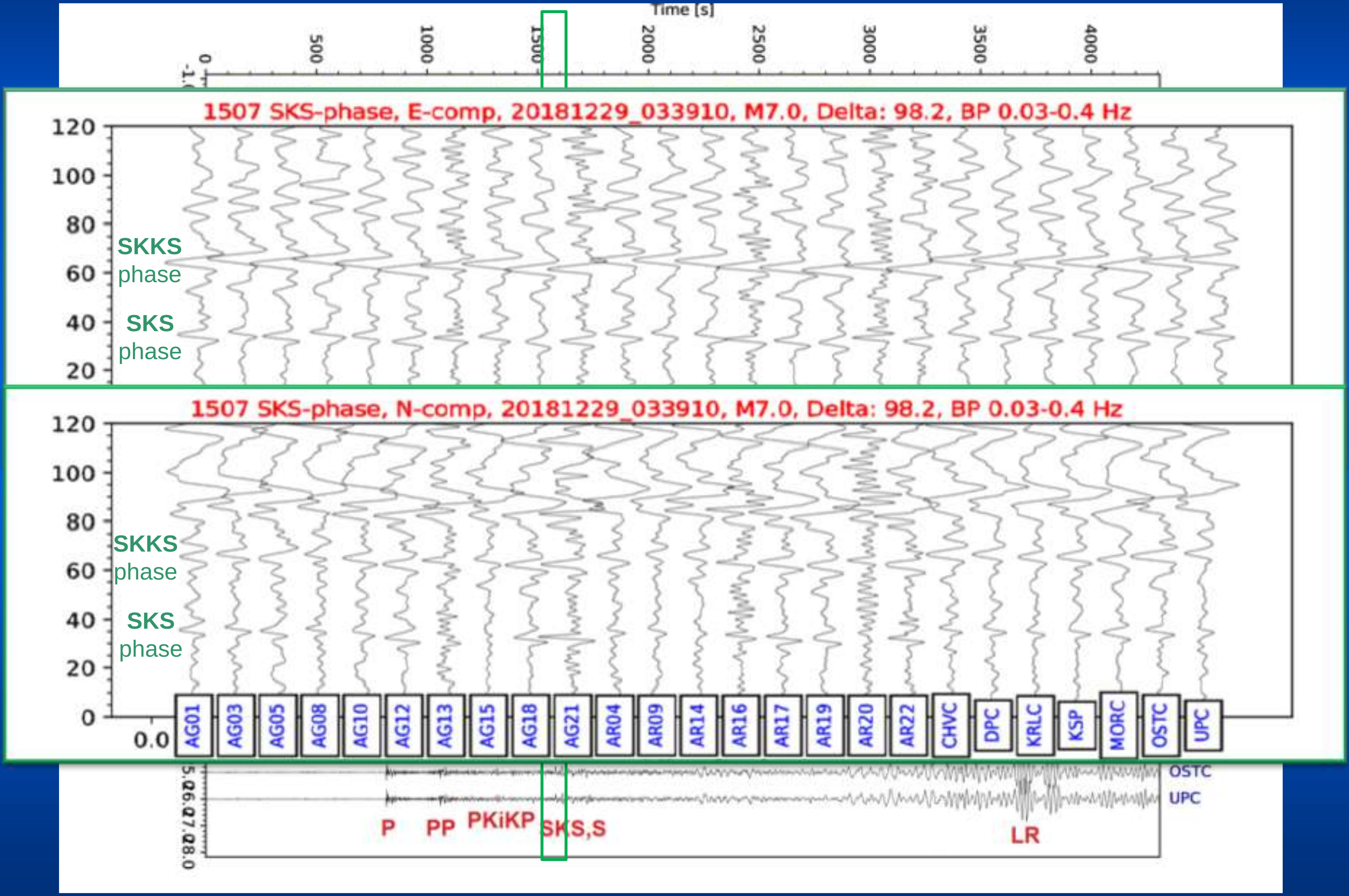

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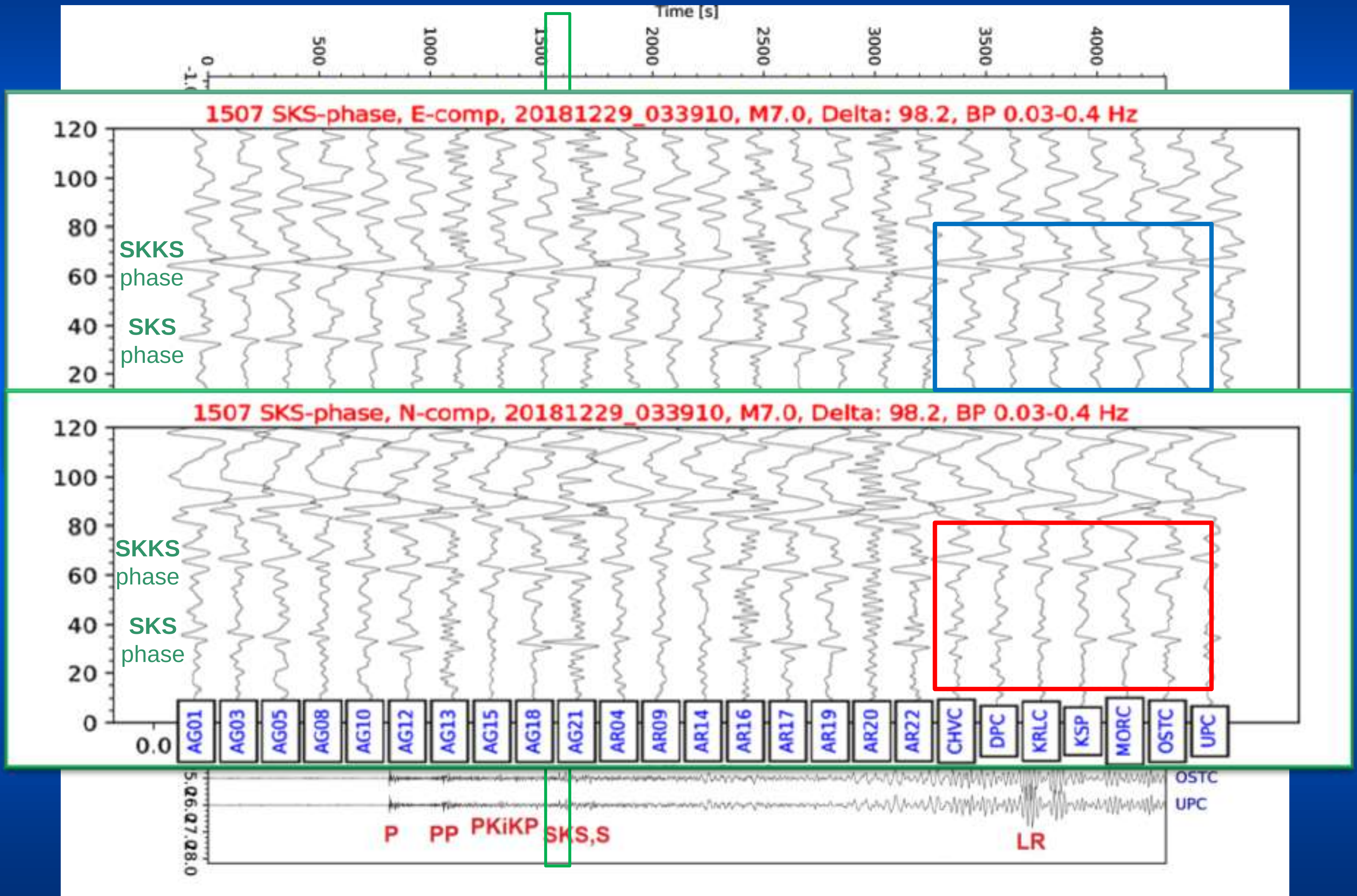

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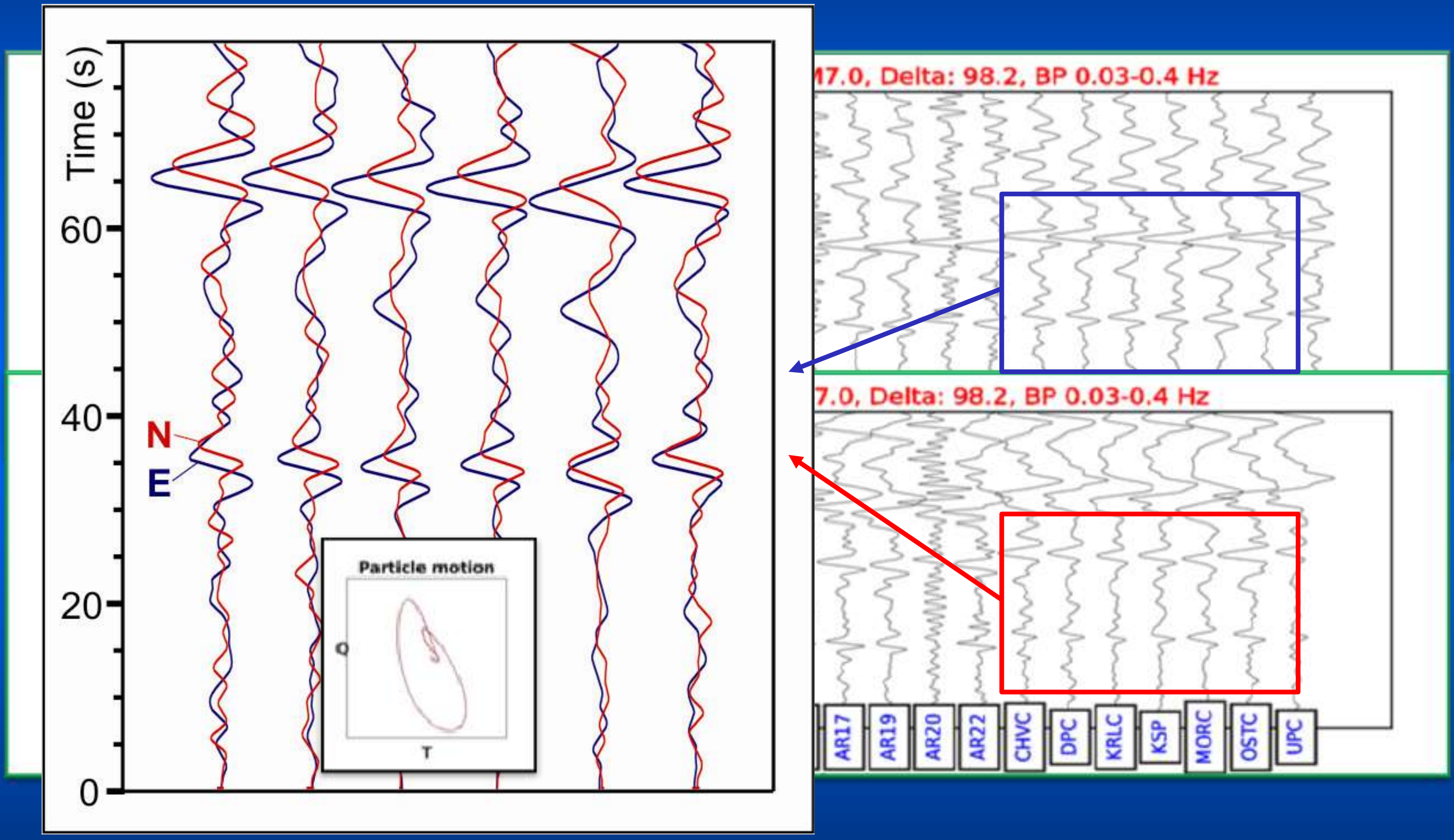
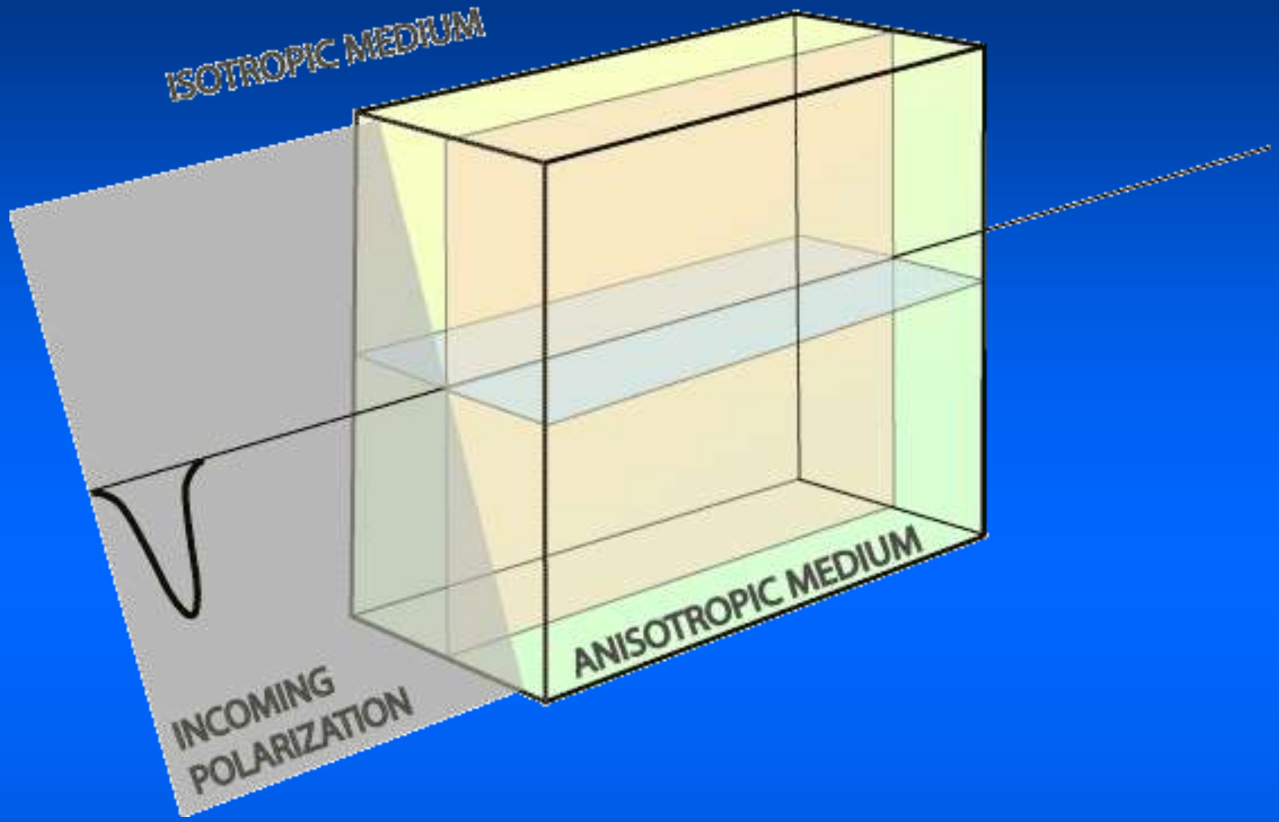



**TIME DELAY => ‚ELLIPTICAL' PARTICLE MOTION => SPLITTING => ANISOTROPY**

# SKS SPLITTING




- Entering the anisotropic medium, linearly polarized shear wave splits into a fast and slow component.
- Accumulated time diference between components results in approximately elliptical polarization
(time delay larger than wavelength results in separation into two orthogonal, linearly polarized wave pulses).
- Parameters describing splitting: time delay (δT) and orientation of fast velocity axis (φ).

(Garnero, http://garnero.asu.edu/research_images; Crampin, 1981)

# WHY USE SKS (SKKS, PKS)?

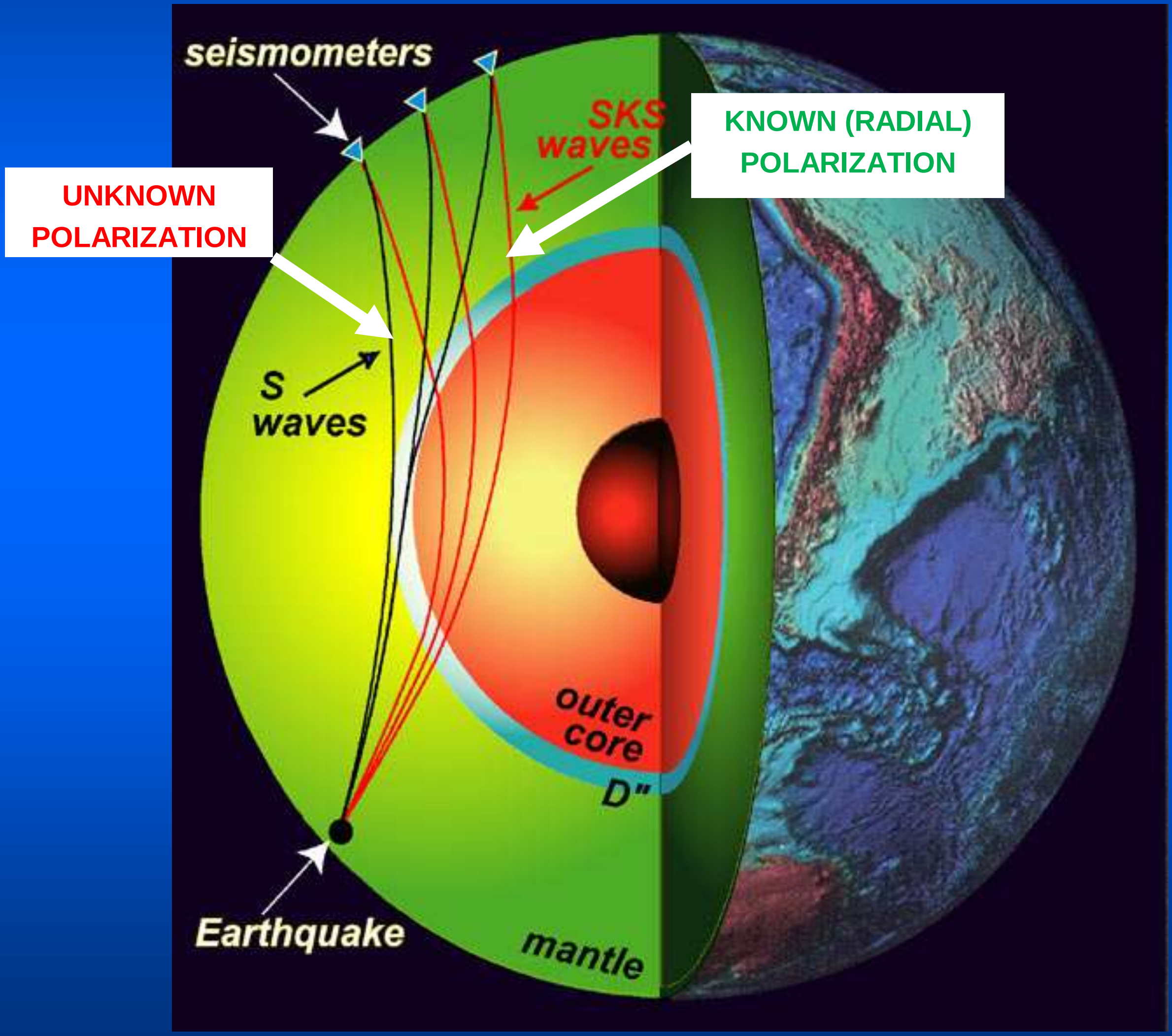
**P → S conversion at the CMB resets polarization to linear and radial (SV). This simplifies the analysis.**

**ADVANTAGES:**

Near-vertical incidence - good horizontal resolution

**WEAKNESSES:**

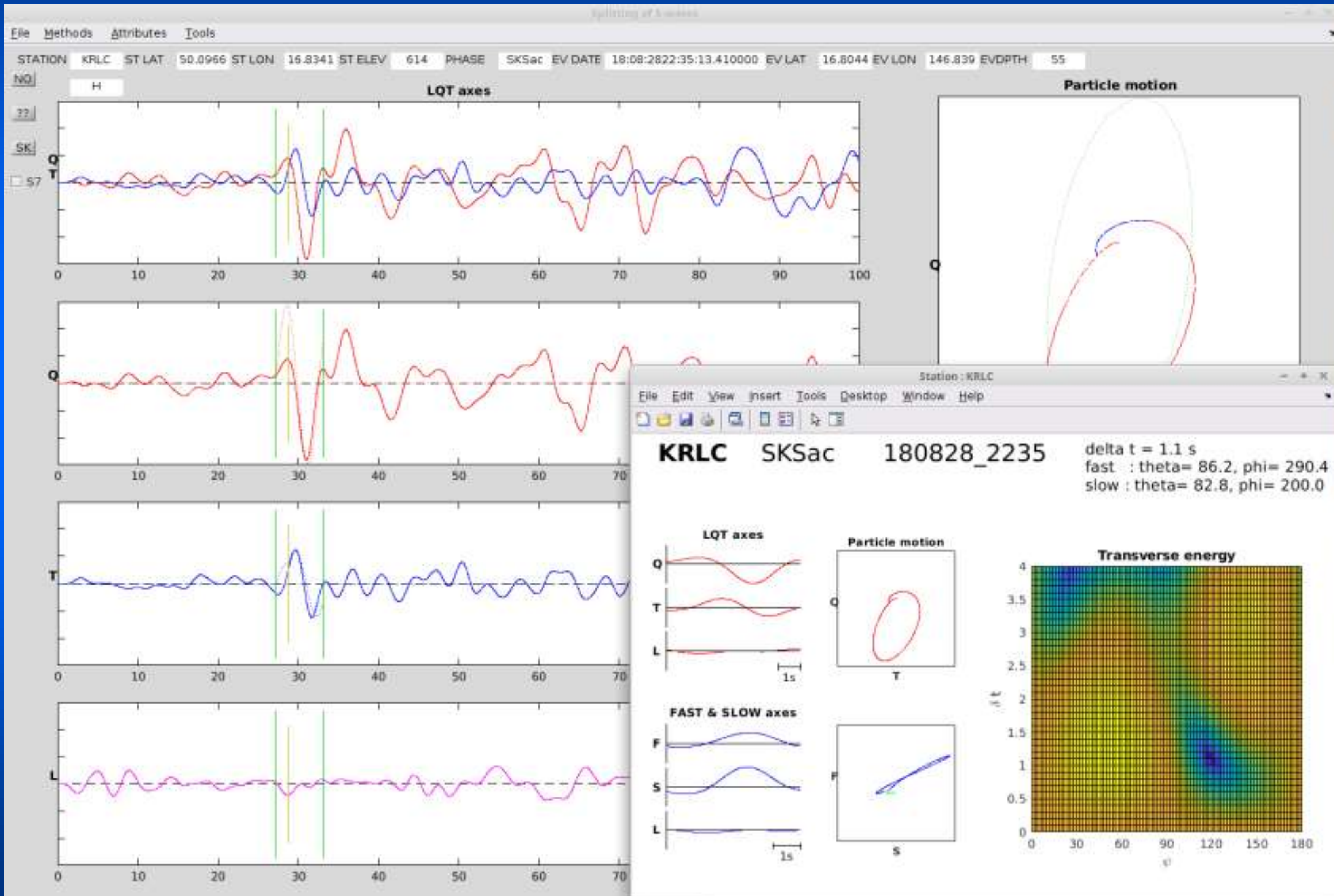
Poor vertical resolution – anisotropy in:
- lithosphere?
- asthenosphere?
- deeper?




(Shearer, http://mahi.ucsd.edu/shearer/SEDI)

# **SKS splitting analysis with SplitShear code** (Vecsey et.al., 2008)

Objective: based on observed particle motion (after splitting, ‚elliptical'), recover PM before splitting (linear). This allows for finding optimal anisotropy parameters (δT – time delay, φ –fast axis azimuth).



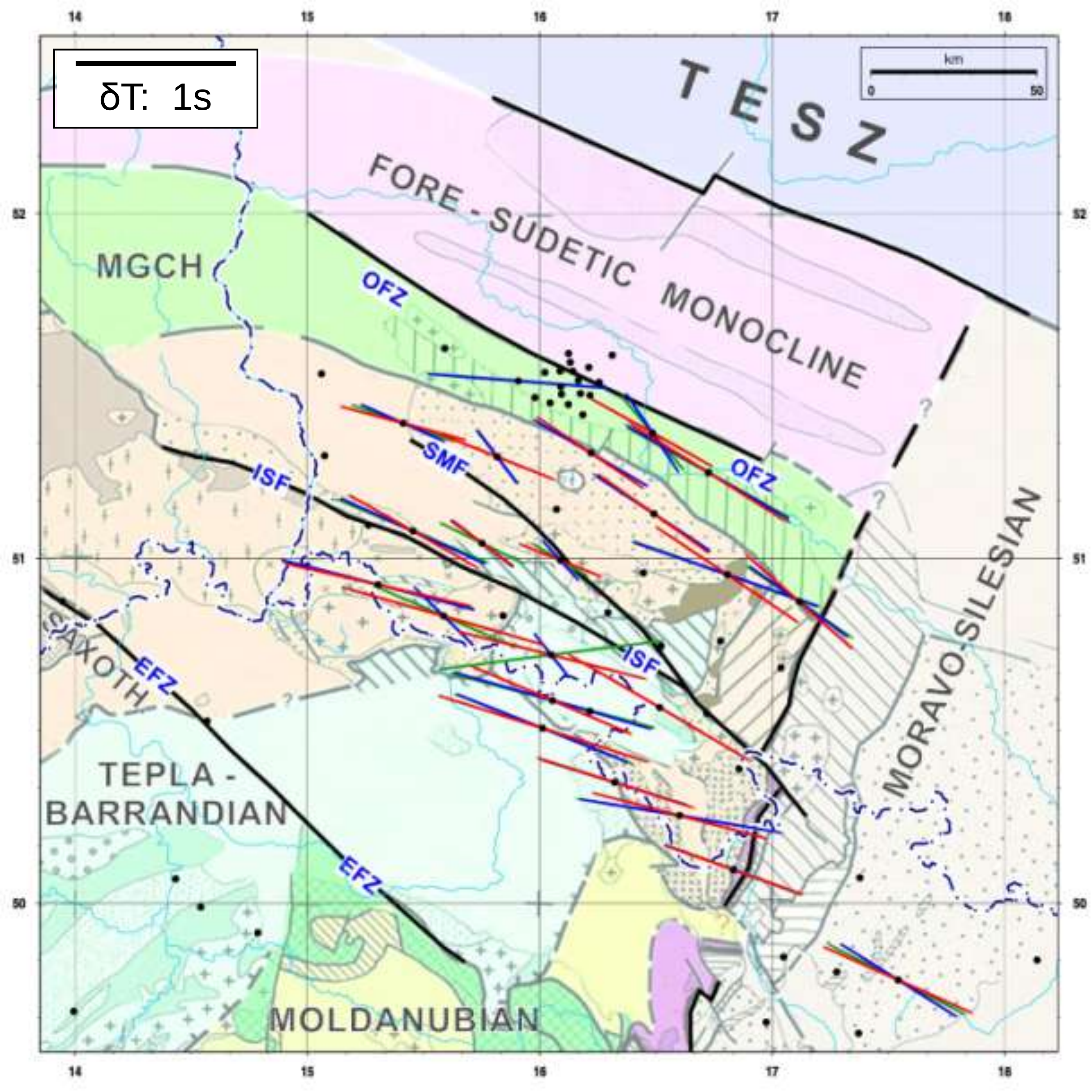
# First (partial) results of *SKS splitting* method (SplitShear code, data from 4 events)

**Averaged results for methods:**

- rotation-correlation (blue)
- eigenvalue min. (green)
- transverse energy min. (red)

**Moderate but systematic difference in fast velocity azimuth to North and South of Intra-Sudetic Fault**

**?**



# THANK YOU FOR ATTENTION

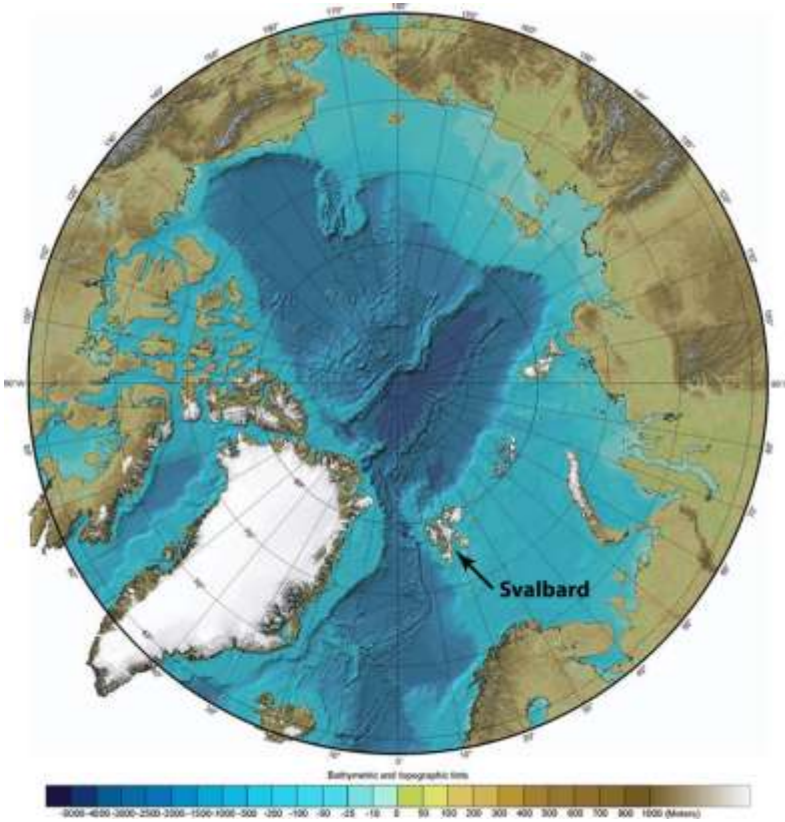
**DZIĘKUJĘ**
**ZA**
**UWAGĘ**

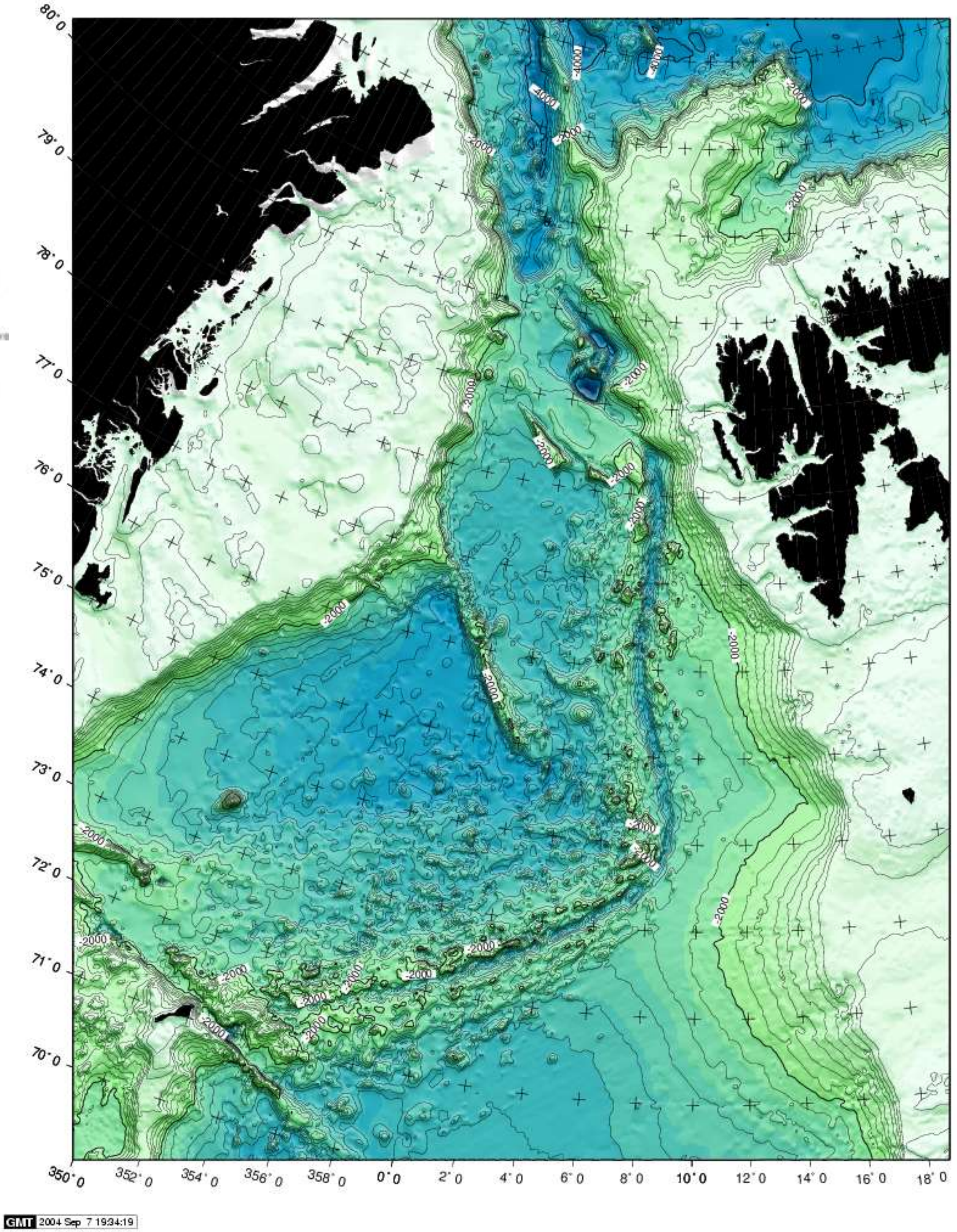
# Knipovich Ridge Seismic Experiments

# KNIPAS & KNIPSEIS
(NSL2)

Wojciech Czuba


Annual reports
Warsaw,
February 2019

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# KNIPAS

**Kni**povich Ridge **Pa**ssive **S**eismic Experiment

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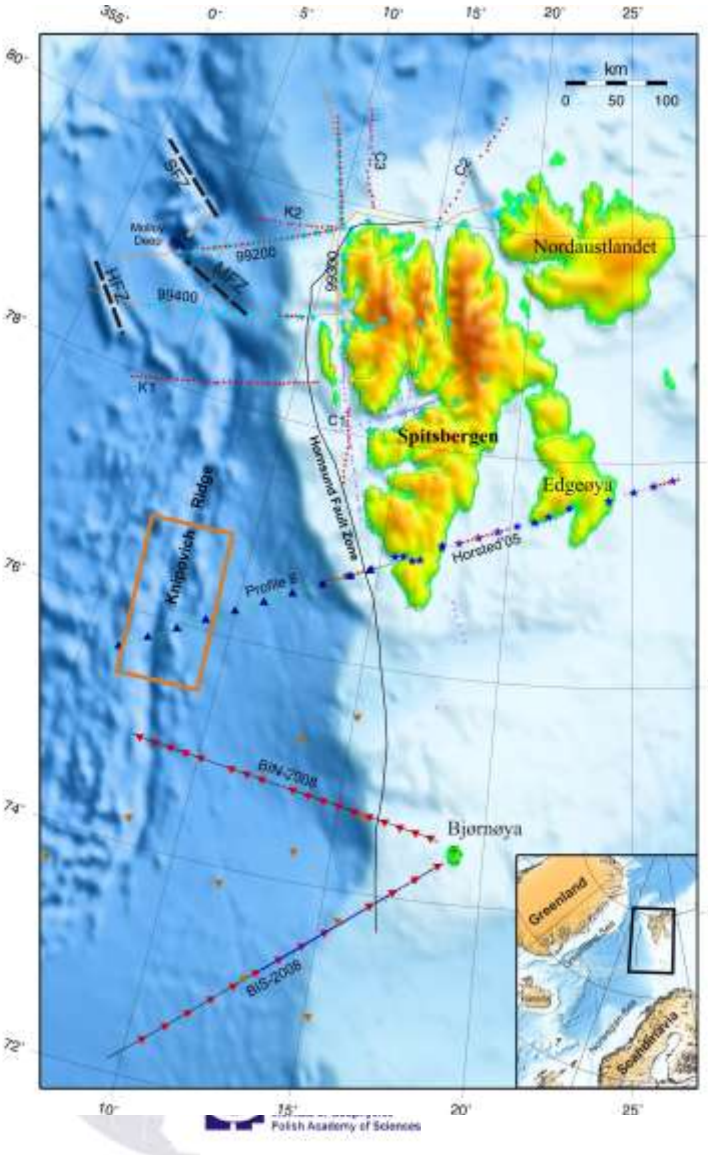
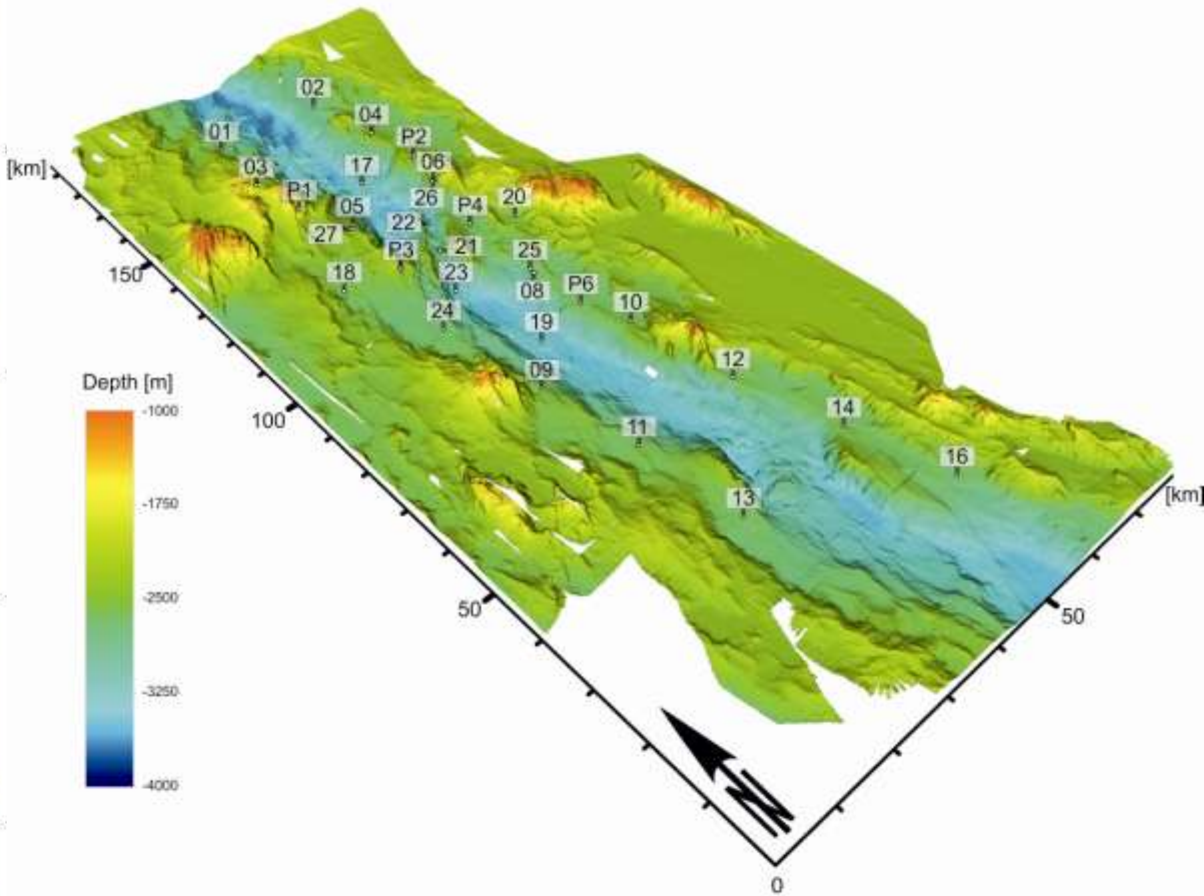
**KNIPAS is one of the first segment-scale seismicity survey of any ultraslow spreading ridge and hence it is a leading edge experiment in mid-ocean ridge research**



# Knipovich Ridge passive seismic German-Polish experiment (KNIPAS)

The active spreading processes at ultraslow spreading mid-ocean ridges are still poorly explored because the main representatives, the Arctic Ridge System and the Southwest Indian Ridge (SWIR) lie in regions with difficult working conditions. We study for the first time ultraslow spreading processes at segment scale. With 30 OBS deployed along 160 km of Knipovich Ridge for 13 months, KNIPAS is the largest OBS network deployed on any mid-ocean ridge. It closes the gap between detailed local OBS studies of microearthquakes and hydroacoustic or teleseismic studies that allow ridge-scale studies of spreading processes but cannot resolve hypocentre locations. The large areal extent combined with small spacing of stations on Logachev Seamount and wide-angle profiling offers the possibility advancing at the same time novel marine passive seismic methods, like ambient noise tomography, receiver functions and surface wave inversion as well as active source seismic modeling.

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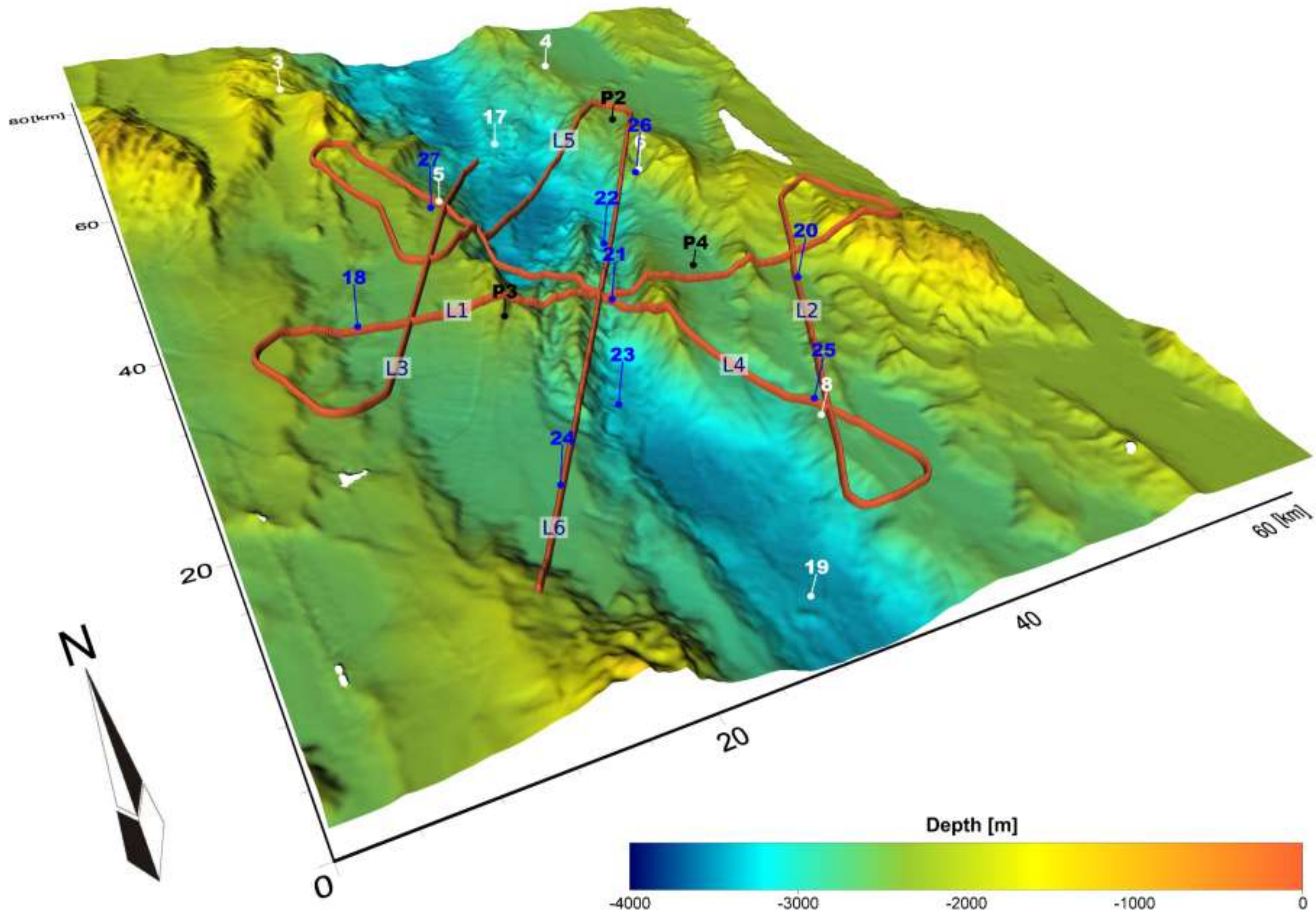
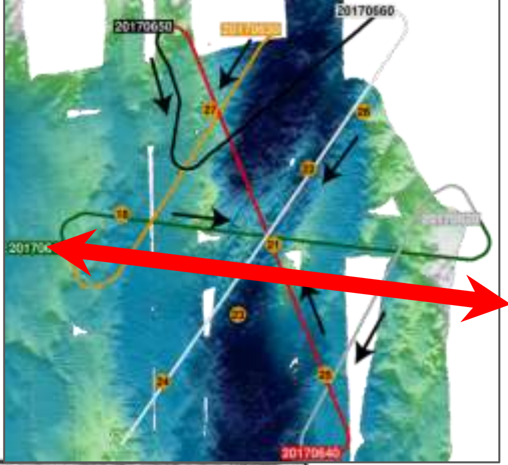
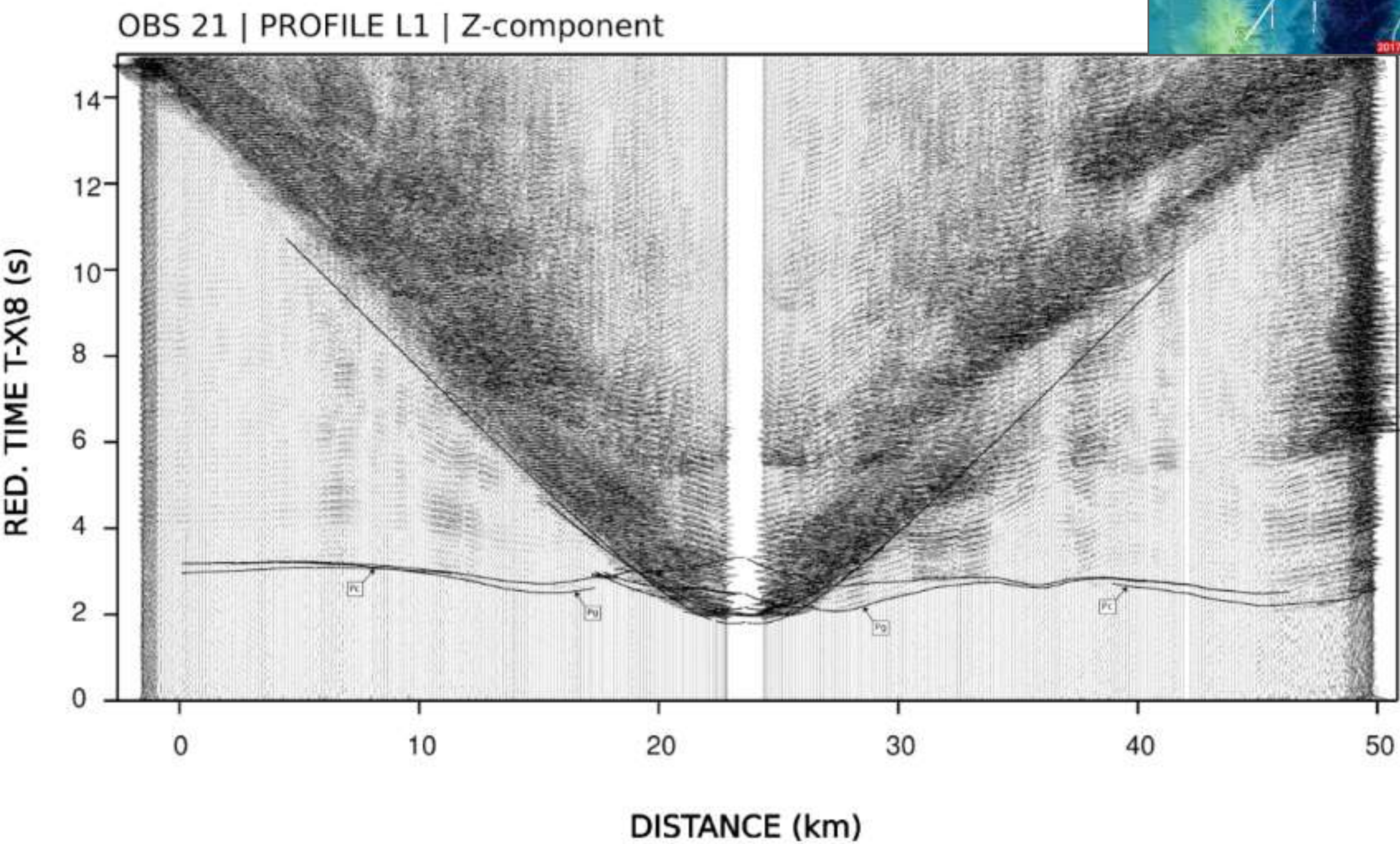
# Seismic modeling in the region of the Knipovich Ridge, active part of the KNIPAS project



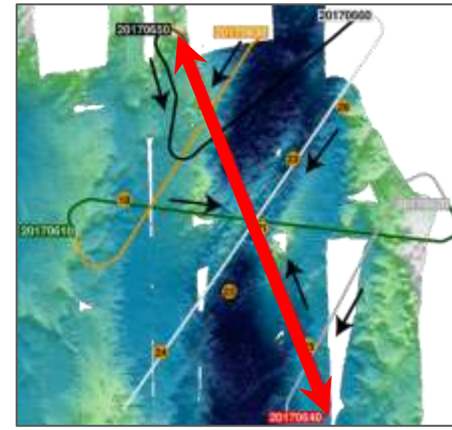
**Example of seismic record section (receiver gather) from OBS 21 on the profile L1 with calculated travel-times**

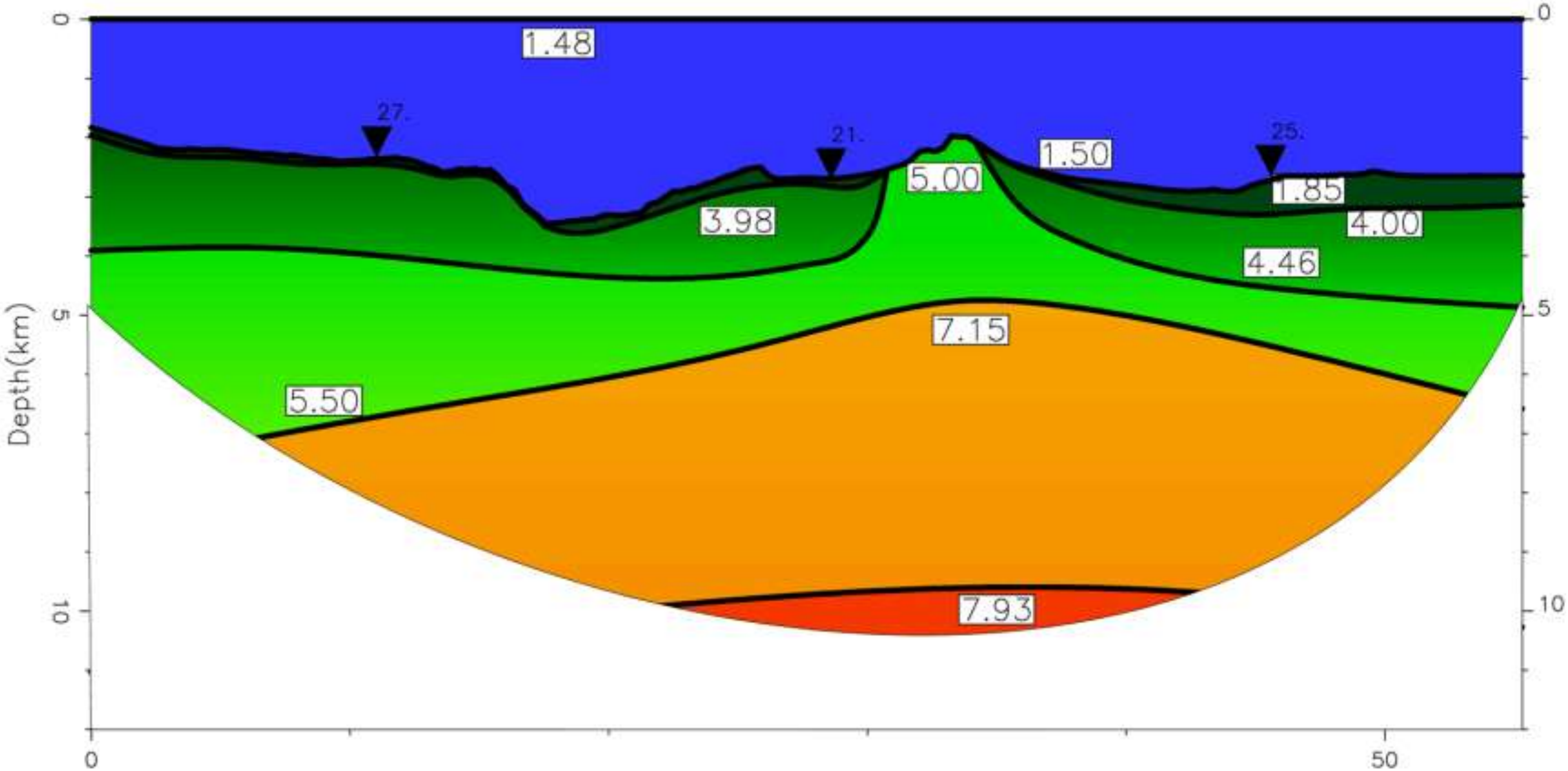




# Model of the L4 profile

## LOGACHEV SEAMOUNT






Distance along profile [km]

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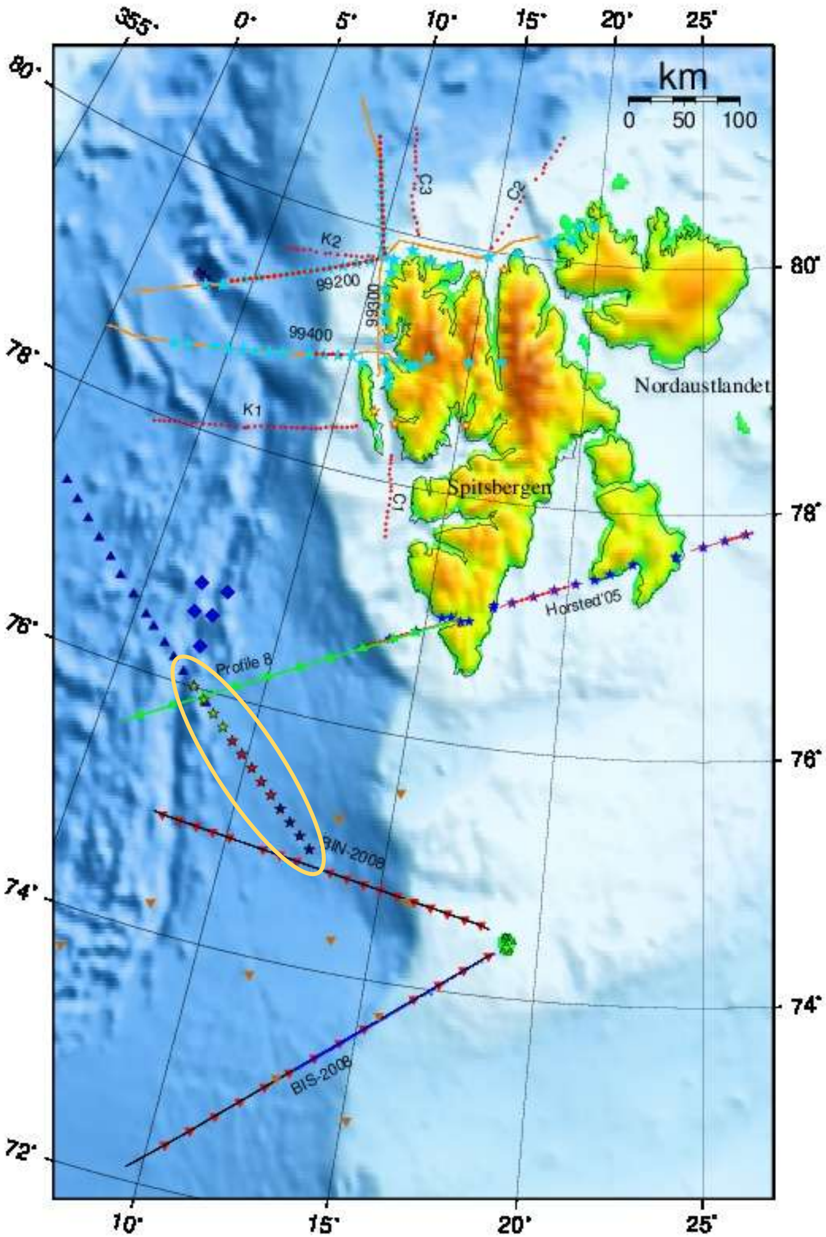


# KNIPSEIS project

## National Science Centre grant OPUS13

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Last Updated on December 28, 2015

Expedition planned on 24.07 - 06.08.2019
Cruise leader dr hab. Wojciech Czuba + 5 persons from IGF PAN

# Thank you for your attention