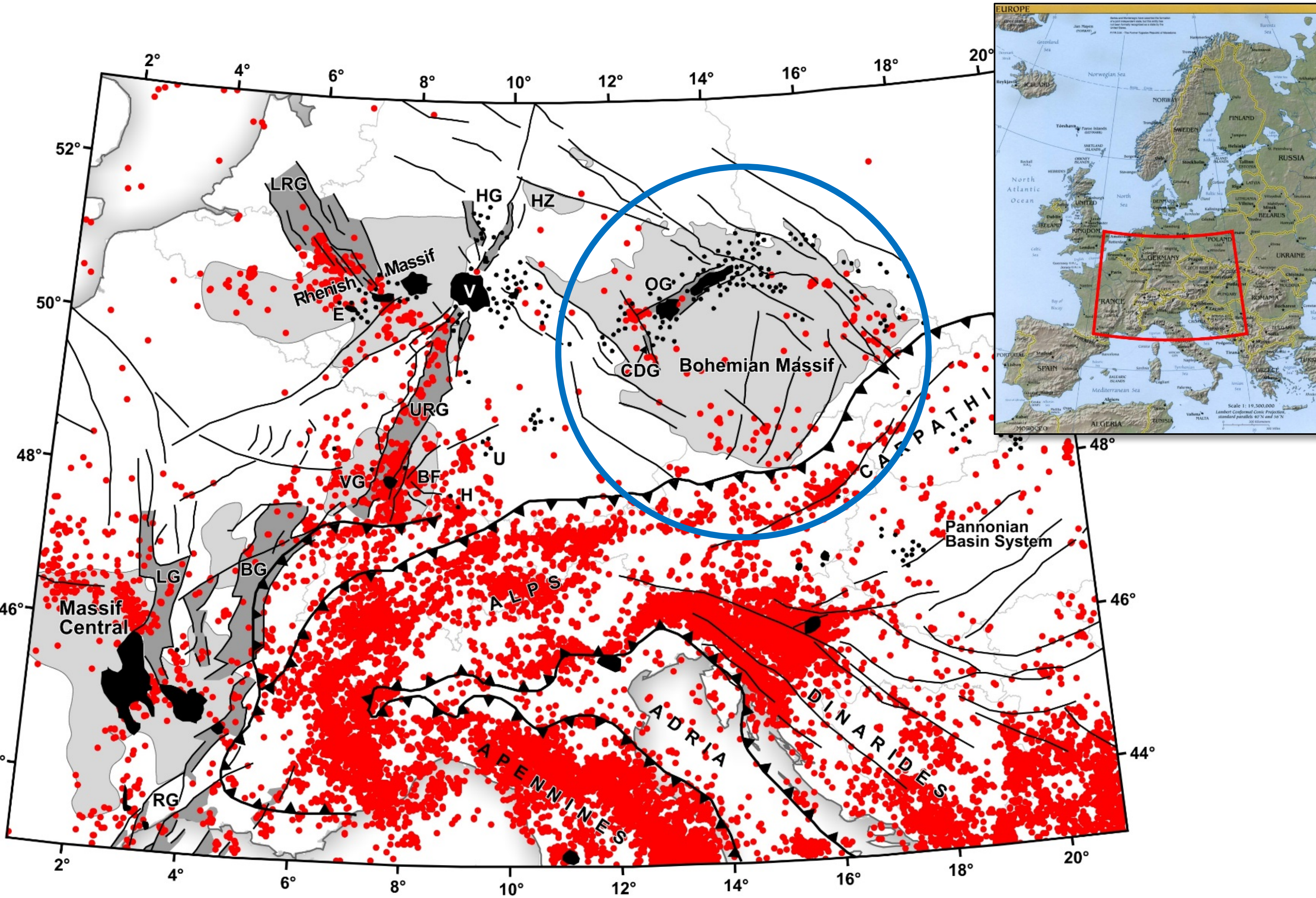
Seismic Activity of the NE Bohemian Massif and its Geological Context

Institute of Physics of the Earth
Masaryk University Brno

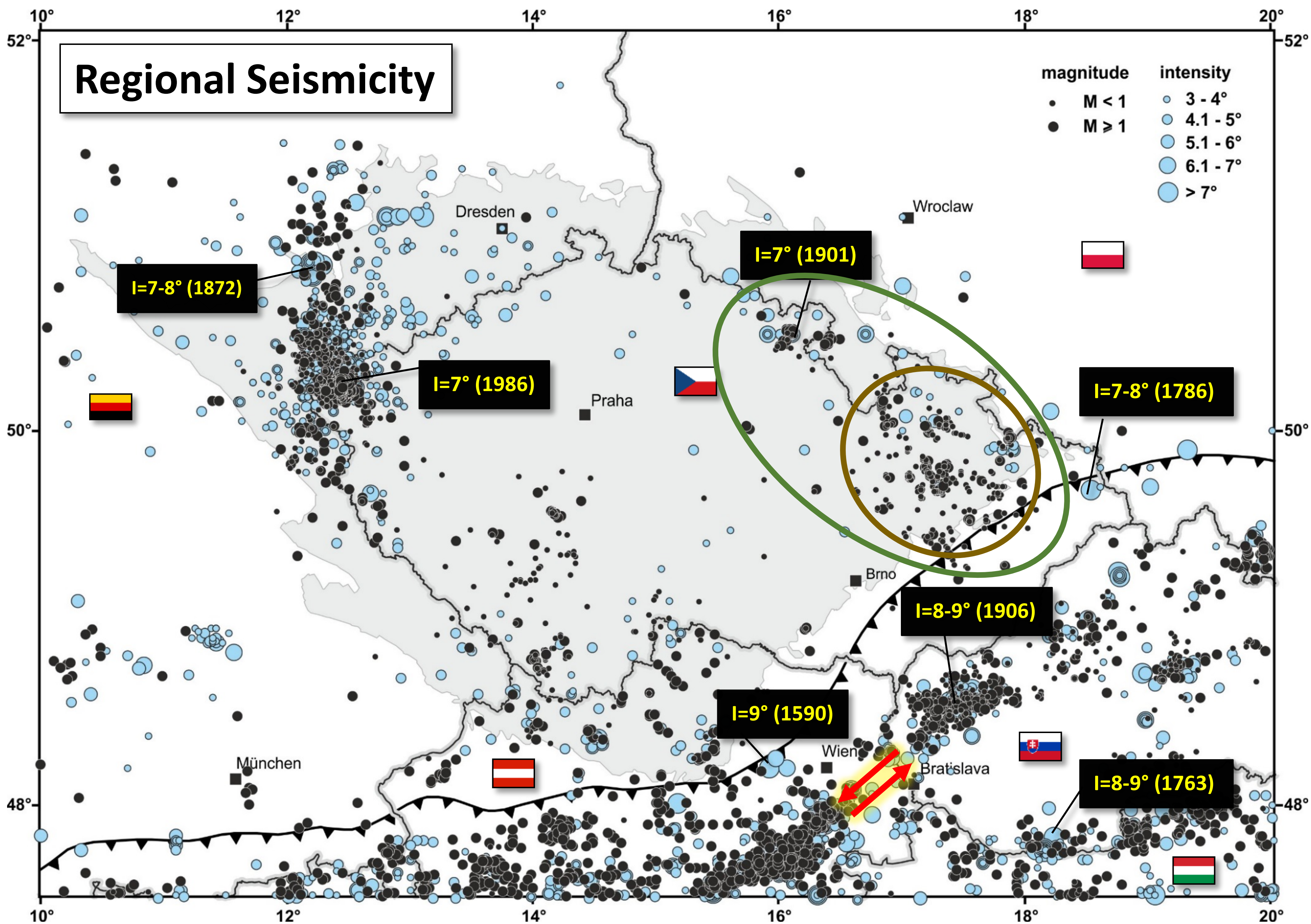
within the scope of

CzechGeo/EPOS

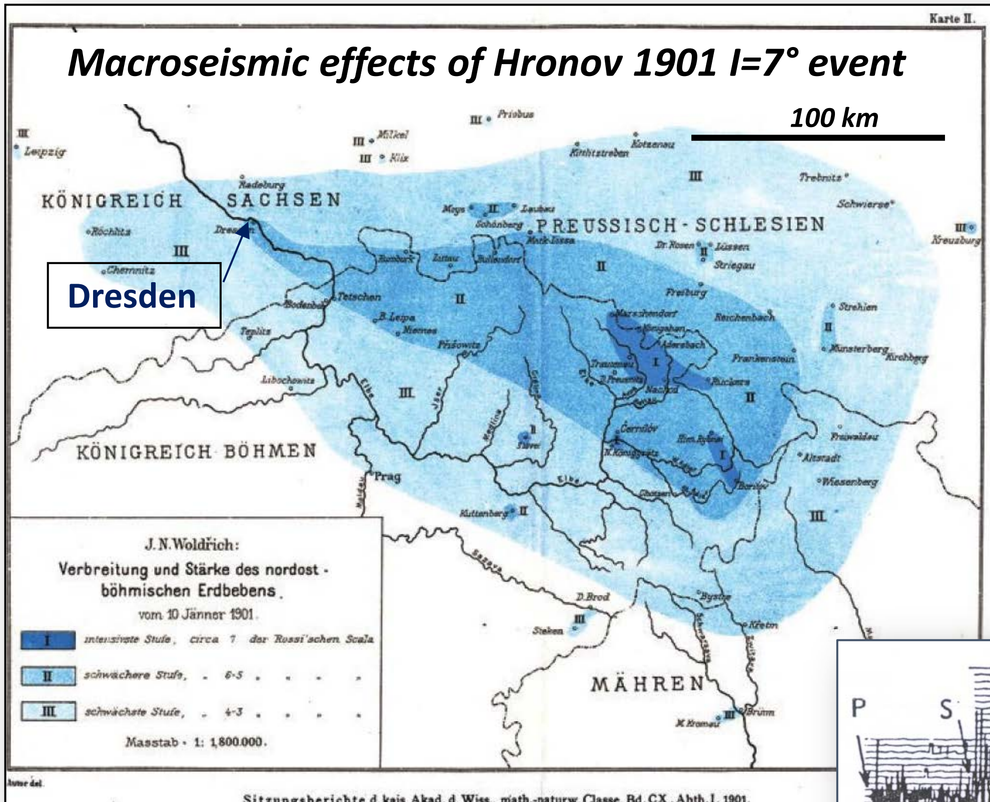
Results of **IPE-MONET Team**; presented by Petr Špaček



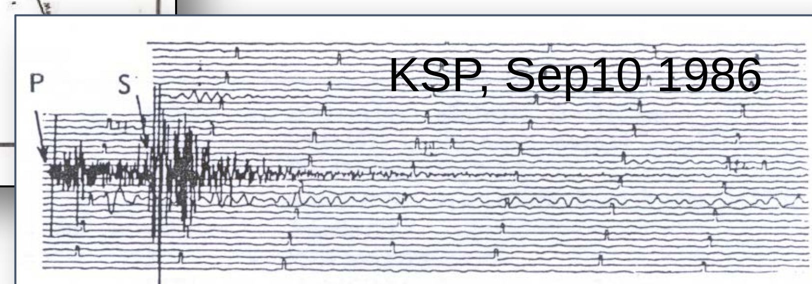
LRG
HG
HZ
Rhenish Massif
V
E
OG
CDG
Bohemian Massif
URG
VG
BF
U
H
CARPATHI
Pannonian Basin System
LG
BG
Massif Central
ALPS
ADRIA
DINARIDES
APENNINES
RG
EUROPE


Regional Seismicity
magnitude
M < 1
M ≥ 1
intensity
3 - 4°
4.1 - 5°
5.1 - 6°
6.1 - 7°
> 7°
I=7-8° (1872)
I=7° (1986)
I=7° (1901)
I=7-8° (1786)
I=8-9° (1906)
I=9° (1590)
I=8-9° (1763)
Dresden
Wroclaw
Praha
Brno
Wien
Bratislava
München
10°
12°
14°
16°
18°
20°
52°
50°
48°

Historical seismicity



- **I_{MSK} ≈ 7°:** 1562 Klodsko, 1786 Těšín, 1901 Hronov
- **I_{MSK} ≈ 6°:** 1931 Opava
- **I_{MSK} ≈ 5.5°** / M3.8 1986 near Šumperk (14 felt earthquakes during 3 months – Nový Kostel type swarm?)



Motivation for detailed monitoring

- Regionally anomalous present-day seismicity
  and
  Historical records of moderate earthquakes
- Regionally anomalous geology
  and
  Geological indications for increase of activity in Pleistocene

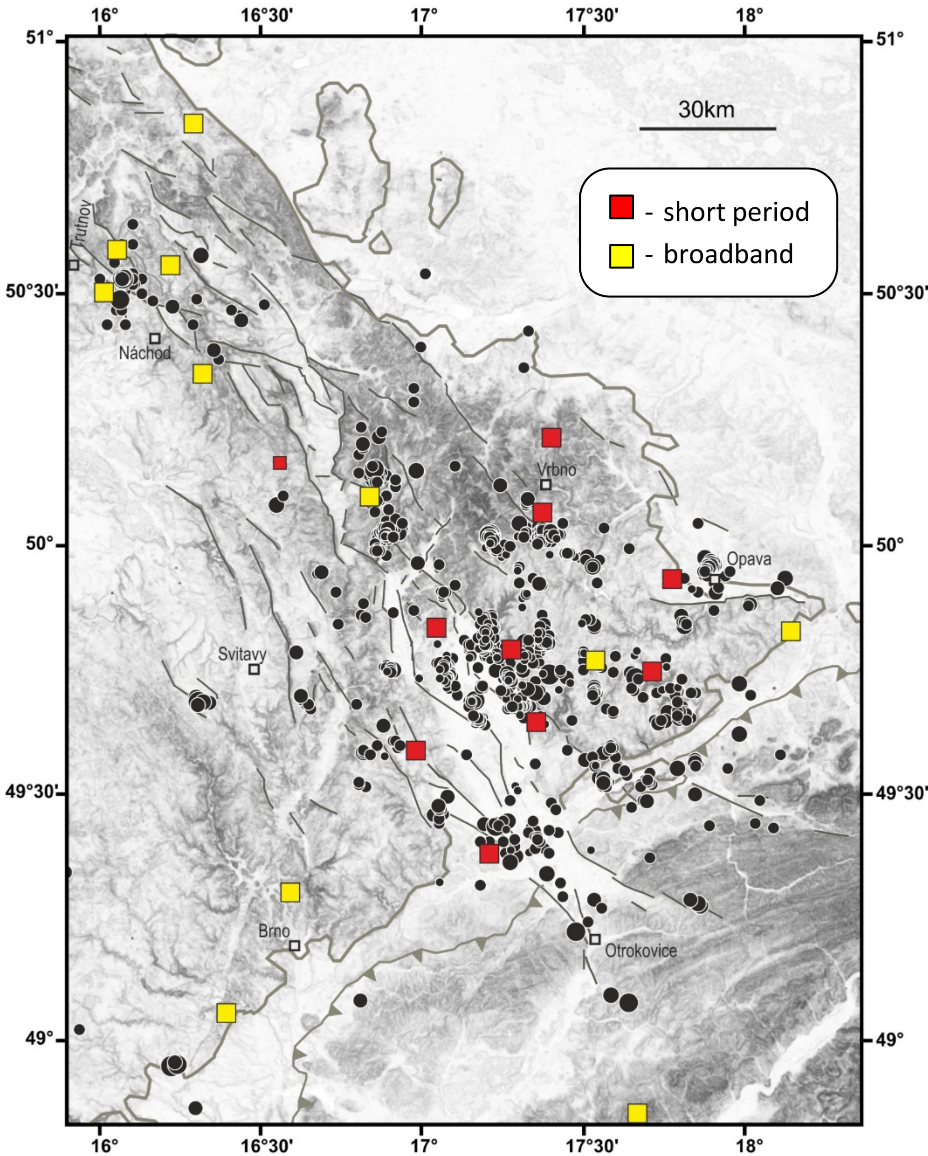
→ **QUESTIONS:**

- **Why is there increased activity?**
- **Can we expect some stronger earthquake to occur?**

Monitoring infrastructure
MONET and other stations

- developing since mid 1990s
- large seismically active area to be covered: >20000 km^2 inner perimeter
- today:
  - infrastructure of 4 institutions, all in CzechGeo/EPOS
  - Inner perimeter: 9 ½ stations of MONET (mostly short period)
  - Outer perimeter ~8 BB stations

    (mostly continuous recording and real-time transmission)
- data processed at IPE MU Brno



Present-day Seismicity

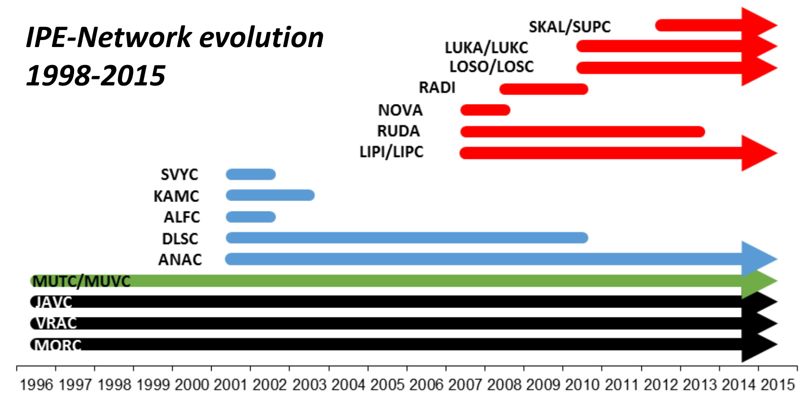
- 1996-2015 Catalogue:

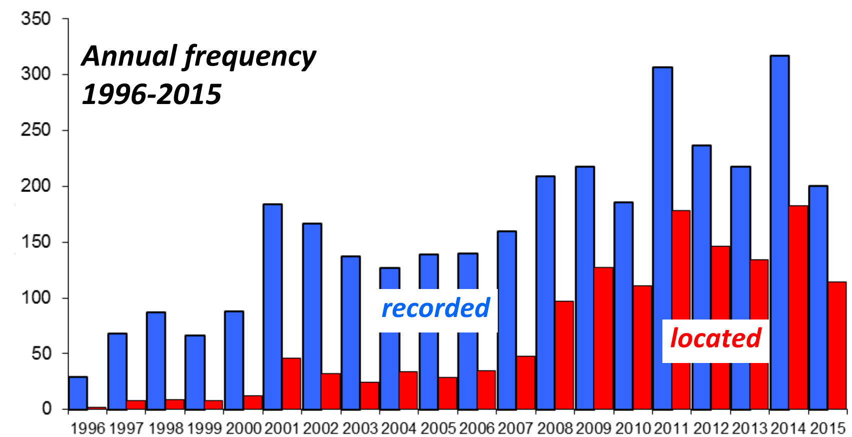
  ~3300 registered events

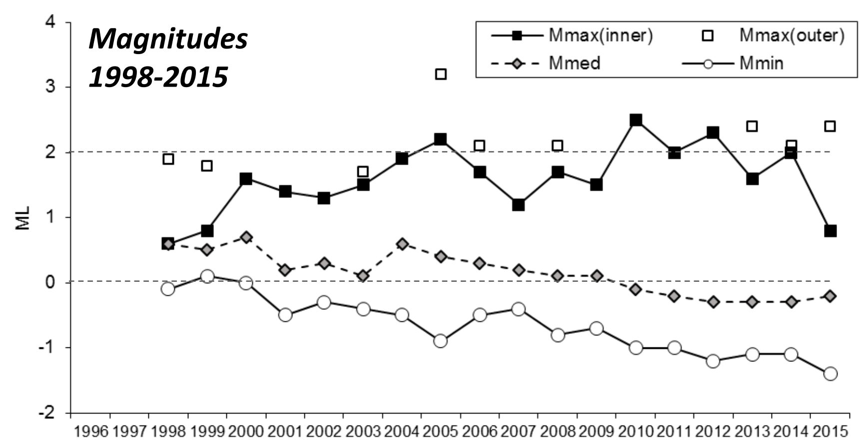
  ~1400 located events

- After major upgrades of network:
  - 200-300 recorded events/year
  - 100-200 located events/year

- Magnitudes are low:
  - Inner perimeter: M_{max}: 1.2 - 2.5
  - Outer perimeter: M_{max} = 3.3





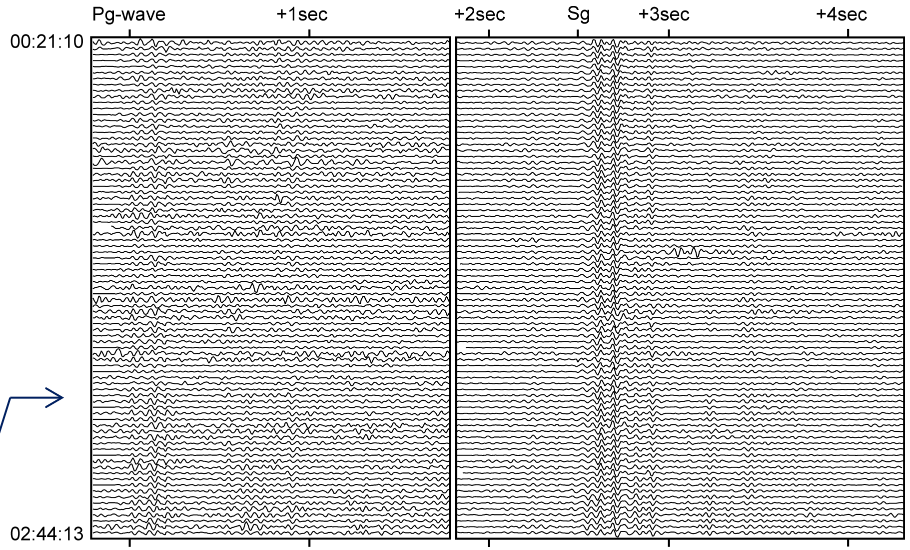


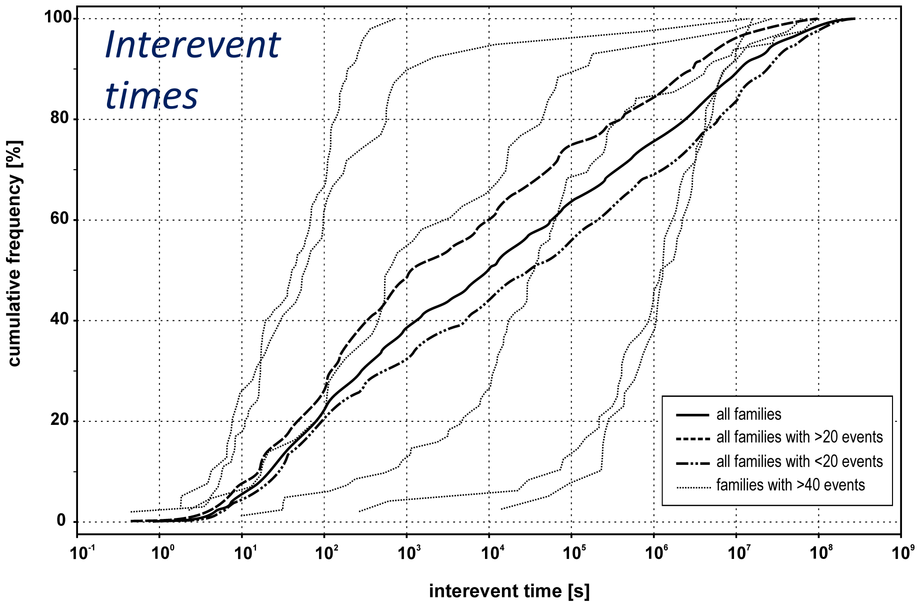
Present-day Seismicity

- Cross-correlation analysis

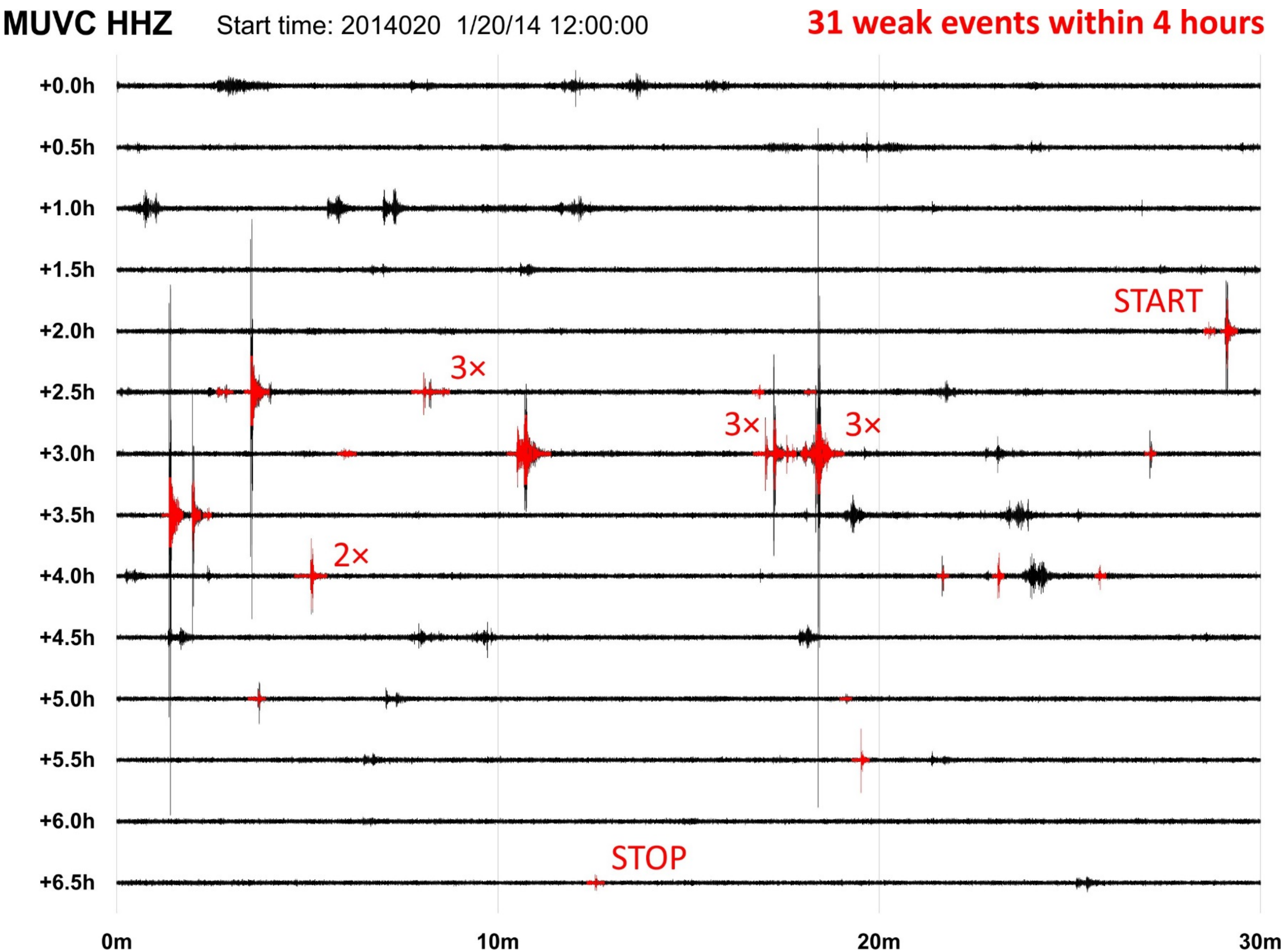
  ⟶ Ca. ¾ of recorded events are **duplets** or **multiplets** of other earthquakes (closely co-located foci)

  ⟶ variable dynamics of multiplet recurrence, e.g. 2.5-hour **microswarm** of 100 weak events or ~12-year sequence of repeated rupturing





Example of a microswarm



Present-day Seismicity

- Cross-correlation analysis

  → relocation:

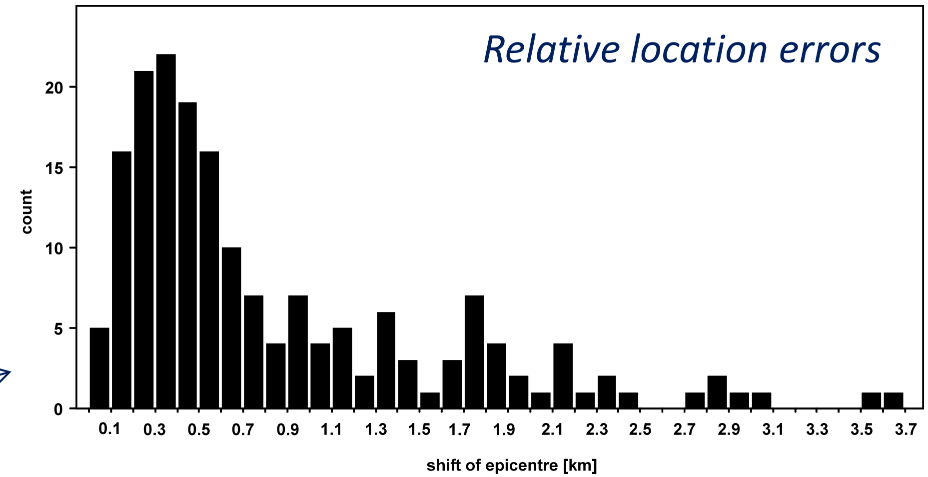
  Typical relative location error prior to relocation <700 m

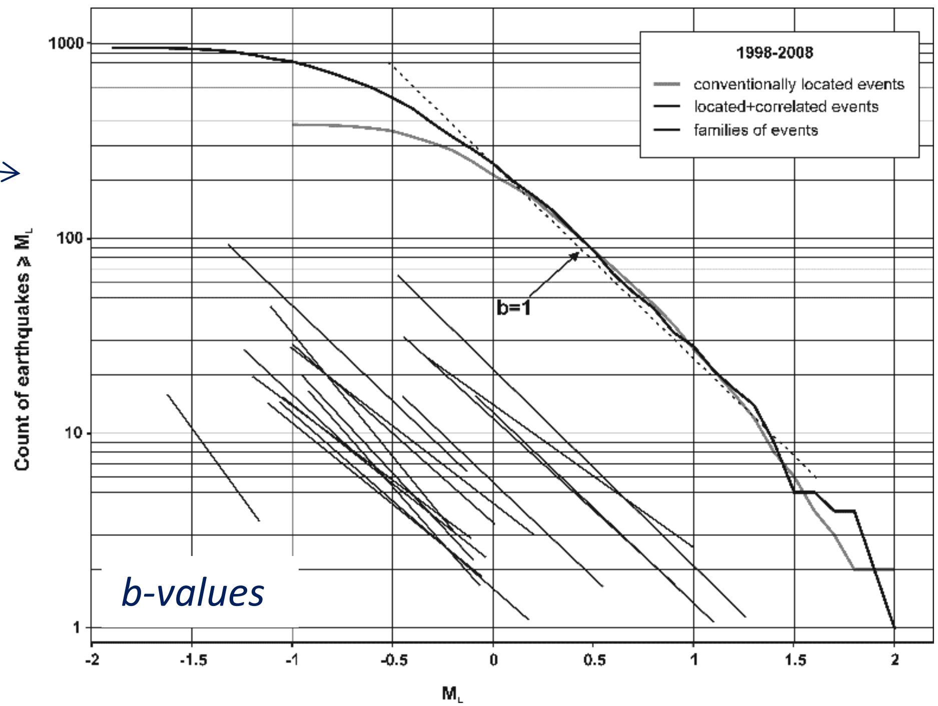
  → b-values:

  b=1 for whole catalogue

  b≈0.8-1.2 for individual multiplet families

Completeness: close to M=0 within inner perimeter

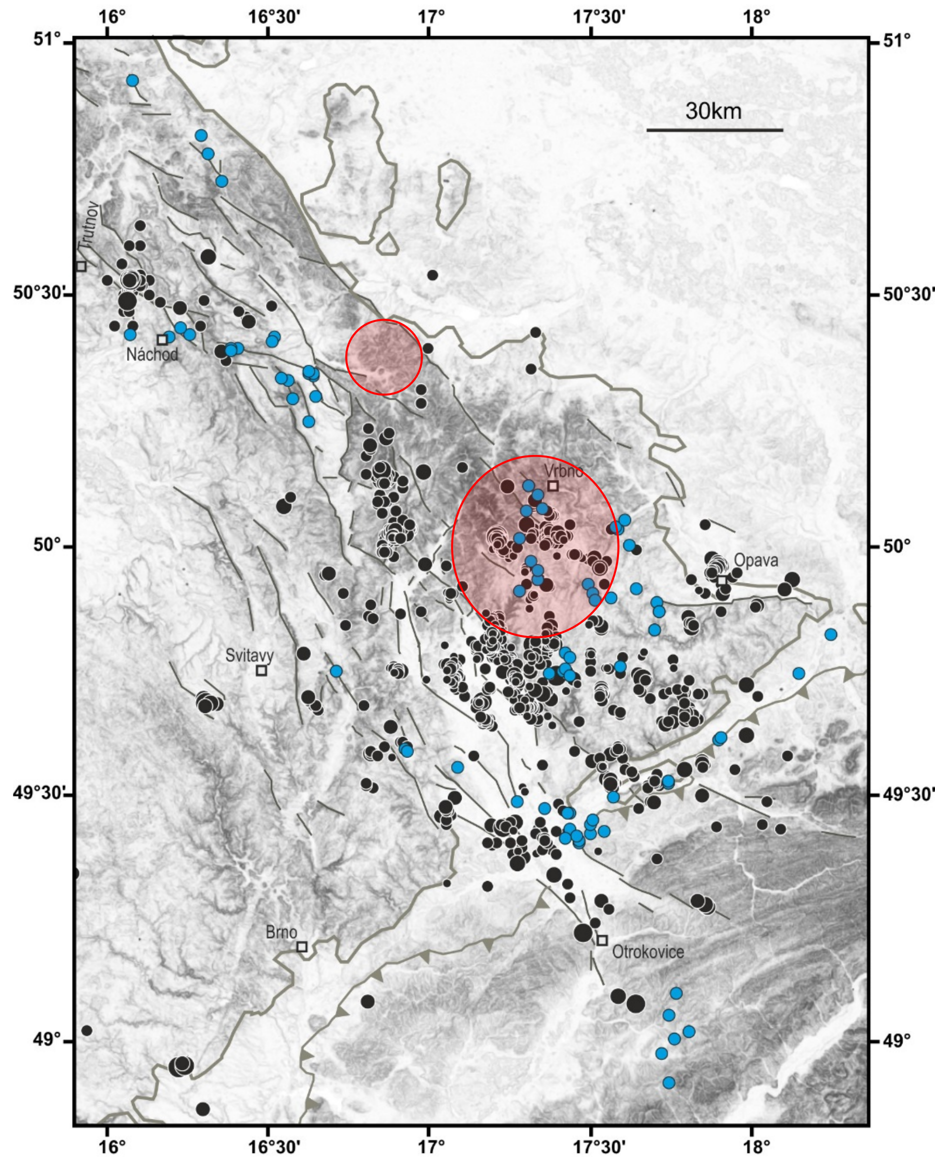




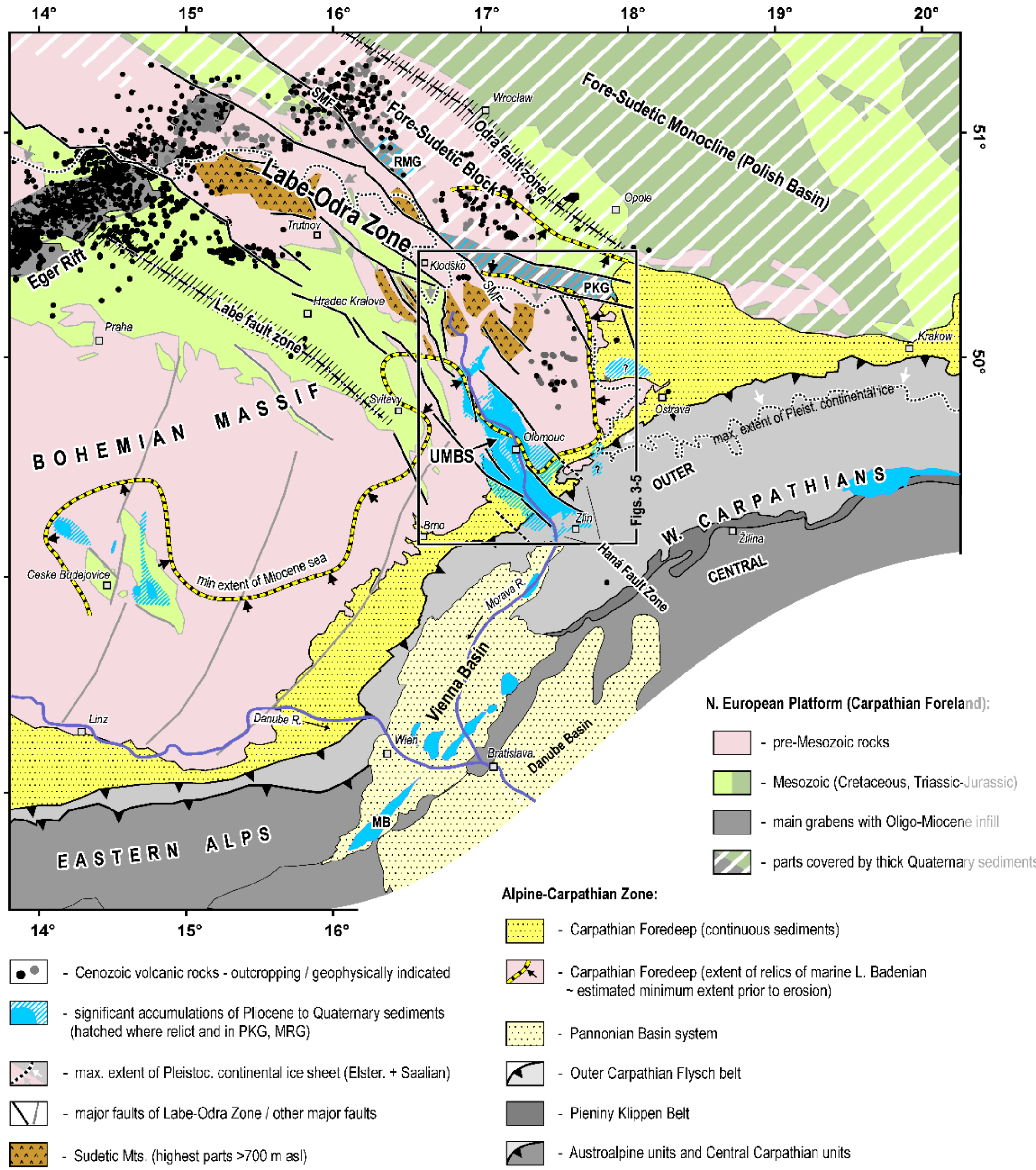
Present-day Seismicity

Coincidence with (post-) magmatic activity

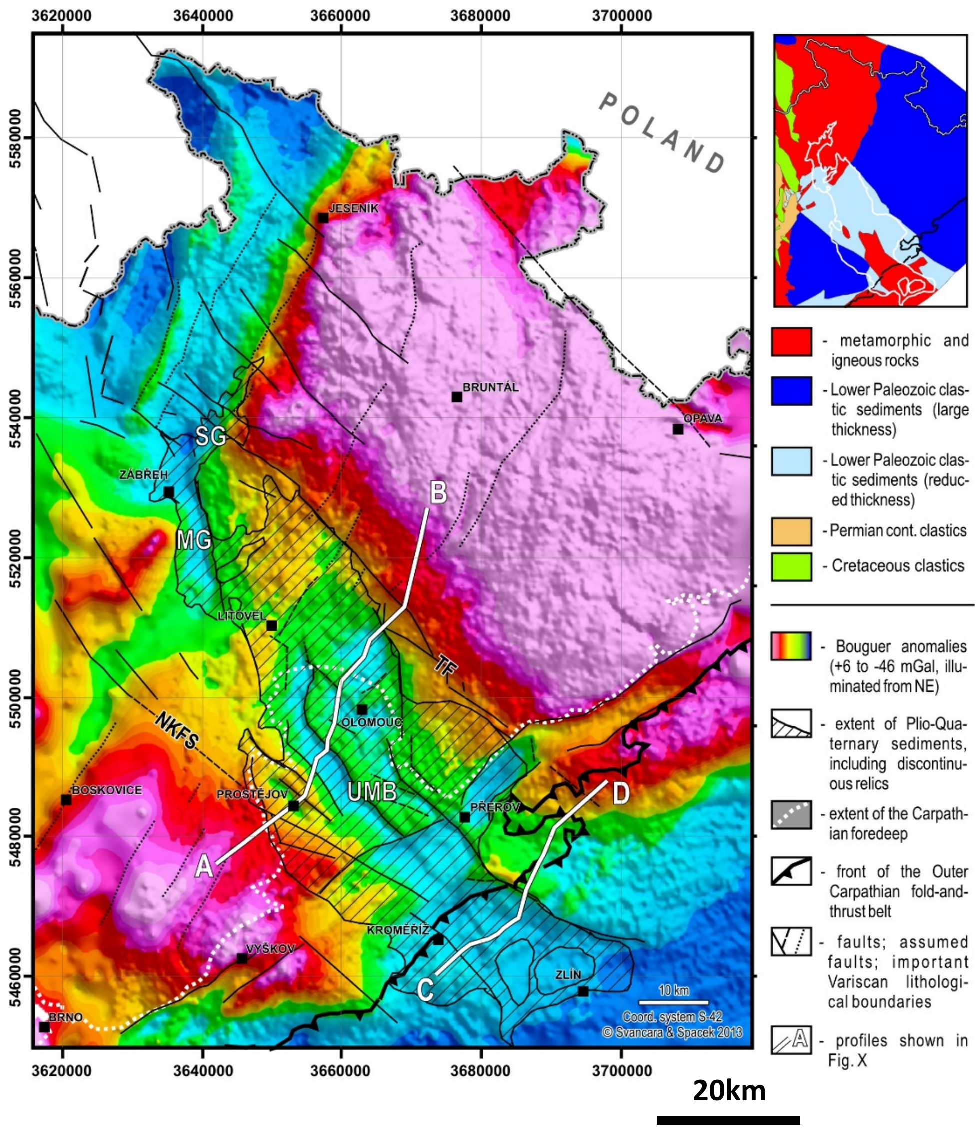
- Pliocene and Pleistocene basaltic eruptions – youngest 0.8-1.0 Ma (K-Ar)
- >80 carbonated min. springs
- Teplice: CO_2 flux up to 500 t/y



Upper Morava Basin System (UMBS)

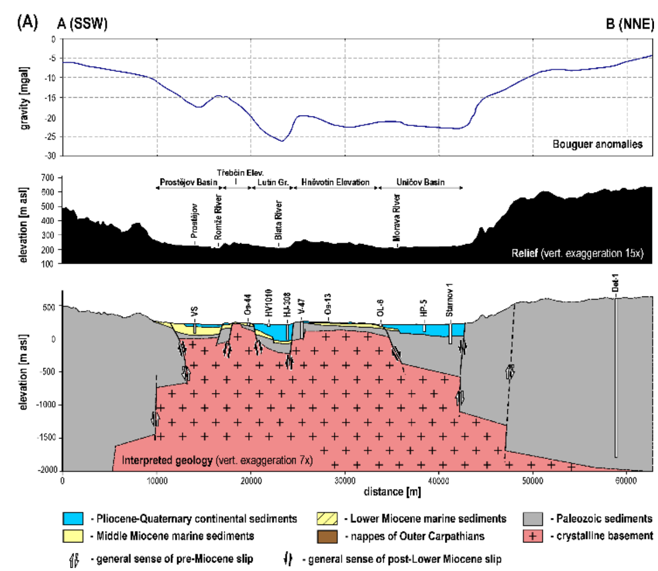


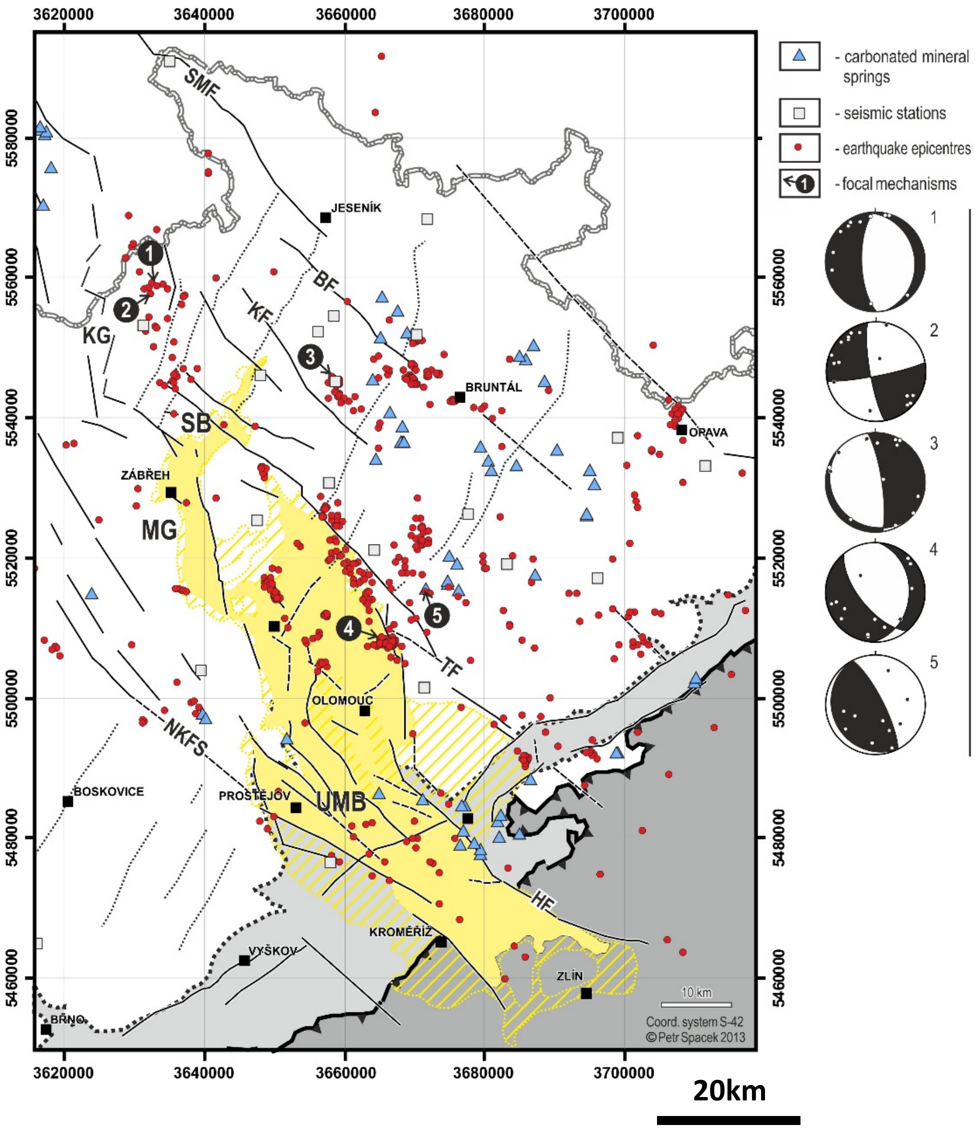
- part of Paratethys in Miocene
- largest **accumulation of Plio-Quaternary sediments** in the region
- superposed onto Carpathian deformation front and foreland basin
- in a close contact with and roughly perpendicular to the Vienna Basin



Fault Zone controlling subsidence in UMBS

- Haná fault zone with long and complex slip history
- >2 km Paleozoic sediment missing here due to pre-Miocene uplift and erosion

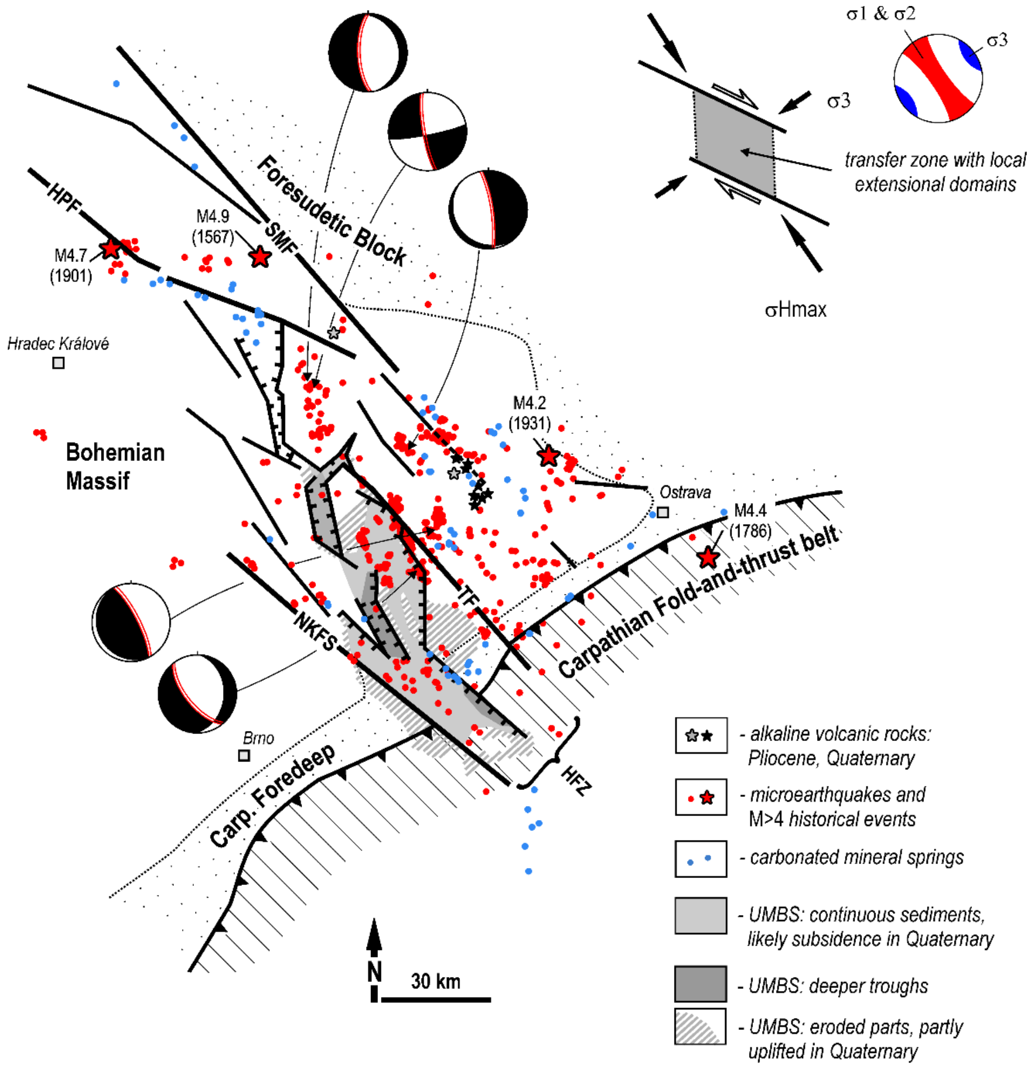




Young basin subsidence

UMBS

- superposed onto Carpathian deformation front and foreland basin
- pronounced morphology: flat relief 200-400 m lower than the adjacent uplands
- 300+ m of Pliocene sediment in narrow grabens (mostly lacustrine)
- up to 60 m of Pleistocene (Elsterian) sediments in narrow grabens (fluvial/lacustrine)
- coincidence of epicentres with major faults at NE margin and other parts of basin
- rare focal mechanisms indicating dip-slips, and dextral strike slip on steep, N-S to NW-SE striking faults



Tectonic summary

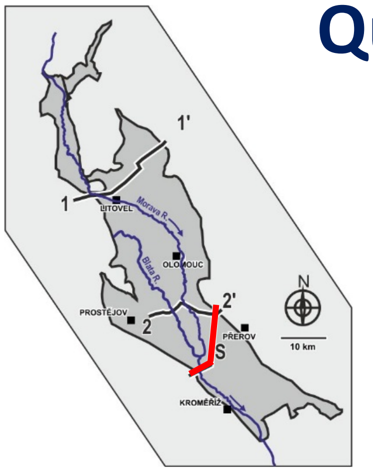
(Late Cenozoic and present)

- rhomb-shaped region with well defined WNW-ESE to NW-SE boundaries
- regional-scale coincidence of seismicity and CO_2 flux
- focal mechanisms: dip-slips, and dextral strike slip on steep, N-S to NW-SE striking faults
- indication of local permutations of σ_1 and σ_2

→ **transfer zone with extensional (transtensional) domains**

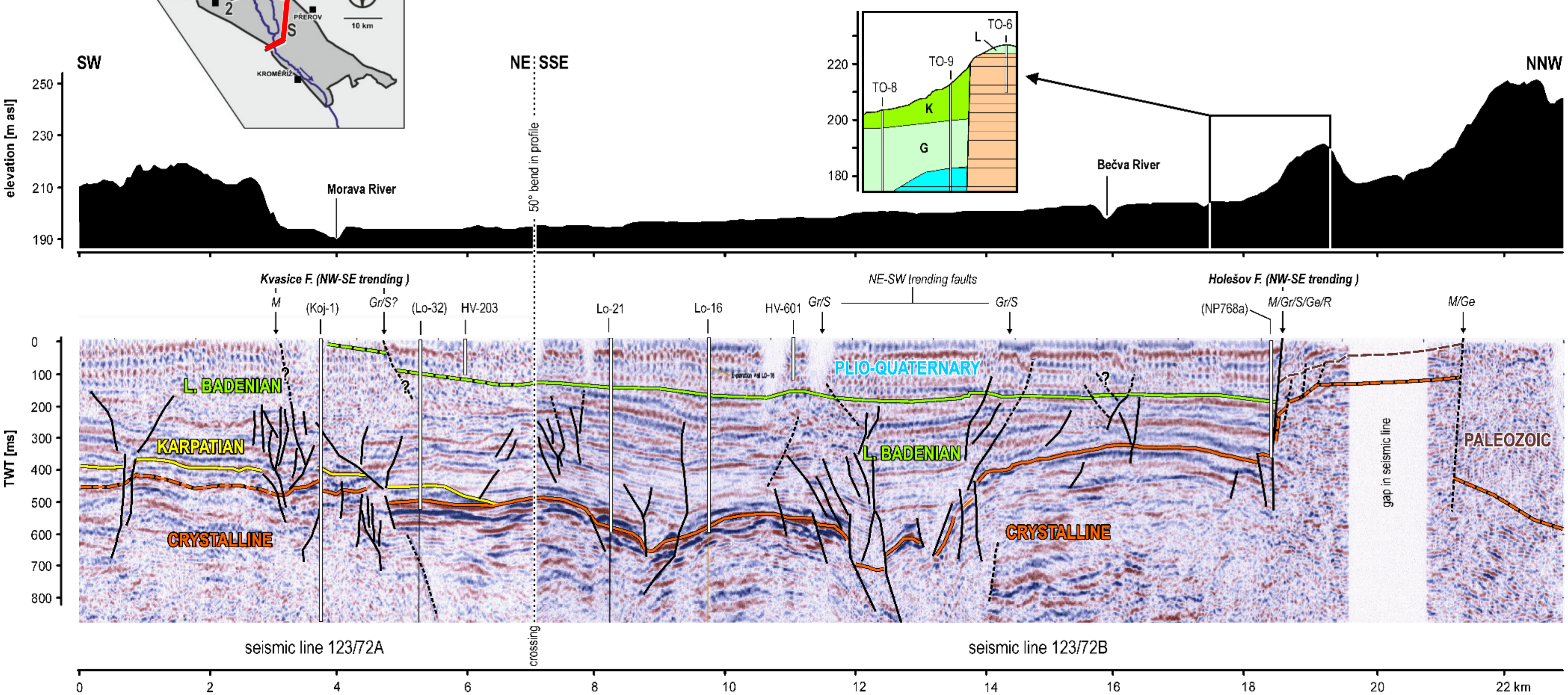
- similar mechanism for both the Plio-Pleistocene basin system and present-day situation?

Quaternary faulting



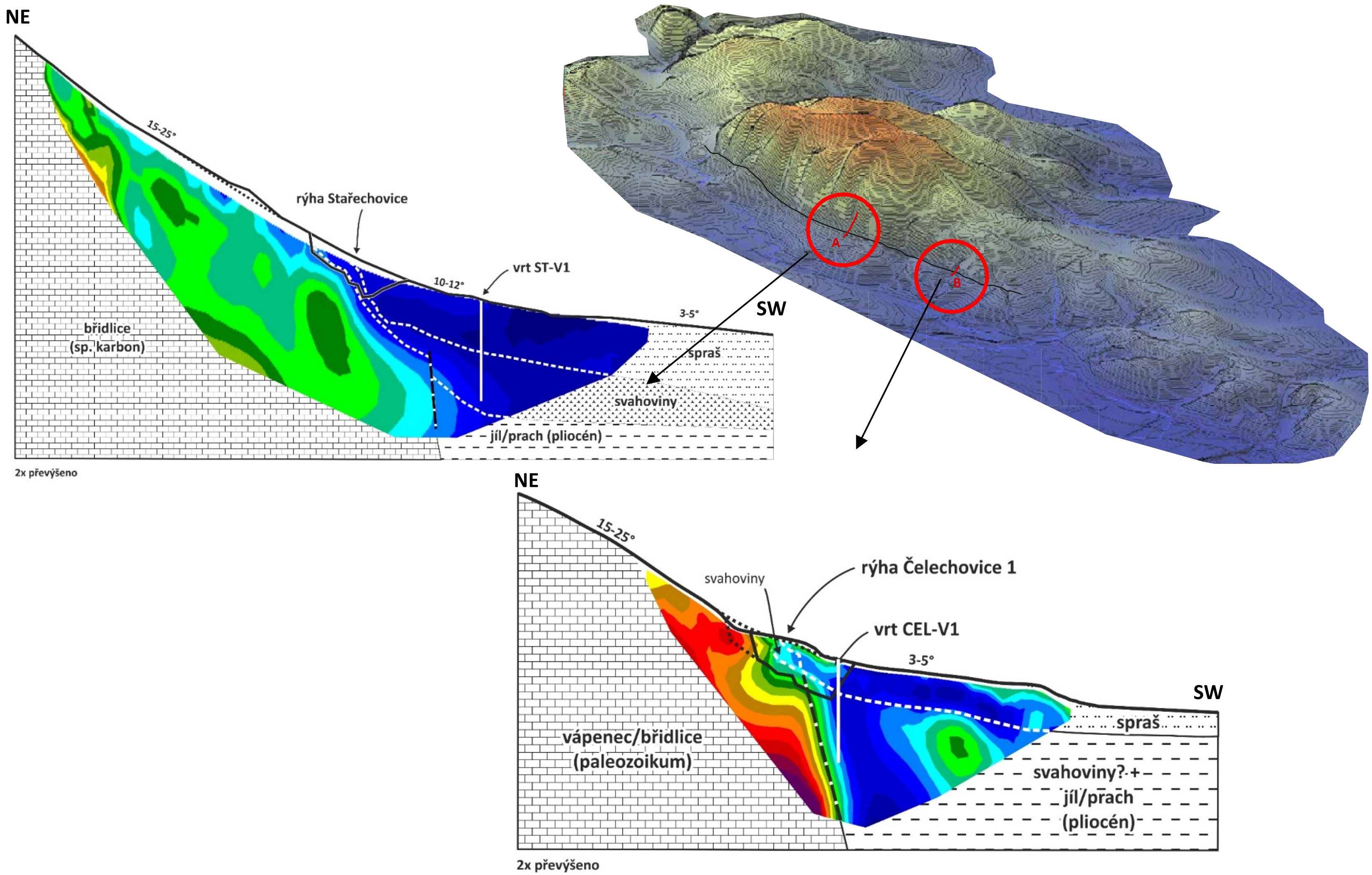
Seismic section across NE margin of the UMB

- Holešov fault – ~60° dip, ~300 m apparent vert. throw since L. Badenian; min. 20 m post-Early Saalian (240 ka) throw



Field data by Geofyzika 1972; reprocessed by M. Novotný in Dvořáková et al. 1998; reinterpreted by Špaček

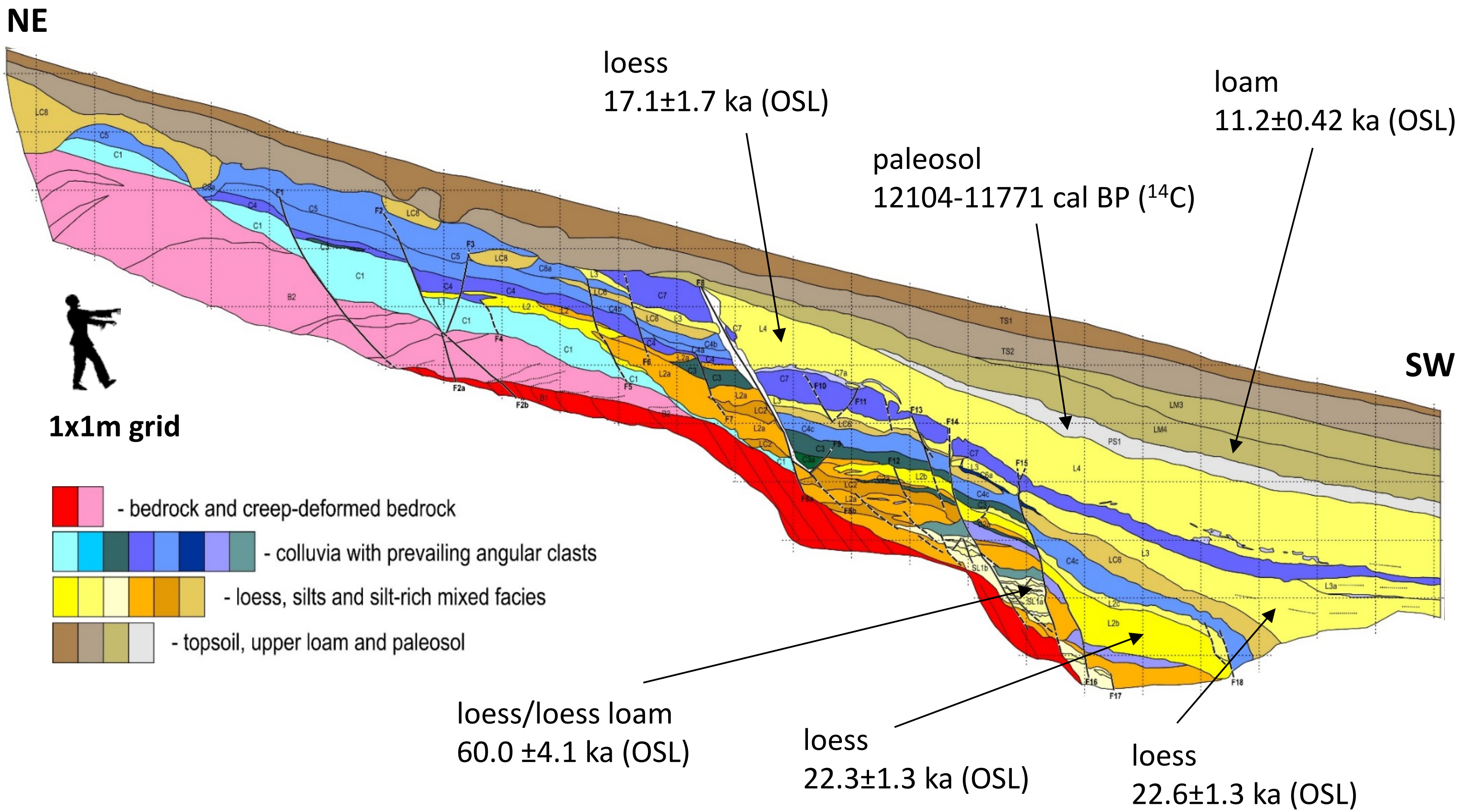
Pre-historic seismicity? Trenching at the Kosíř Fault




STAR-R1
CEL-R2

Example of a trench on the active fault

- **youngest fault: ~1.6 m slip between ~17-11 ka**



Late Quaternary slip at Kosíř Fault

Conclusions based on 3 trenches + boreholes

- Oblique normal fault with minimum slip of 15 m in the last ~60 ka
- Last slip within 11-17 ka, prior to formation of Holocene soil
- Surprisingly large slip rate ~0.1-0.3 mm/a in this late phase
- Surface faulting related to earthquakes not ruled out
- No slip in Holocene
- To date unknown regional extent of faulting

Summary and perspective

- Whole-crustal (whole-lithospheric) faulting: relations between seismicity, (post)magmatic activity and subsidence
- Weak seismicity as the only source of data on present-day deformation in the seismogenic crustal levels
- Detailed monitoring by CzechGeo/EPOS infrastructure

  → Location of active fault zones

  → Focal mechanisms and stress

  → Understanding tectonic regime

  → Trenching on active faults

  → Inputs for SHA

The End. Thank You!