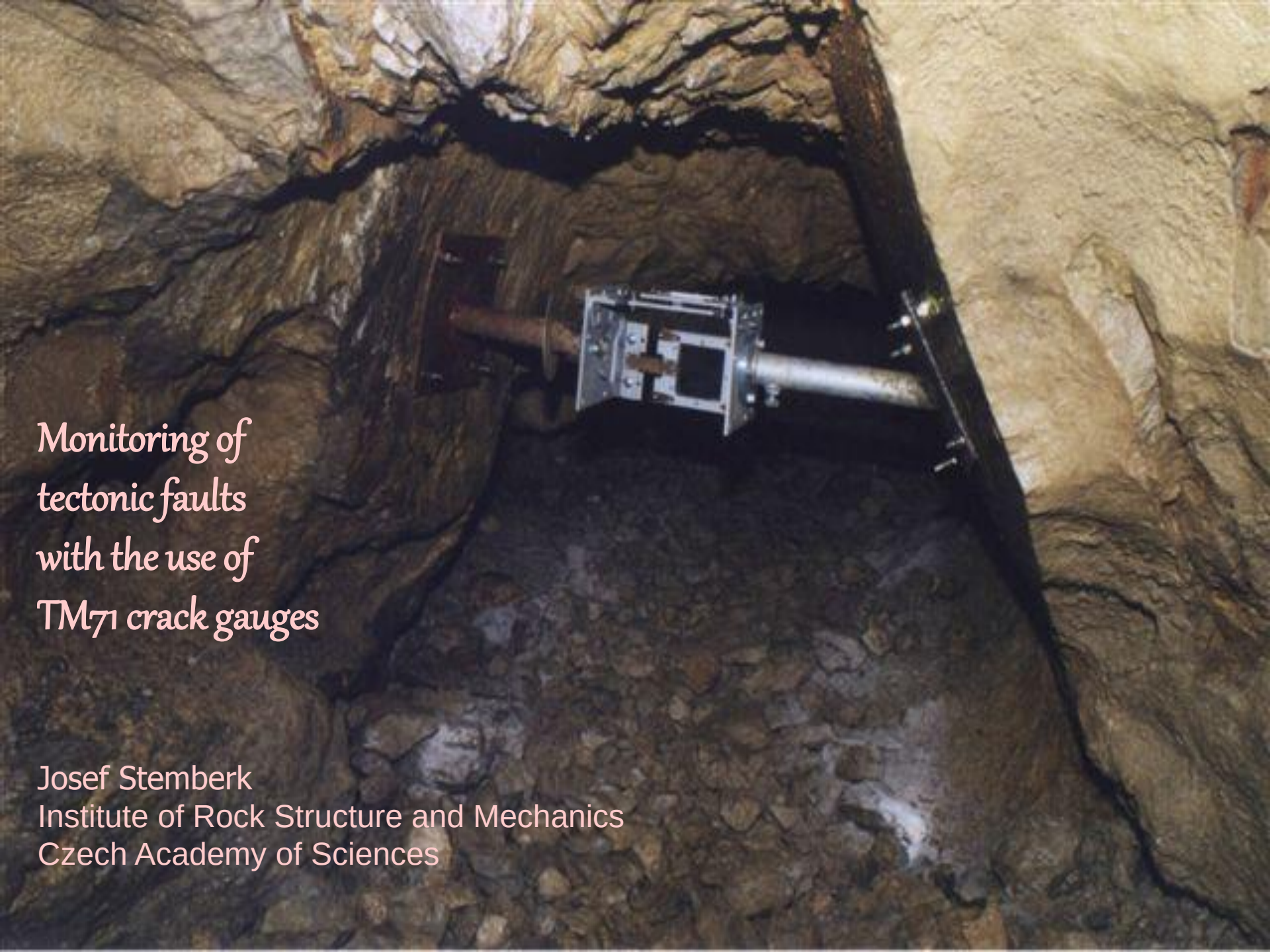
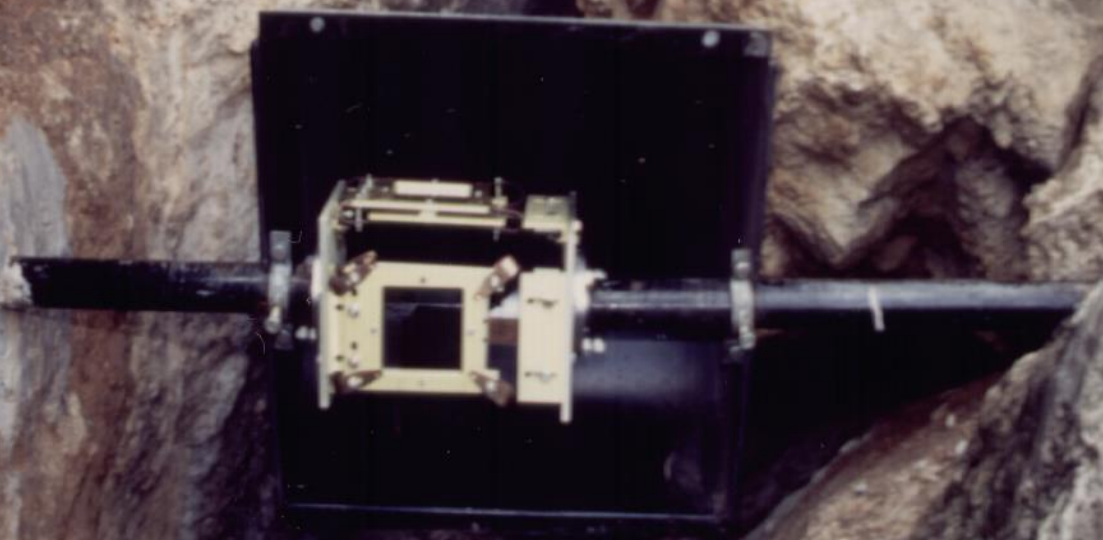


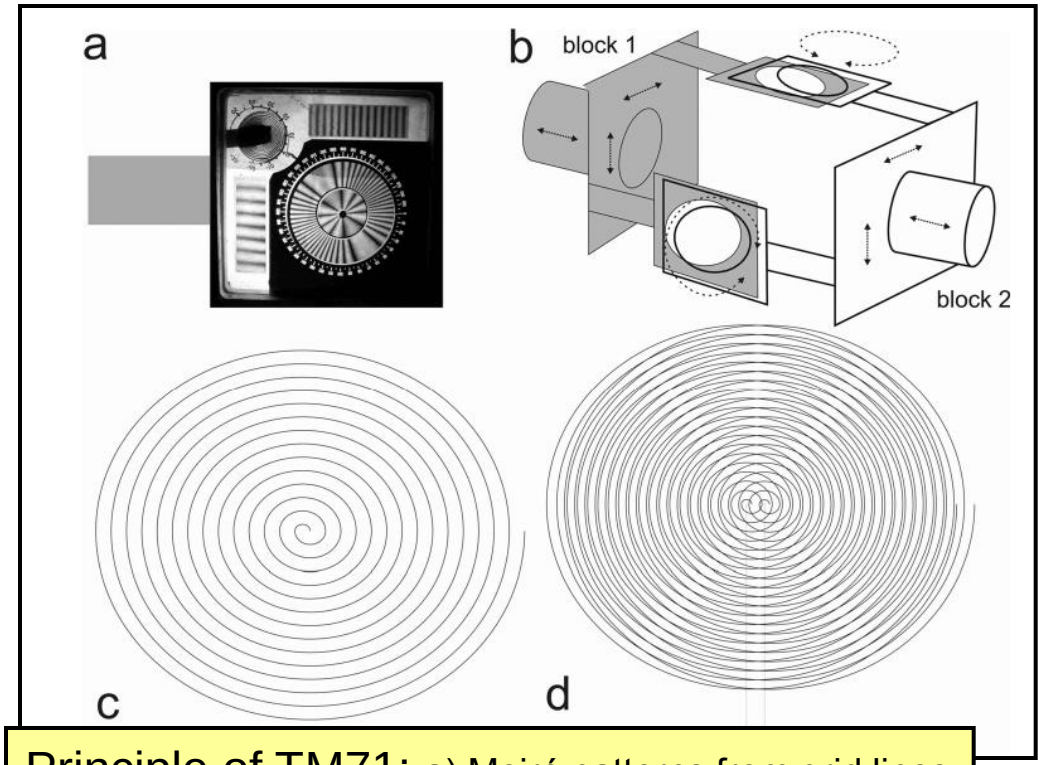
Monitoring of tectonic faults with the use of TM71 crack gauges

Josef Stemberk
Institute of Rock Structure and Mechanics
Czech Academy of Sciences

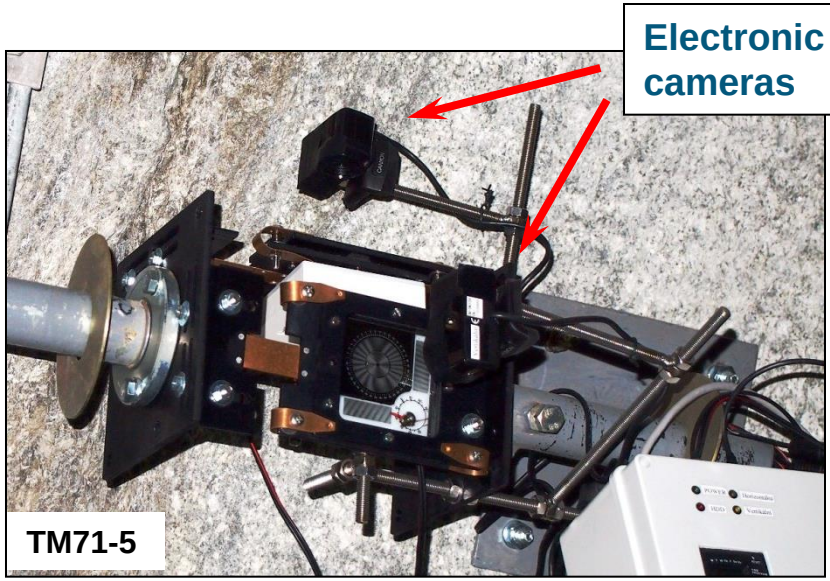
For recording of very small displacements a 3-D gauges (TM71) was developed
- sensitivity in order of 0,0X – 0,00X mm



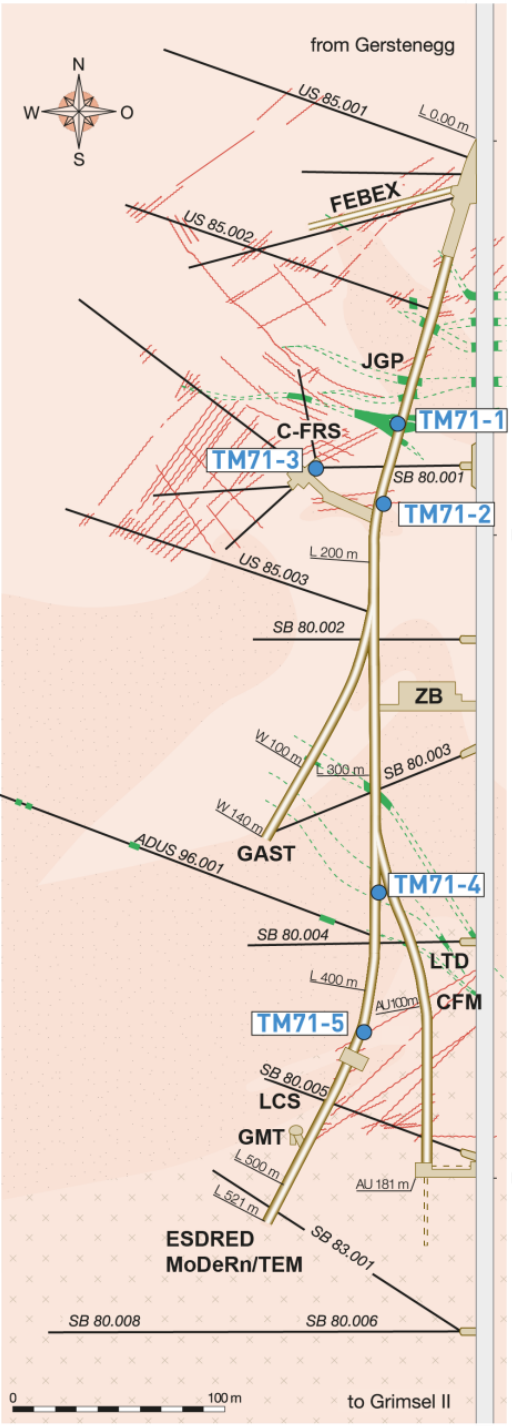
Basic presumption:
Recent stress is transformed along discontinuities (faults) which disrupt rock massif to micro-displacement between blocks



Principle of TM71: a) Moiré patterns from grid lines
b) installation for 3-D measurement; c) single grid line;
d) interference of two identical grid lines



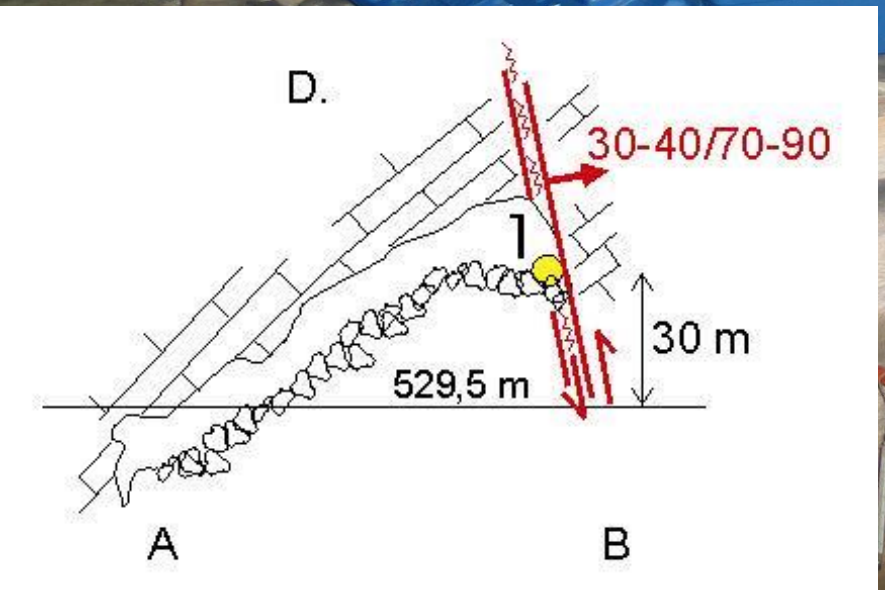
Interferences are scanned once a day (00:00 CET, 23:00 GMT)
Transfer via internet to IRSM for evaluation (see www.tecnet.cz)



Instrument	*Position*	*Geological feature*	*Feature orientation*	*MAC adress*	*IP:*
	Tunnel meter		*Azimuth/Dip [°]*		*Port number*
TM71-1	L124.5 W face	~2 m wide lamprophyre, strongly sheared and foliated zone TM71 is attached to CAGR bedrock and CAGR inclusion in the lamprophyr	195/83		
TM71-2	L175.3 E face	Thin shear zone in CAGR	168/67		
TM71-3	BK northern arm ESE face	Shear zone with fault gouge, 3-4 cm wide	232/77	00:60:e0:54:4e:8b	192.168.10.142:1194
TM71-4	VE, L352.0 E face	Sheared lamprophyr, ~8 cm wide	185/70		
TM71-5	VE, L418.5 E face	strongly foliated shear zone in granodiorite	150/77	00:60:e0:54:4e:8b	192.168.10.142:1194

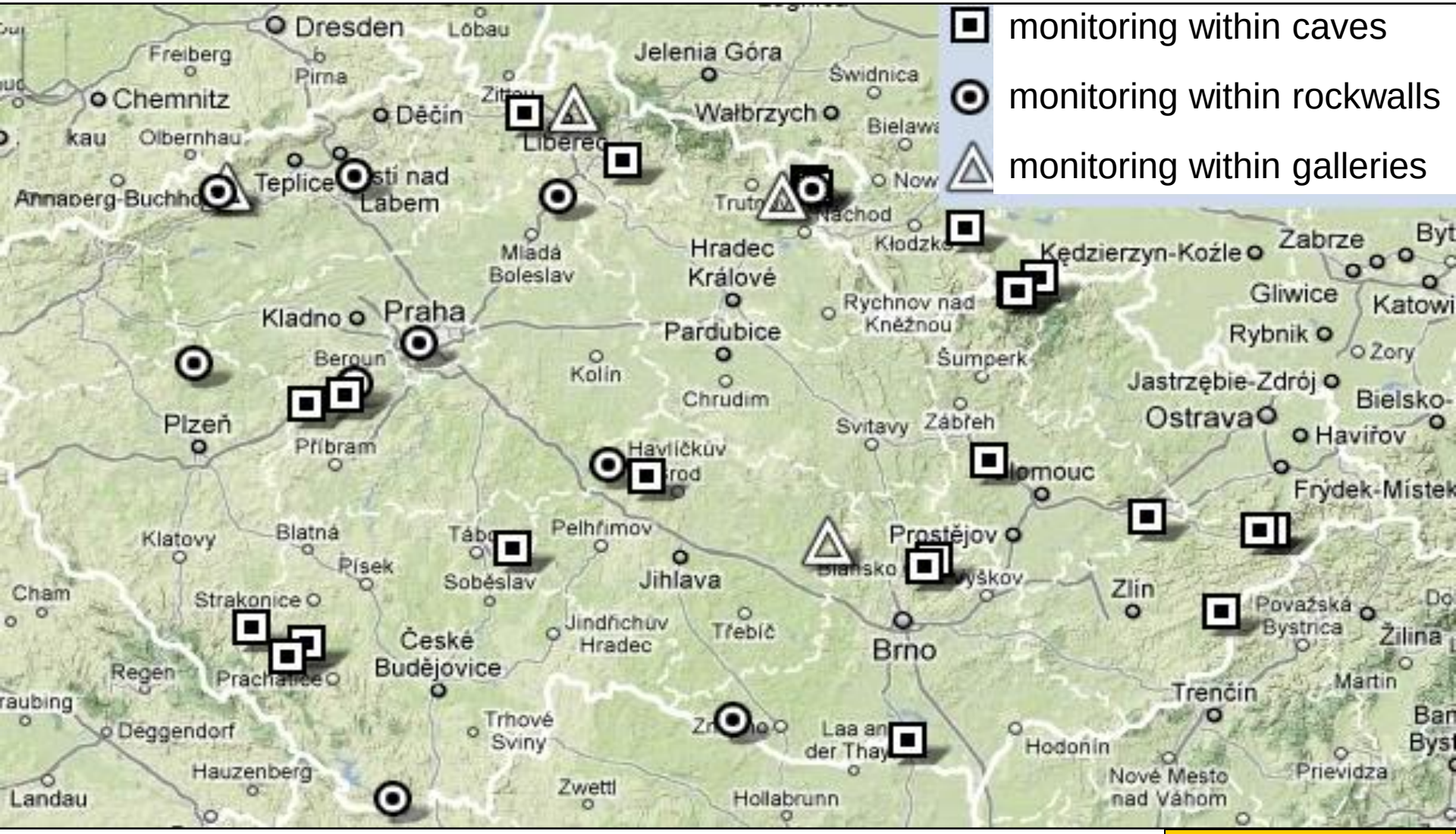
Postojna Cave, Slovenia

Fault plane 30-40°/70-90°



Site No 1

TecNet – Bohemian Massif



www.tecnet.cz

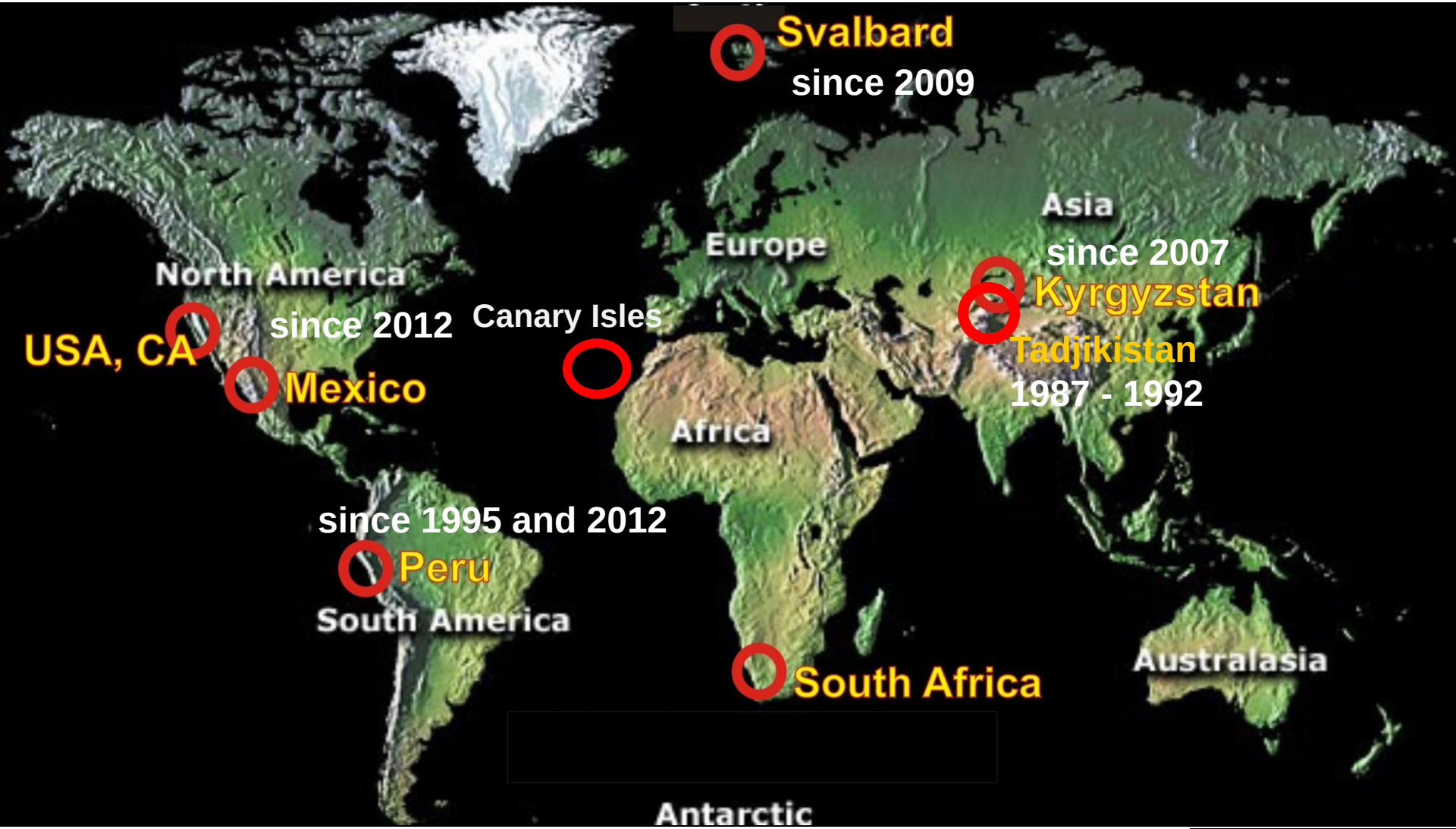
Cooperating European Countries:

- Poland
- Slovakia
- Germany
- Austria
- Switzerland
- Slovenia
- Italy
- Bulgaria
- Greece
- Spain (Canarian Isles)
- Norway (Spitsbergen)
- Belgium
- ……

www.tecnet.cz

Monitoring activities in the Europe

TecNet Global



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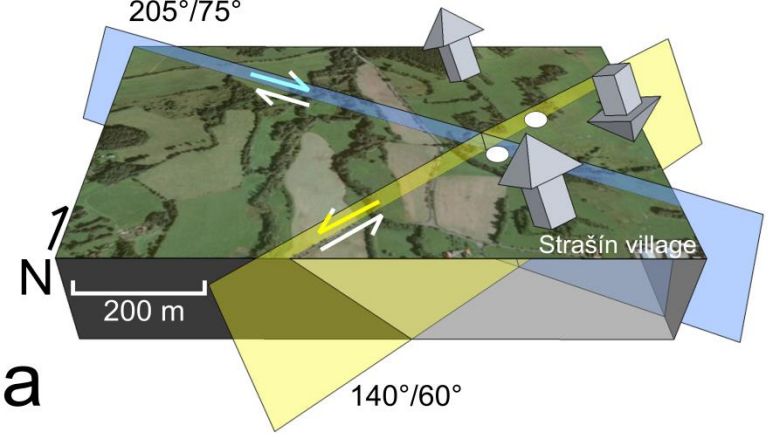
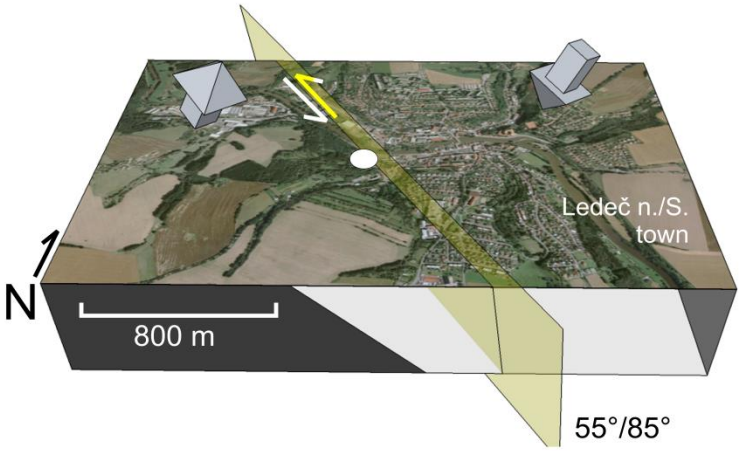
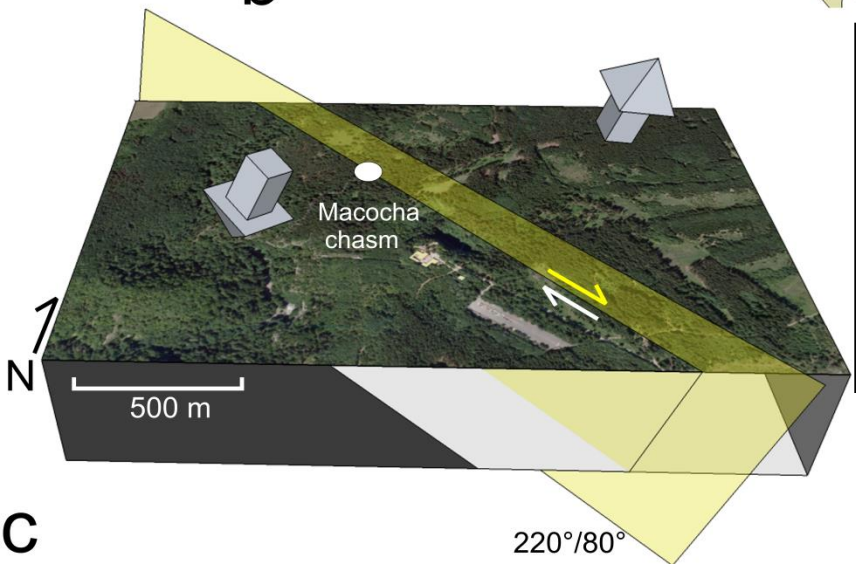
Monitoring activities outside of Europe



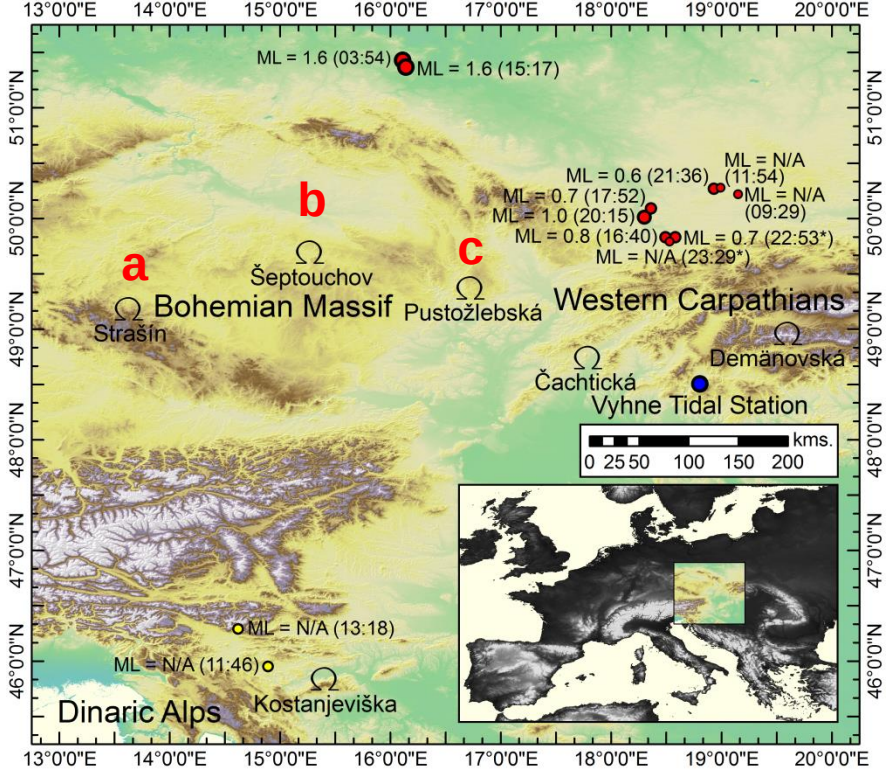
a



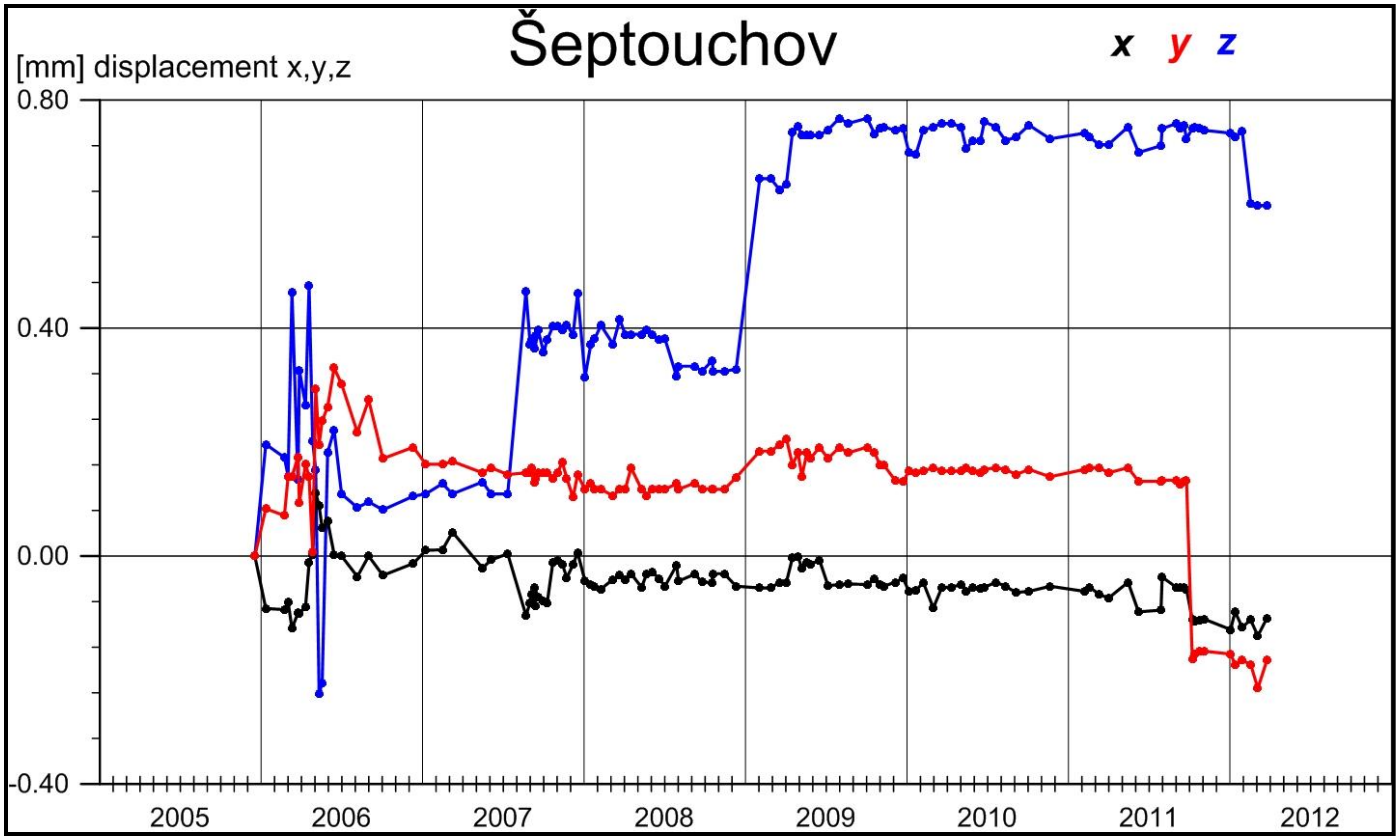
b



c



A series of schematic three-dimensional block diagrams representing the long-term displacements recorded at each site.
(a) Strašín Cave; (b) Šeptouchov Cave;
(c) Pustožlebská Cave



Fault displacment recorded on deep seated Sazava Fault, Central Bohemia

Black lina: displacement along axis x (extension or compression)
Red line: strike slip along axis y
Blue line: vertical displacement along axis z

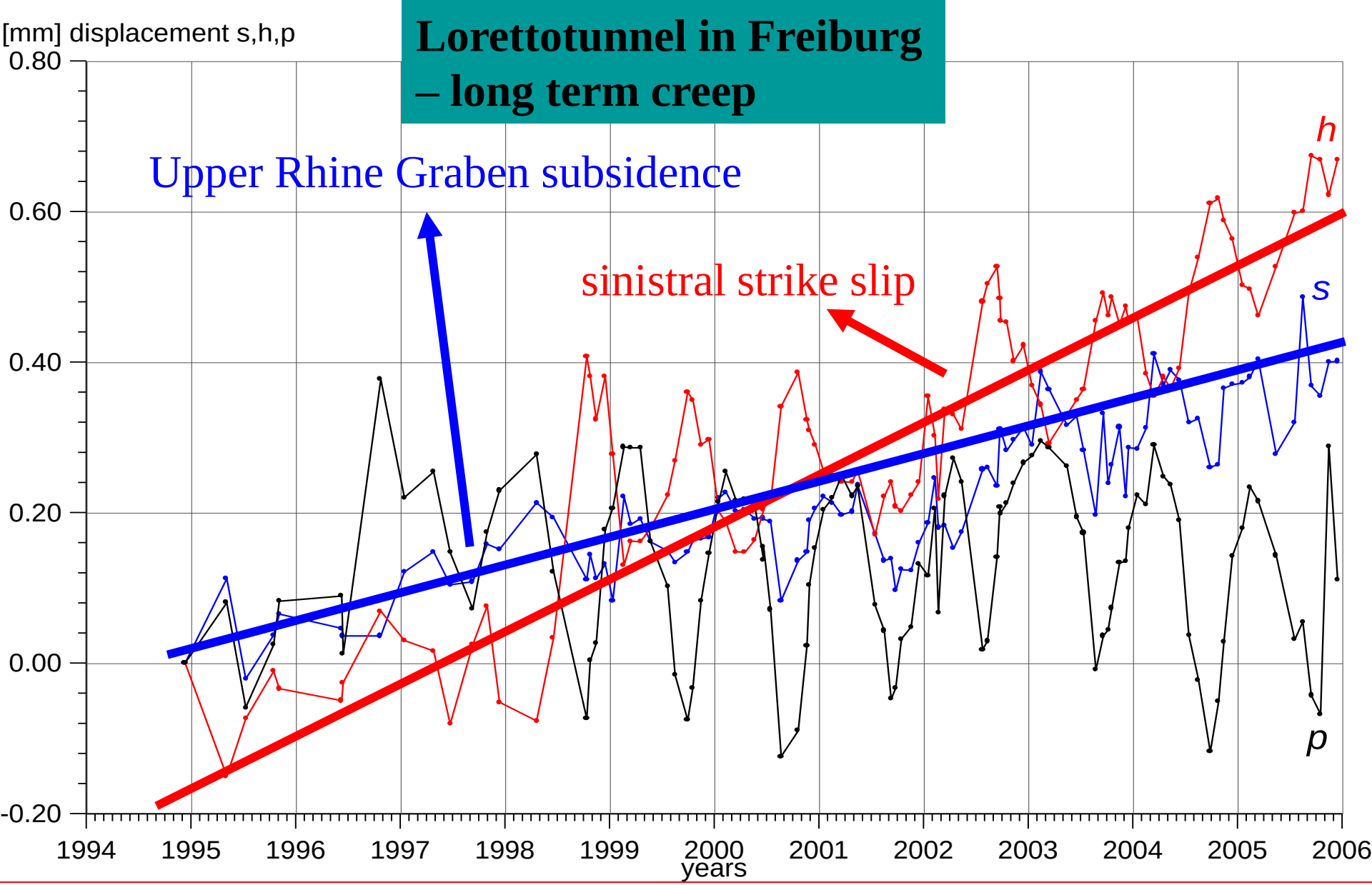
Principal results after 15 years of regular monitoring:

1. **Long term trends (creep x pulse)**

   - pulse movements are recorded across Europe simultaneously (Stemberk et al. 2010 in Tectonophysics)
   - vertical component predominates
2. Temporal changes of movement trend
3. Unusual development before local earthquake

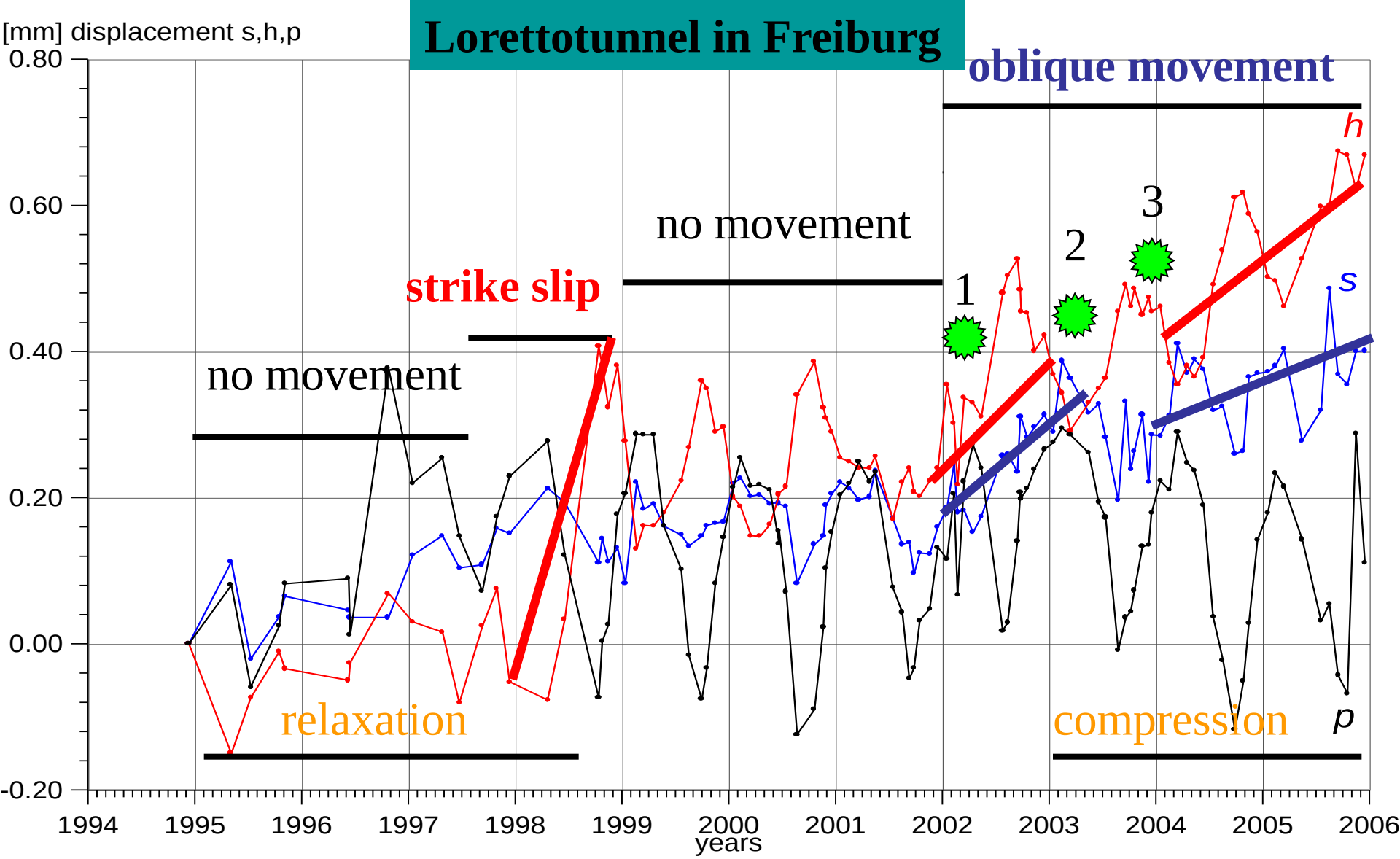
Tectonic creep recorded in Upper Rhine Graben

Lorettotunnel in Freiburg – long term creep



Movement components:

h – strike slip; s – fault slip; p – fault opening/closing



Temporal changes of movement trend

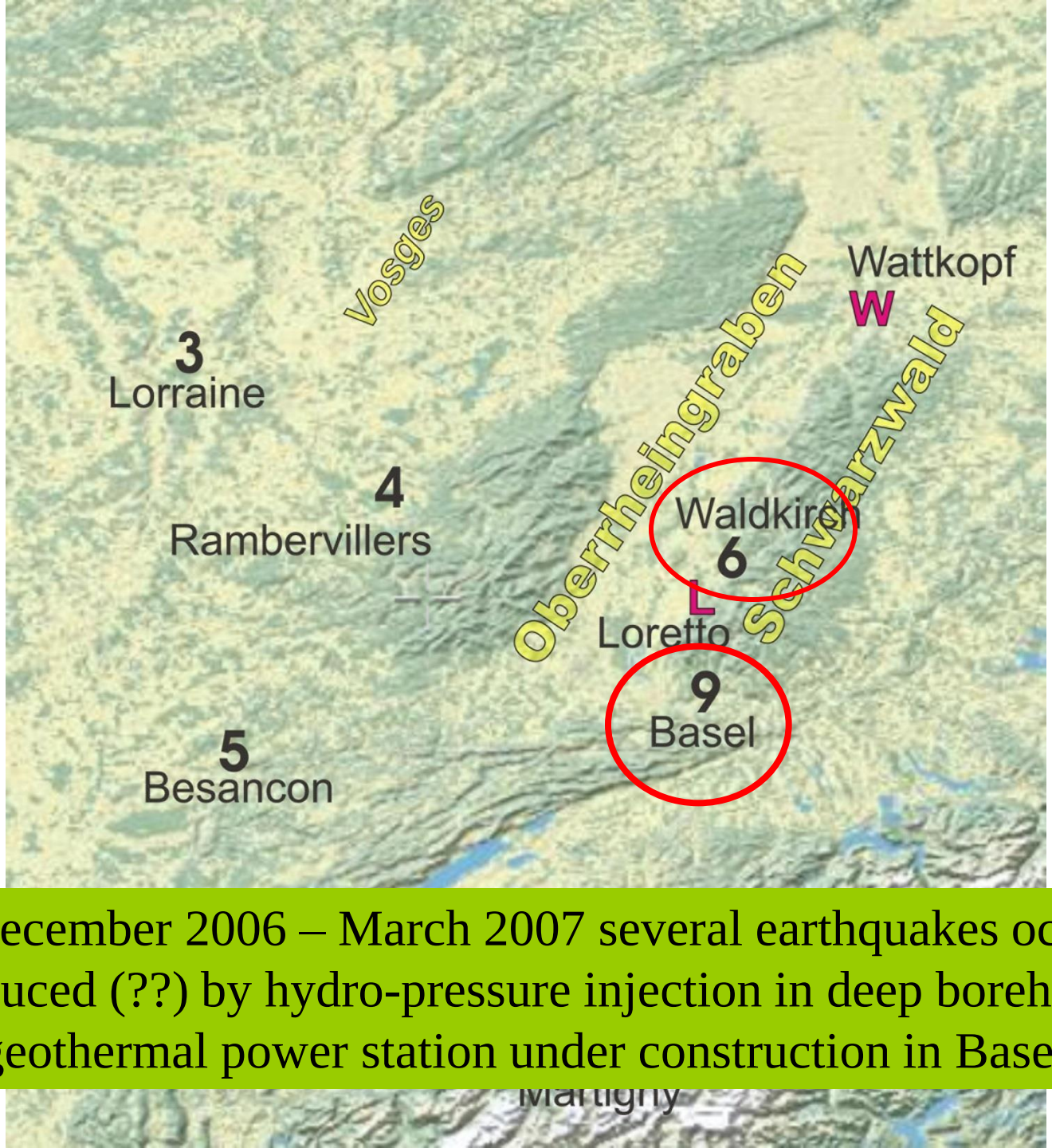
s – fault slip ; h – strike slip ; p – fault opening/closing

(regional earthquakes: 1 – Rambervillers; 2 – Besancon; 3 – Waldkirch)

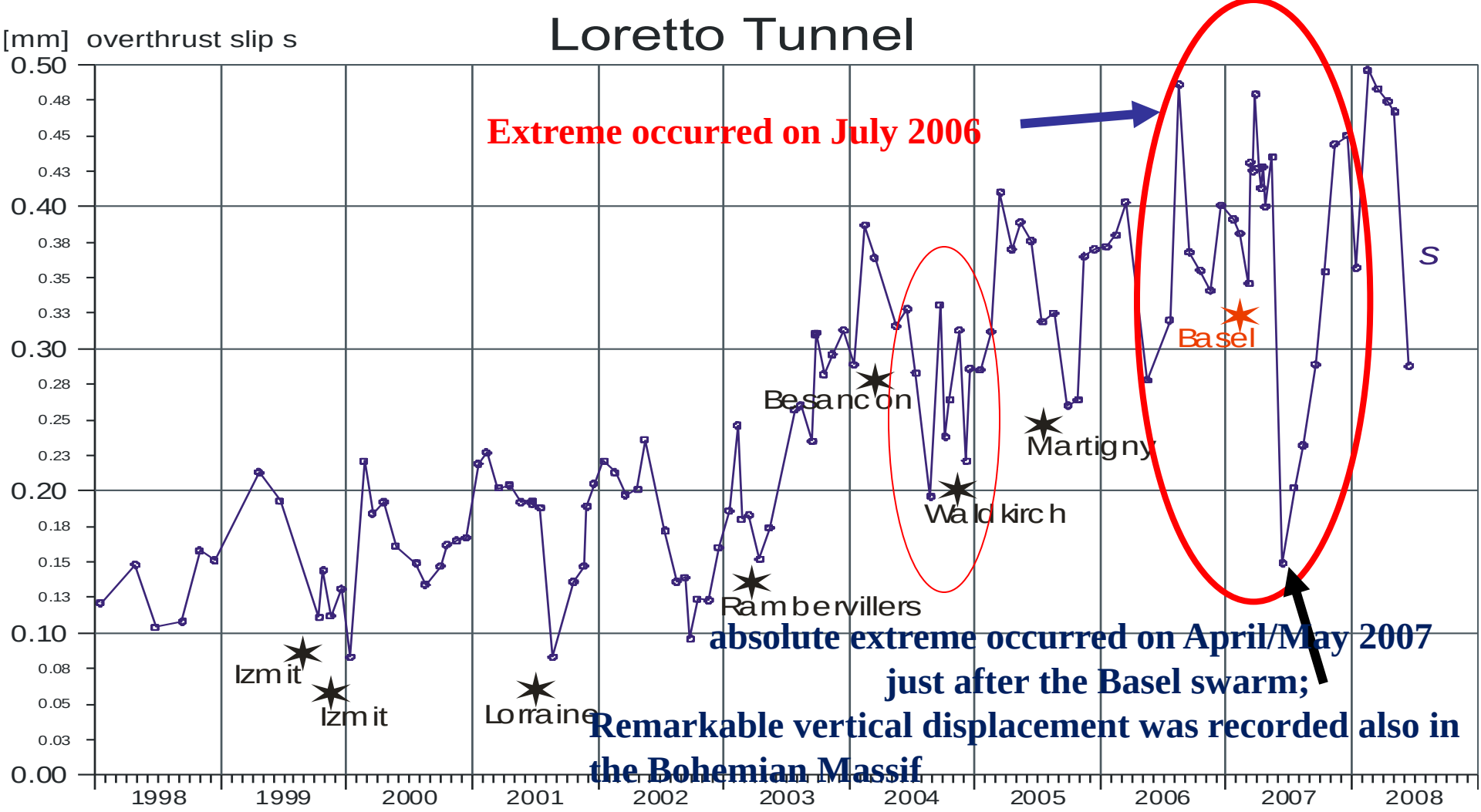
Principal results after 15 years of regular monitoring:

1. Long term trends
2. Temporal changes of movement trend

3. **Unusual development before regional earthquakes**



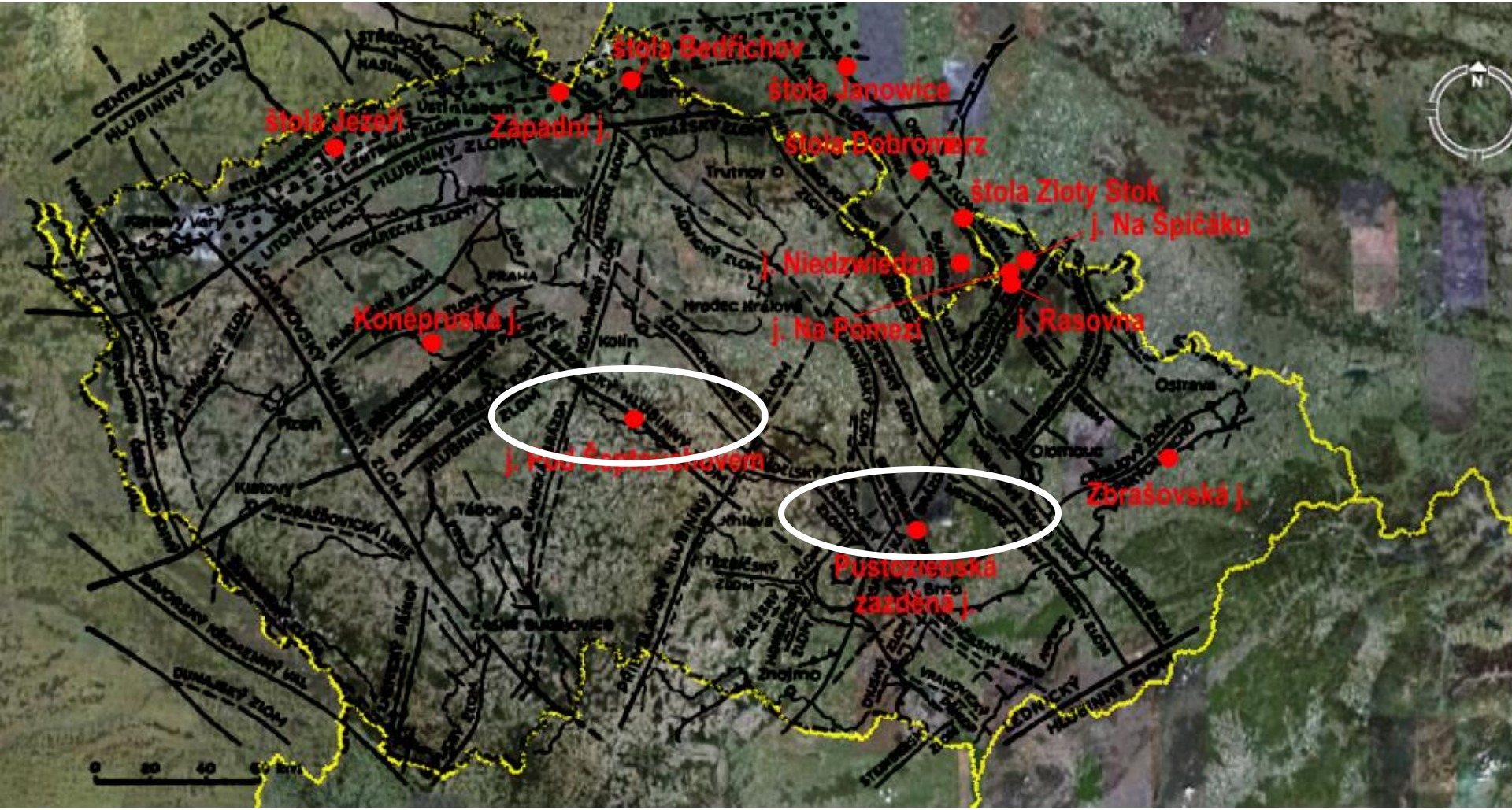
During December 2006 – March 2007 several earthquakes occurred in Basel induced (??) by hydro-pressure injection in deep borehole at the geothermal power station under construction in Basel



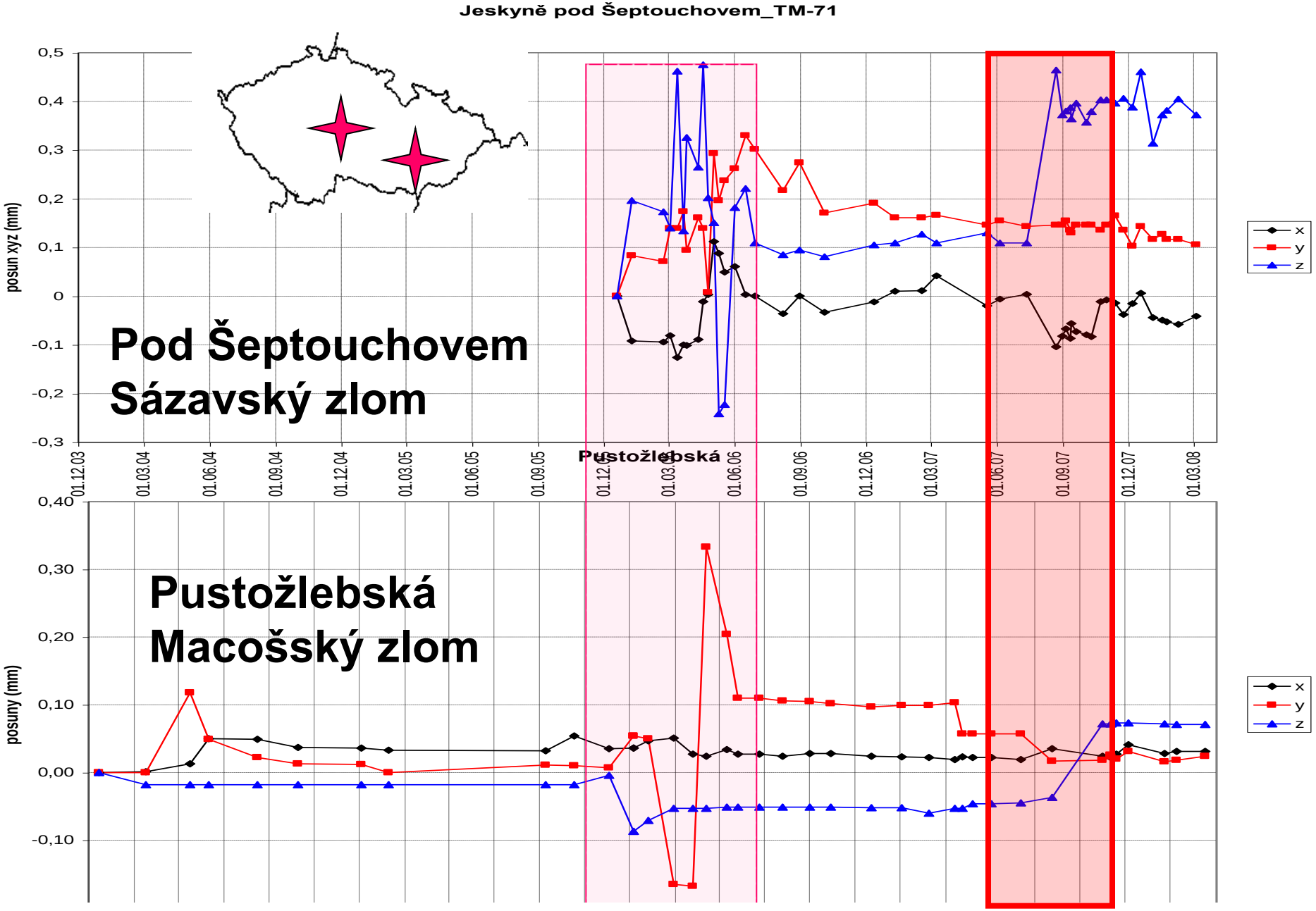
Extreme events that took place during displacement monitoring:

★ Basel swarm of triggered earthquakes

★ earthquakes of natural origin



Example of pulse displacements recorded in the middle of 2007 in the Bohemian Massif



Pulse movements registered in the caves across the Bohemian Massif during November 2005/March 2006 and July/August 2007

Conclusion:

- **Basel swarm occurred during period of extraordinary fault displacement recorded across Europe in 2003/2007 due to stress changes in the crust (published by Stemberk, Košťák, Cacon, 2010 in Tectonophysics)**

- **High probability of the earthquake occurence was predicted for the region of Upper Rhine Graben for period of 2007 (published by Stemberk, Košťák, Rybář in Vesmír, 1/2007)**

- **We suppose, that hydro-pressure injection was operated during highly risk period and therefore resulted in series earthquakes affected the Basel**

- **It could be proposed, that by identification of these risk periods can be reduced seismic risk**


Thank you for your attention