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long-term slope deformations monitoring infrastructure

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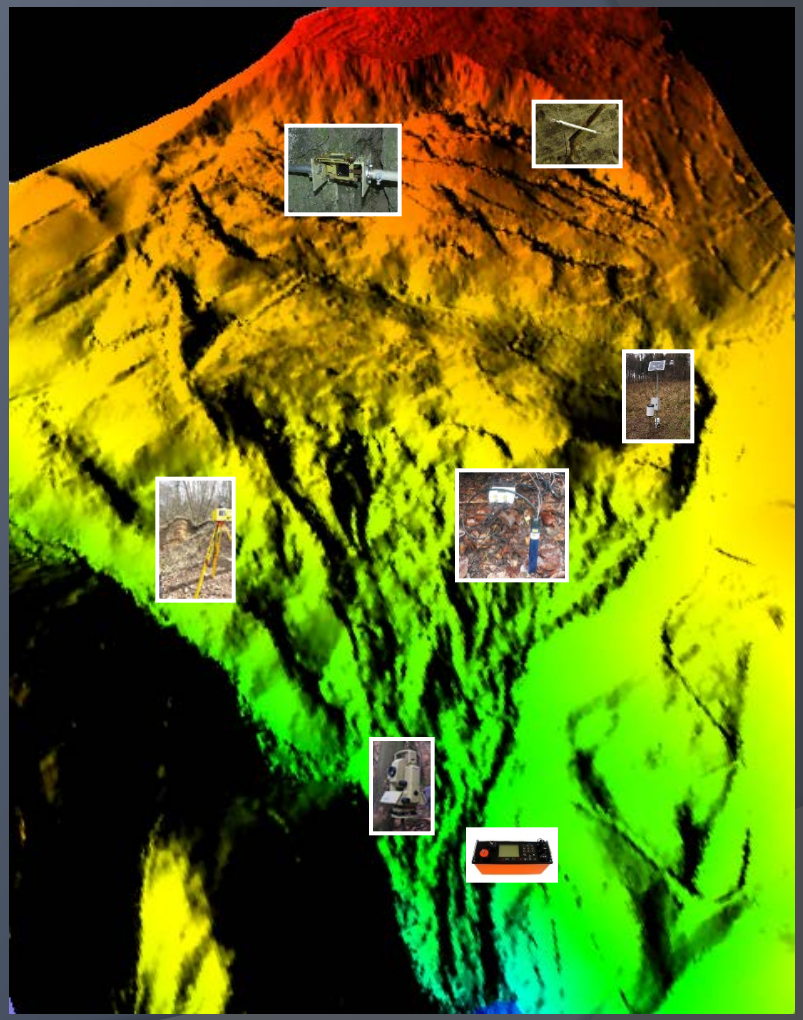

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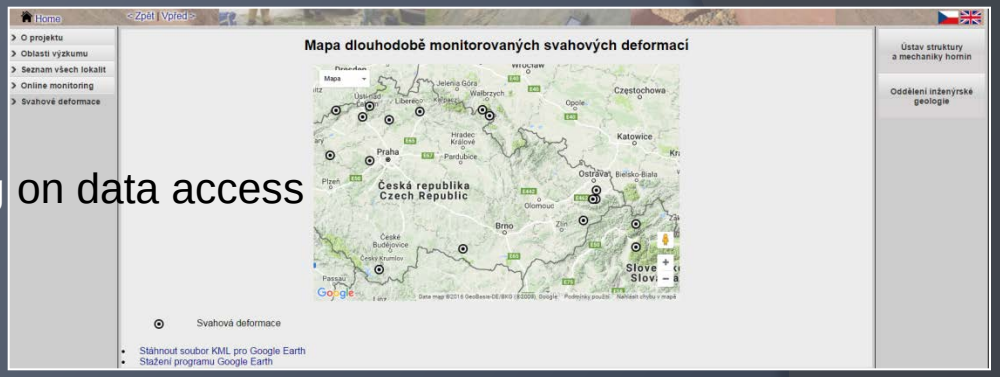
long-term slope deformations monitoring infrastructure

- monitoring network at various slope deformation sites in various geological, geomorphological and climatic conditions both in ČR and abroad
- long term monitoring – since 1970s
- online application: sites info, working on data access



- goal and purposes:

  - application and testing of new methods (and correlation with classic ones)

  - testing newly developed or upgraded devices

  - providing answers in research of low frequency / high magnitude events: high society impact

  - working towards applicable regional warning systems: inputs and thresholds

  - solving challenges of long-term, various frequency, big data volume monitoring

- cooperation and coordination with other RI: TECNET, GNSS, Ringen

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monitoring methods ...and frequency

engineering geological gauges

M

rod dilatometer

M

steel tape extensometer

M

TM-71 crack gauge

H

induction dilatometer

D

automatic extensometer

H

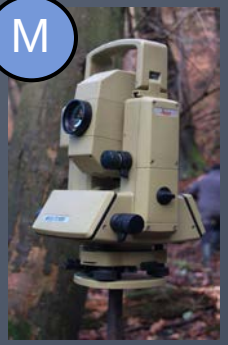
automatic TM-71

geodetic surveying

Q

levelling survey

M



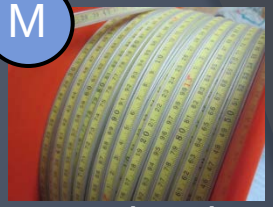
total station survey

Q

TLS monitoring

special sensors & devices

M

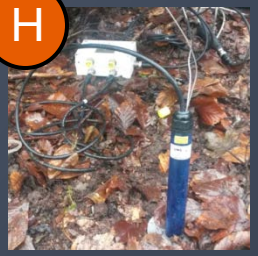


water level gauge

10

automatic water level gauge

H



soil humidity monitoring

10

automatic meteostation

M

time-lapse ERT

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sites overview

	Site	Ls type	Geology	Monitored since	Monitored characteristics	Monitoring techniques
1	Třebenice/ Czech. Rep.	Compound slide	Cretaceous sediments (claystones/marlstones)	1994	Near surface movement; water table; ppt and temp.	tape extensometer; automated water level sensor; meteostation
2	Čeřeniště/ Czech. Rep.	Complex DSGSD	Tertiary volcanics (basalt/tuff)	1998	Near surface movement; ground humidity; ppt and temp.	TM71; tape extensometer; geodetic surveying; time-lapse ERT, meteostation, soil humidity,TLS
3	Ondřejník/ Czech. Rep.	DSL	Mesozoic flysch rock	2007	Near surface movement; ppt and temp.	geodetic survey; cable extensometer
4	Kněhyně/ Czech. Rep.	DSGSD	Tertiary flysch rock	2002	Subsurface movements 57.5 m in crevice cave	TM71
5	Cyrilka/ Czech. Rep.	DSL	Tertiary flysch rock	2000	Subsurface movements crevice cave - 10 m under surface	TM71
6	Parohy/ Slovakia	DSGSD - sagging	Cretaceous carbonites	1973	Near surface movement	TM71
7	San Andrés/ Spain	DSGSD	Quaternary volcanics (basalt/pyroclastic)	2013	Near surface and subsurface (500 m) movements	TM71; ADAS
8	Obří Hrad / Czech rep.	rockslide	Paleozoic paragneiss	2003	Surface - rock blocks, blockfield	Holle dilatometer, steel tape extensometer
9	Příhrazy / Czech rep.	DSGSD, plateau rim disintegration	Cretaceous basin (sandstones /marls)	1991	Near surface - 3 m below surface	TM-71, automatic extensometer, meteostation, water level gauge
10	Valdštejn / Czech rep.	toppling	Cretaceous sandstones	2011-2012	Surface, block movements	automatic extensometers

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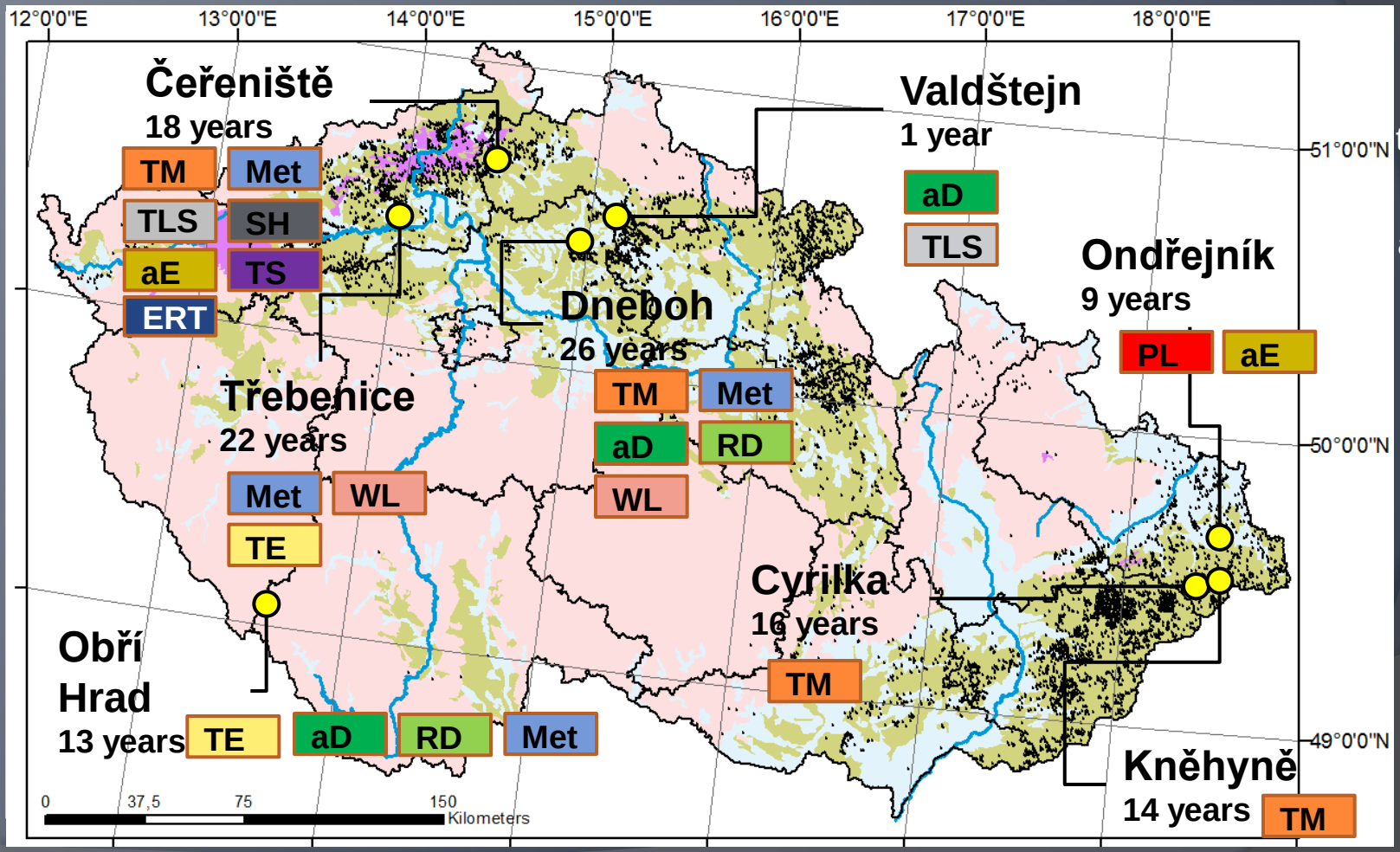
sites overview (ČR)

- long-term monitoring is crucial: slowly developing slope deformations



- various geological and geomorphological conditions

Met meteostation

RD rod dilatometer

aD aut. dilatometer

TE tape extensometer

aE aut. extensometer

TLS repeated TLS

TS TS survey

WL water level

SH soil humidity

PL precise levelling

ERT time-lapse ERT

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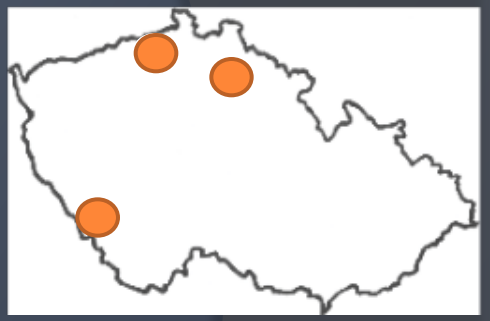
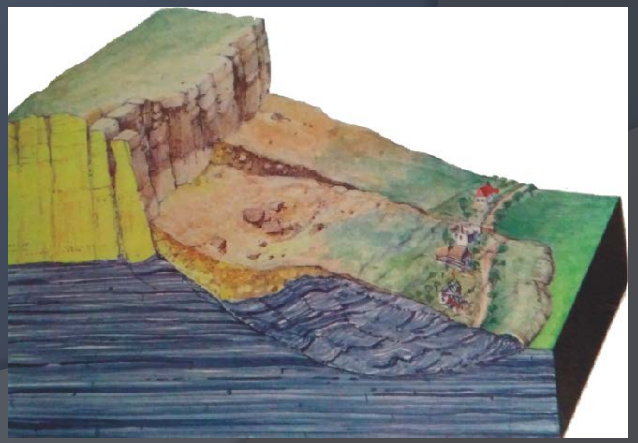
results

- illustrative examples from various geological backgrounds:
  - Obří Hrad (Moldanubicum, crystalline gneisses)
  - Čeřeniště (České středohoří, volcanic tuffs and bazalts)
  - Dneboh (Cretaceous basin, sandstones and marls)



- long-term observation allows analysis of long-term trends and its changes



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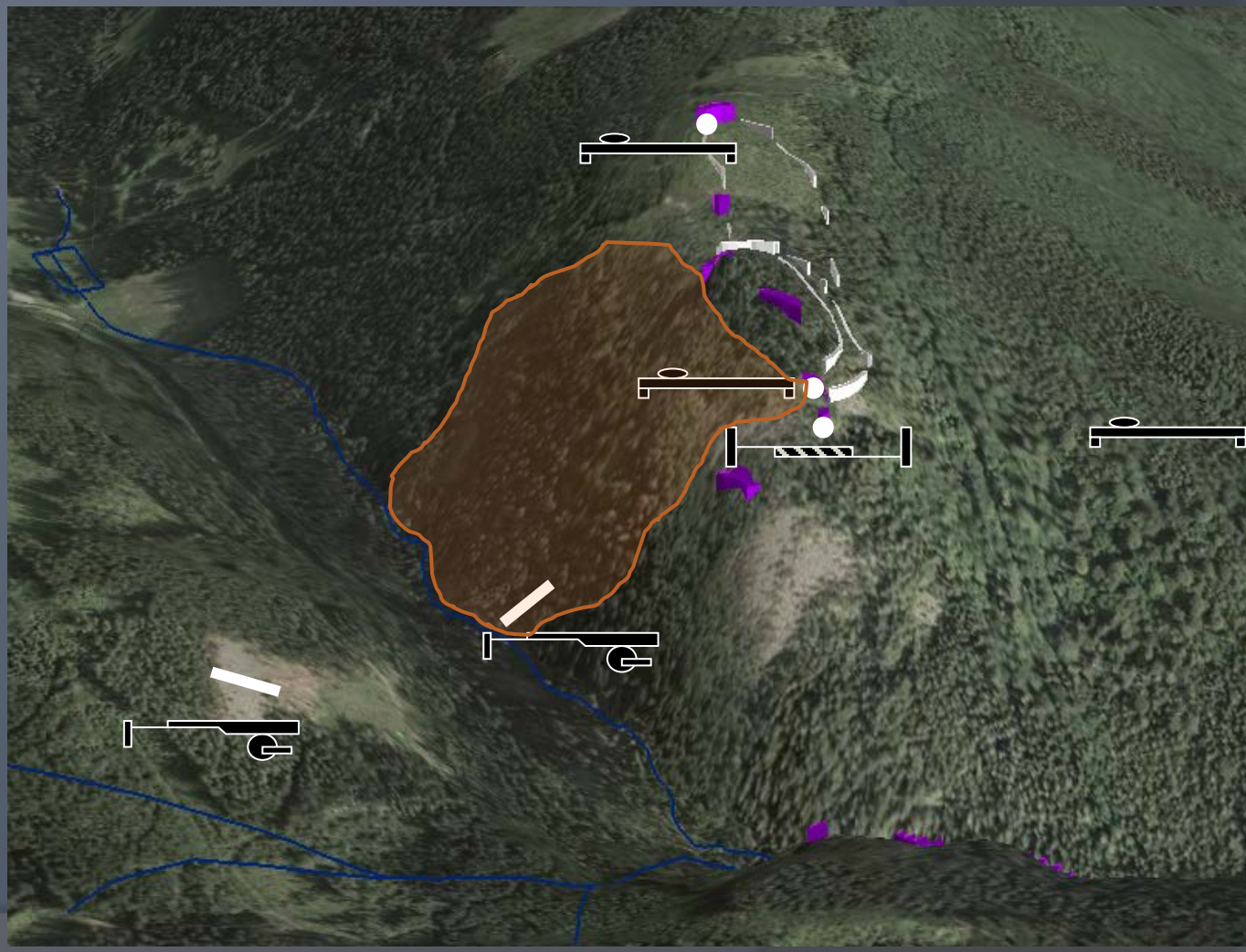
Obří Hrad

- rockslide, block creep
- monitoring equipment:
  - rod dilatometer
  - steel-tape extensometer
  - automatic dilatometer
- since 08/2003



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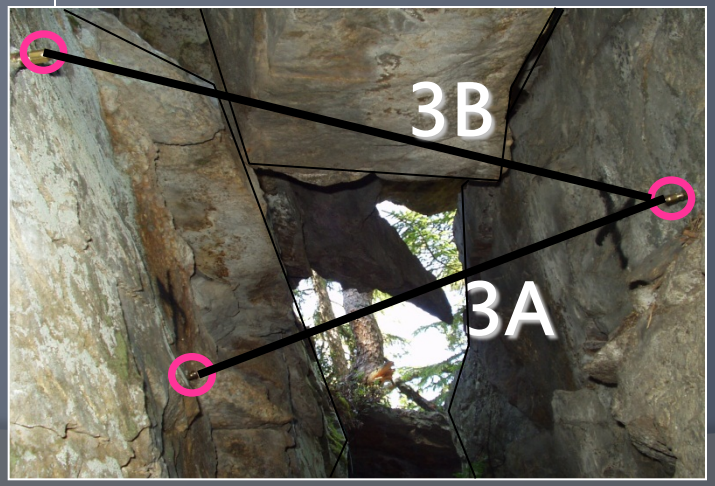
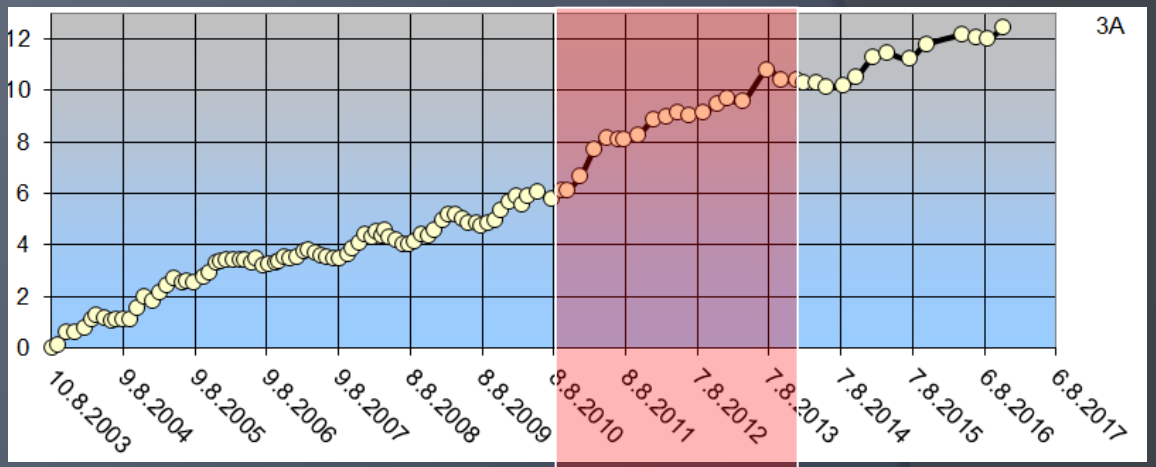
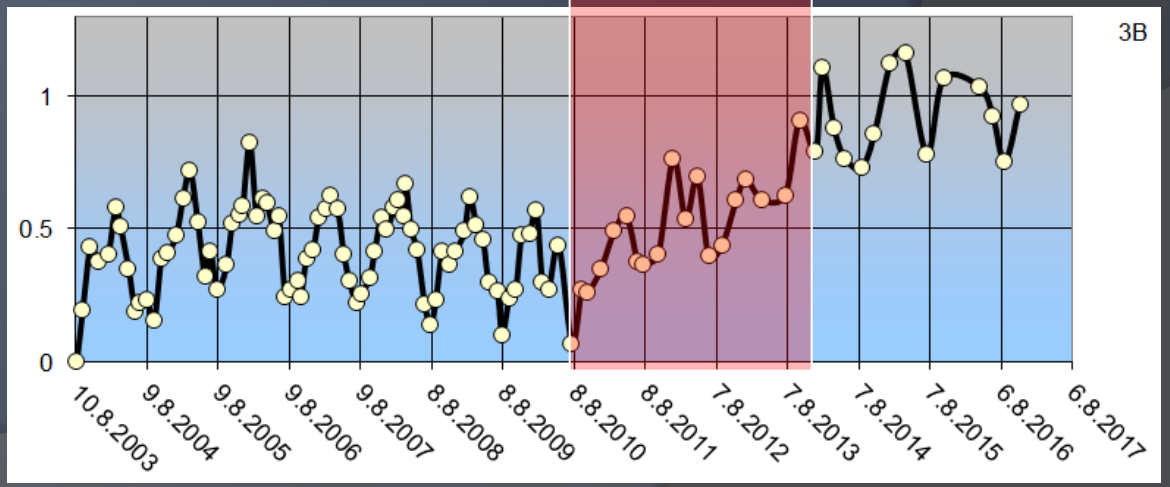
results

Obří Hrad

- 13 years of dilatometric monitoring
- acceleration period 2010 – 2013, then deceleration
- max. absolute dilatation: 13 mm / 13 years (the „Gate“ site)







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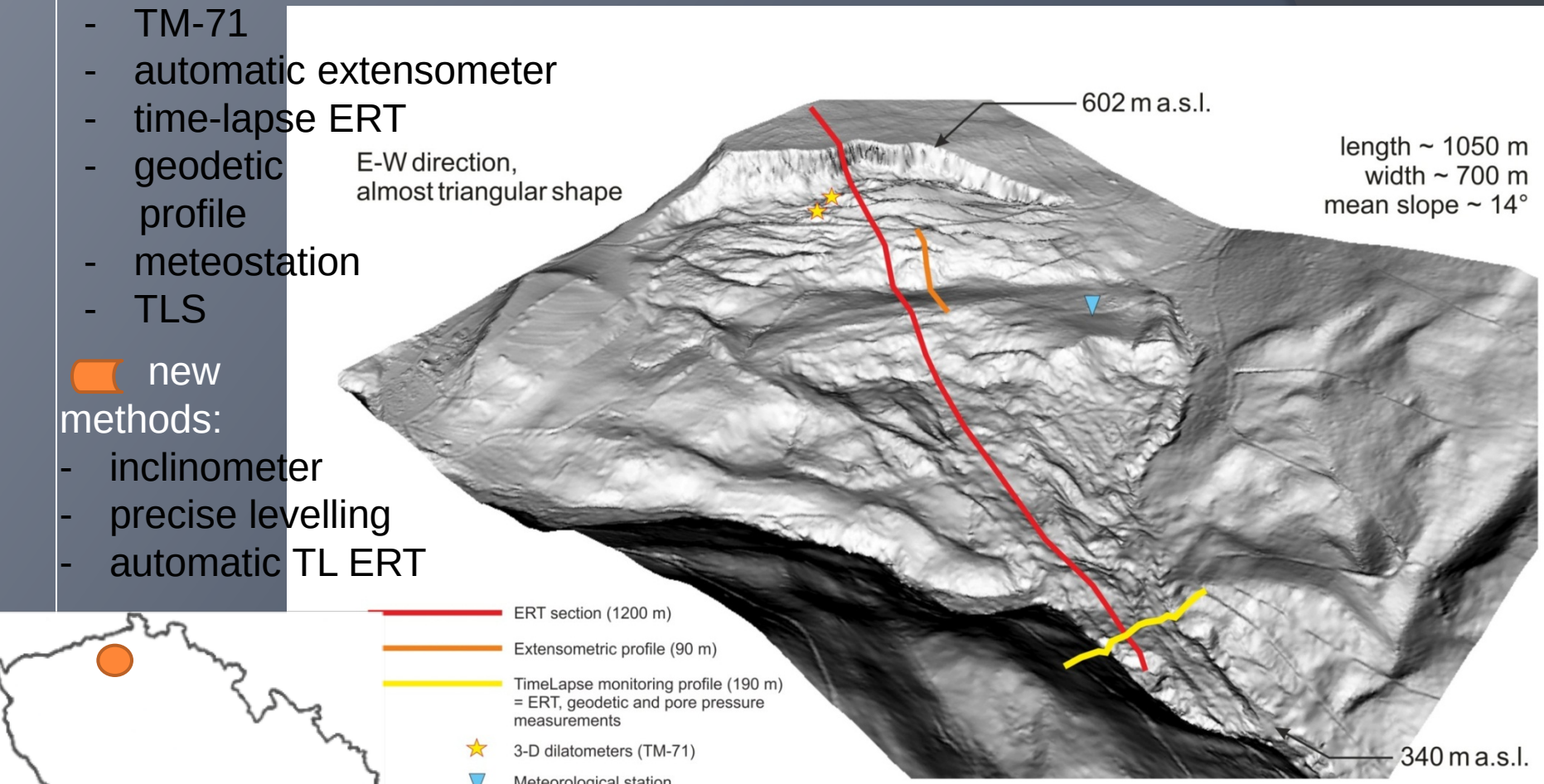
Čeřeniště

- a complex DSGSD – various types of SD = ideal as a natural lab
- concentration of various monitoring and observation systems:
  - TM-71
  - automatic extensometer
  - time-lapse ERT
  - geodetic profile
  - meteostation
  - TLS
- new methods:
  - inclinometer
  - precise levelling
  - automatic TL ERT



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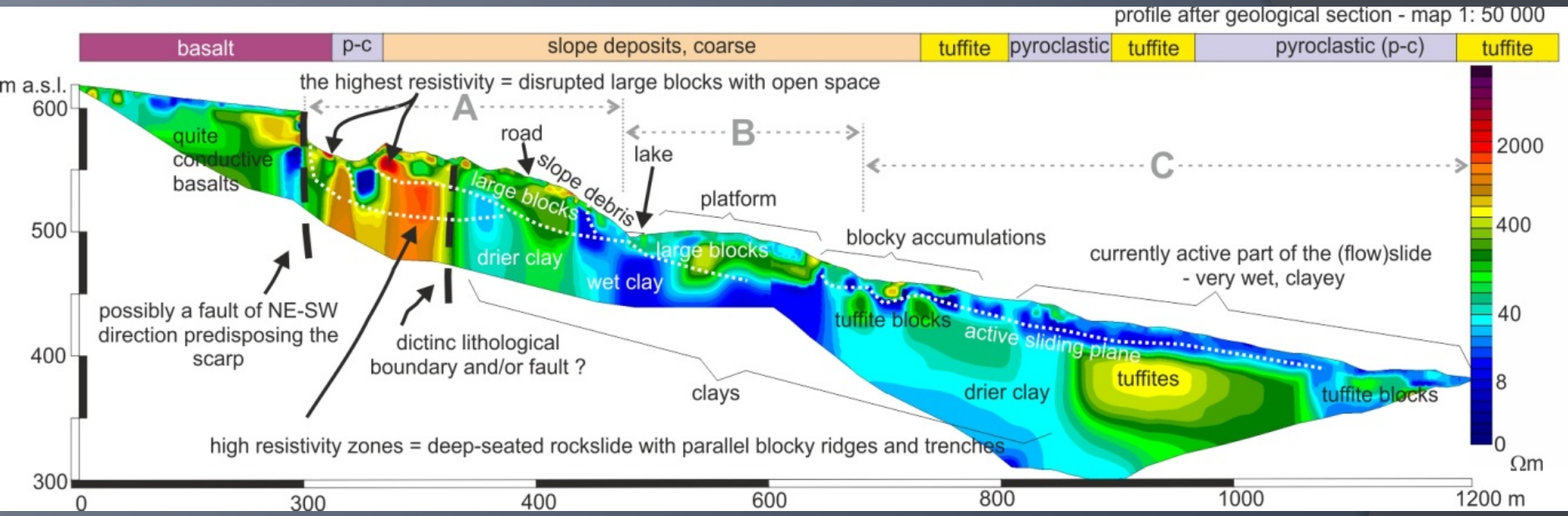
Čeřeniště



- well-studied site
- ERT profiles confirm complicated structure – complex slope deformation

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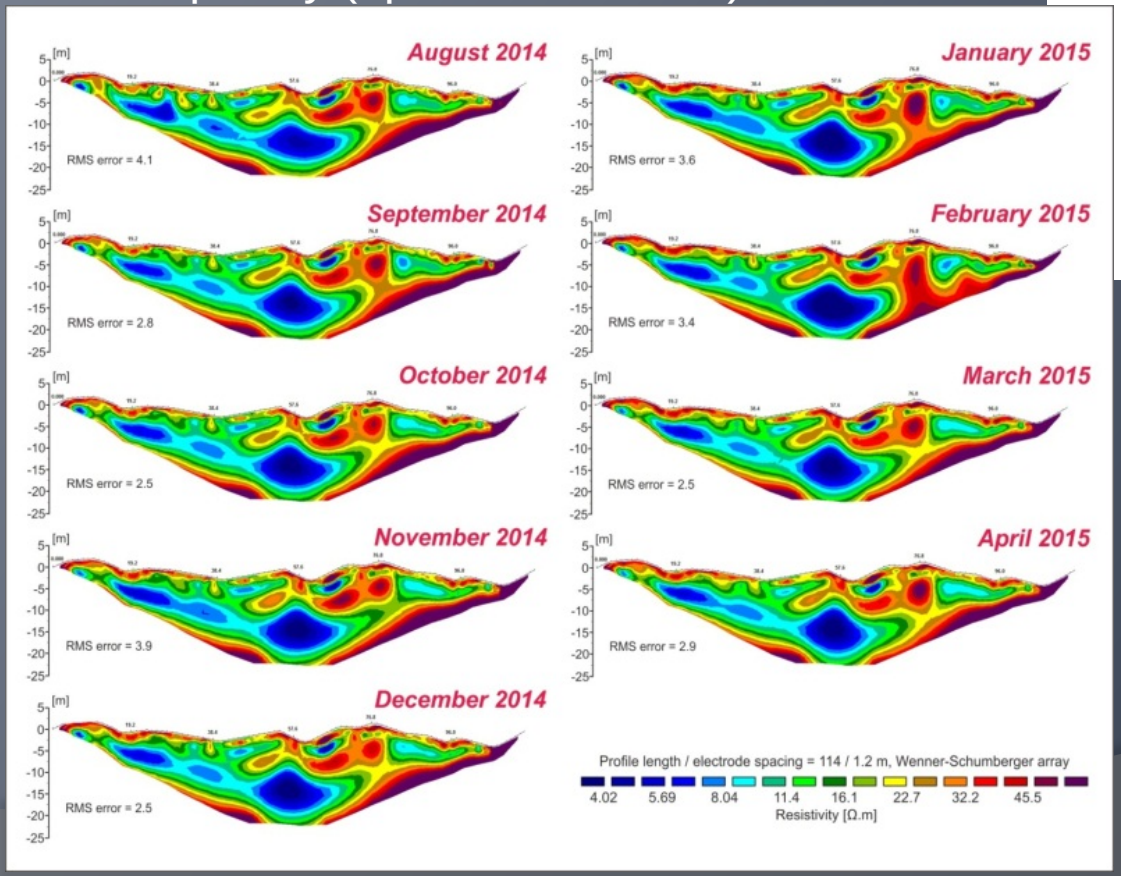
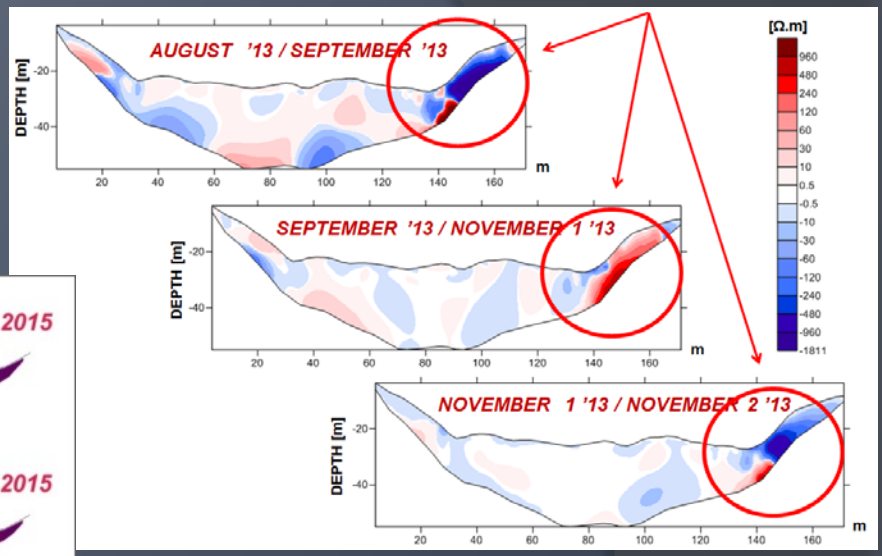
results

Čeřeniště

- time-lapse (repeated) ERT monitoring – 1x month
- intention of automatization – higher frequency (up to 1x / 4 hours)





- generally reflects water content - other parameters stays constant
- very slight changes – biggest at slope with dry / wet deposits
- might work as early warning – particularly if automatized

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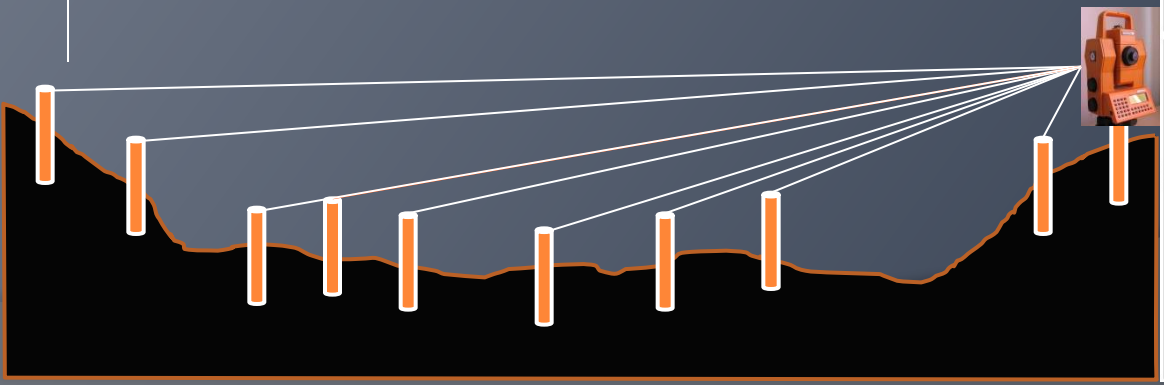
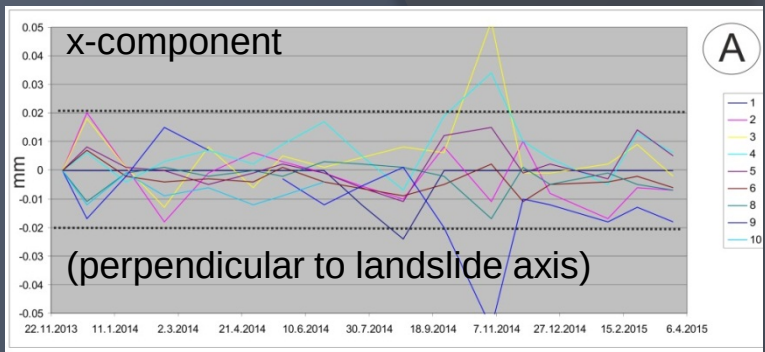
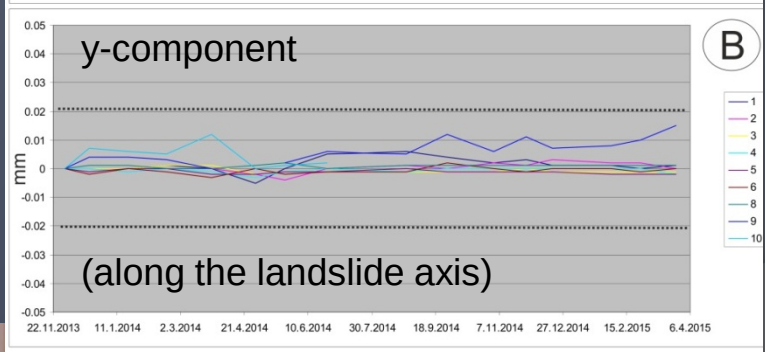
results

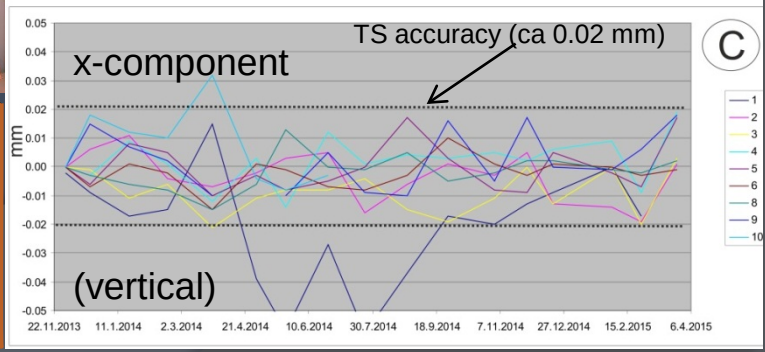
Čeřeniště

- geodetic monitoring of surface movements: distal, flow-like part of landslide
- TS Leica TC1010
- since 12/2013
- no significant movements – dry years









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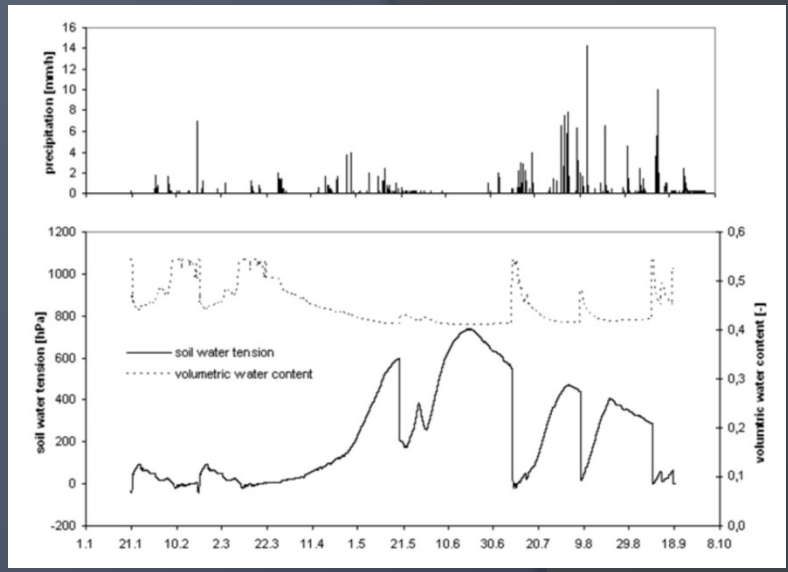
results

Čeřeniště

- continuous measurement of soil water pressure (tenziometer):
  - calibration of resistivity model
  - important parameter for landslide activation = „effective“ humidity
- 2 depths: 20 and 50 cm
- 1m planned for spring – better idea of water infiltration



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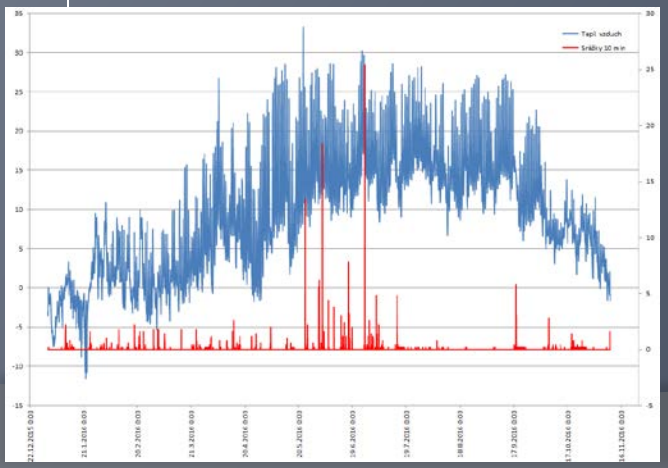
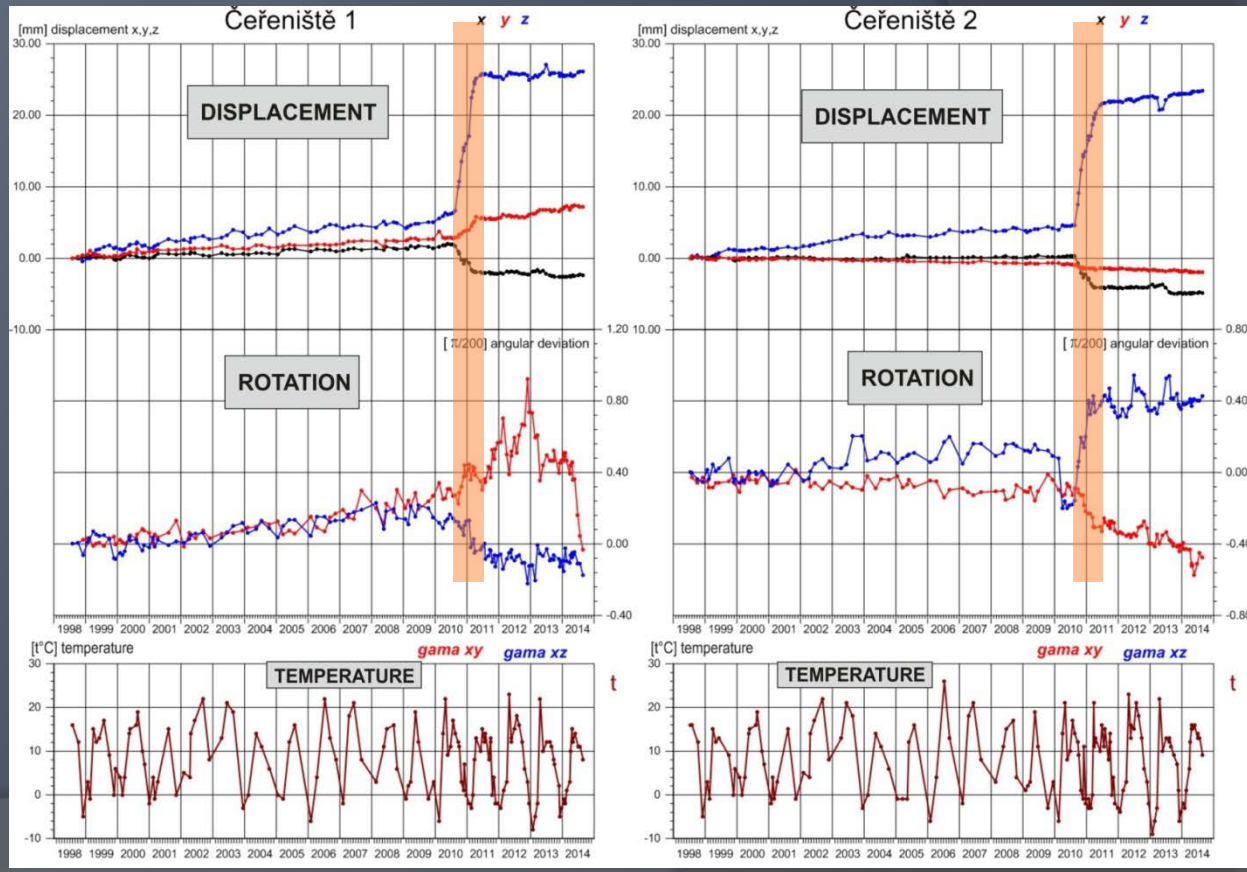
results

Čeřeniště

- automatic meteostation: atmospheric parameters compared with movement data
- 2010-2011 unprecedented activation – total displacement 15 - 20 mm!
- triggered by very wet weather – long-lasting precipitation
- unfortunately, our meteostation was not yet operational (since 11/2013)





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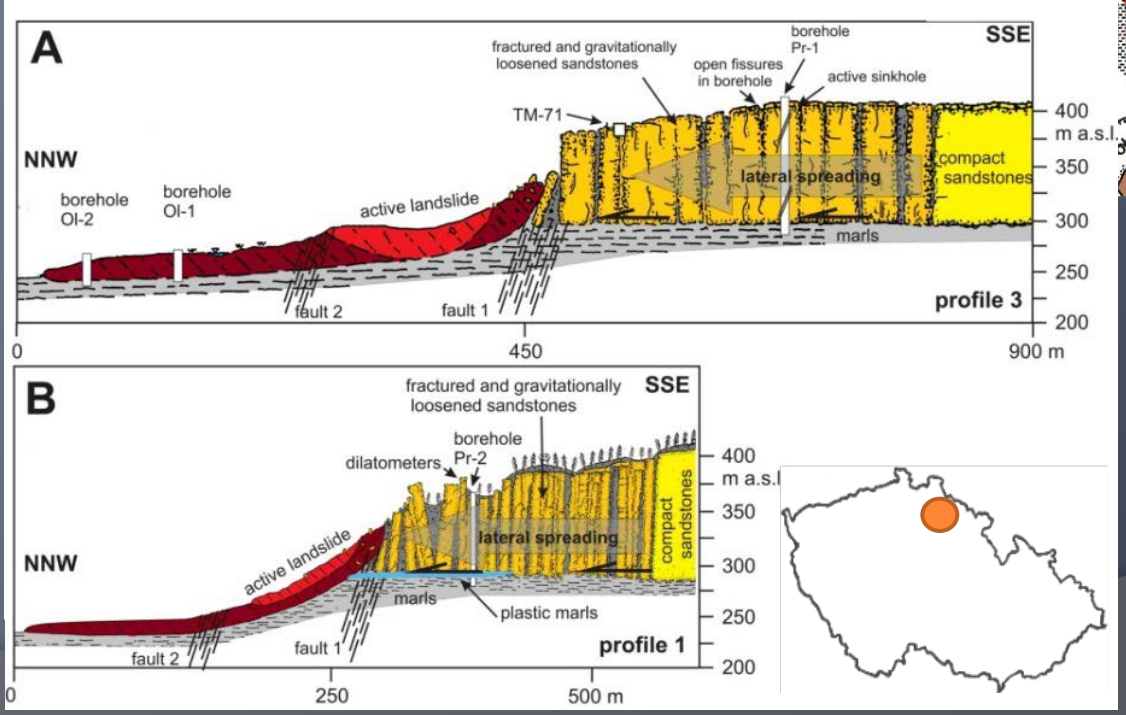
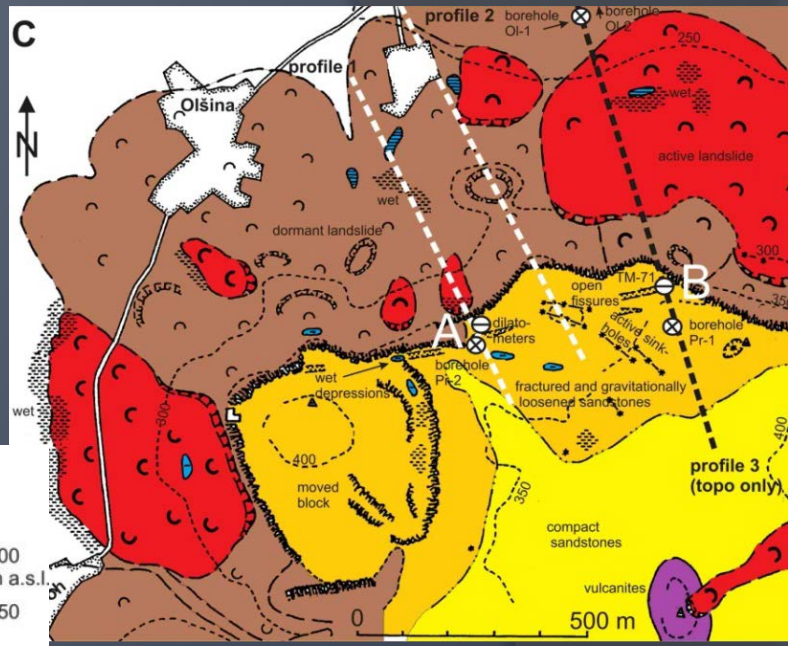
Dneboh

- plateau rim disintegration, toppling, landslides
- classic site studied since 1926 landslide, current monitoring since 1990
- geophysical and geodetical profiling – active landslides





- various monitoring systems:
  - TM-71
  - dilatometers
  - aut. dilatometers
  - water level observation
  - meteostation

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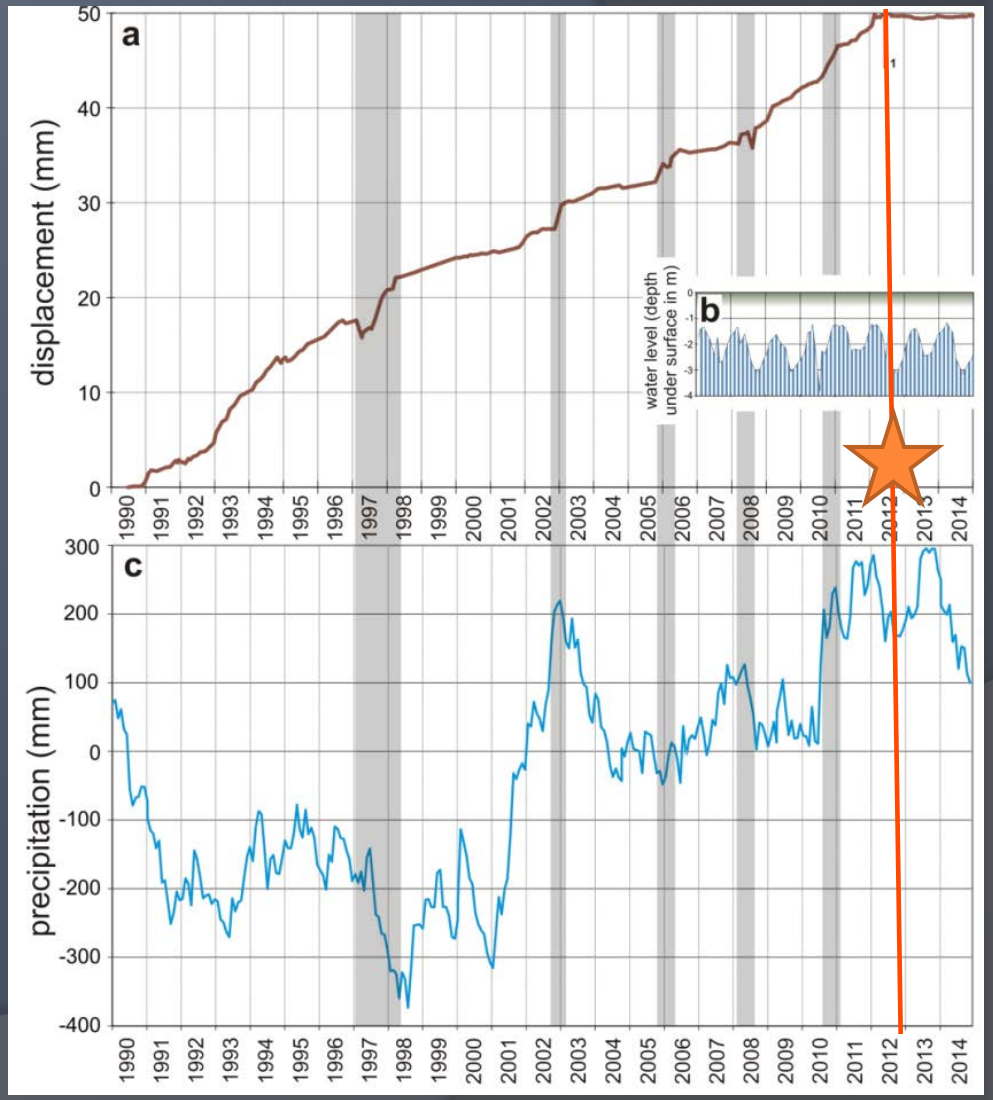
results

- dilatometric measurements of a rock tower (dilatometers, since 2015 also automatic)

- collapse of part of the tower in June 2012 = end of movement trend



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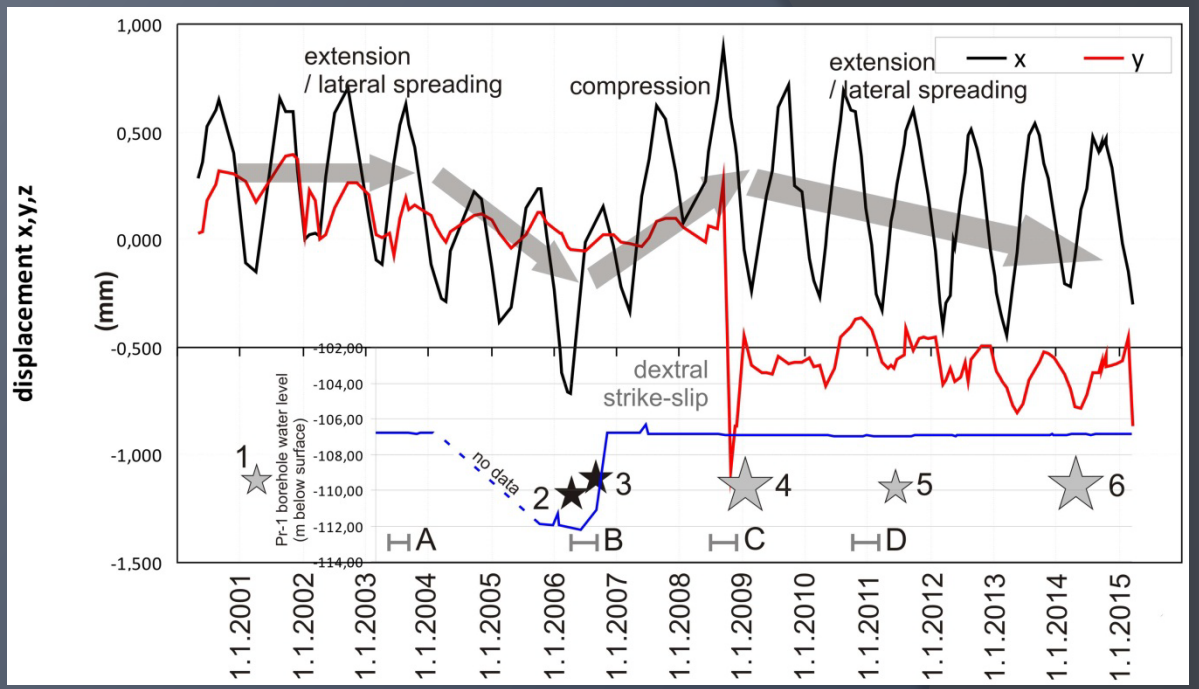
results

Dneboh

- TM-71 observes plateau disintegration:

  - possible tectonic influence



- compression and extension = increase and decrease of water level in boreholes

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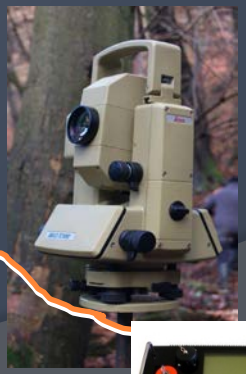
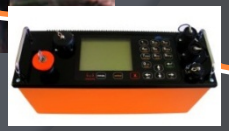
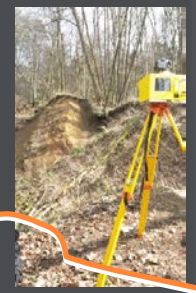
summary

- long-term slope deformation monitoring network
- uses combination of various monitoring methods and techniques
- testing of experimental methods and /or upgraded devices
- effort to concentrate numerous methods on suitable „natural labs“





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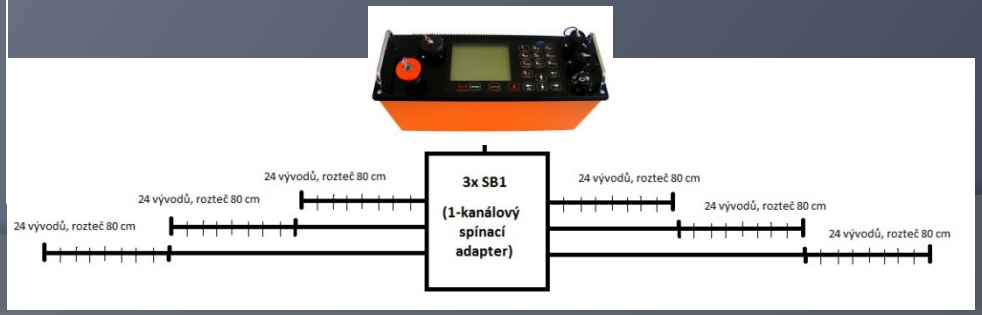
current year & future

2016

- installation of multiparametric inclinometer at Třebenice (+ drilling core analysis)
- installation of automatic extensometer at Čeřeniště
- installation of meteostations at Dneboh and Třebenice

2017

- installation of multiparametric inclinometer at Čeřeniště (+ drilling core analysis)
- installation of meteostation and soli humidity gauge at Ondřejník
- installation of an experimental automatic TL-ERT at Čeřeniště (with GF Instruments)
- precise levelling survey at Čeřeniště
- testing of newly developed resistivity soil humidity gauge at Čeřeniště (with Chemcomex, a.s.)
- web interface: meteorological and automatics data
  regional landslide susceptibility



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thanks for attention