The ANDES laboratory: Contributions from Seismology and Geophysics

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&

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Outline

- Seismicity and modes of displacement in a subduction zone environments
- Underground observatory:
  Black Forest Observatory (BFO)
- Opportunities (Wish list…) & suggestions

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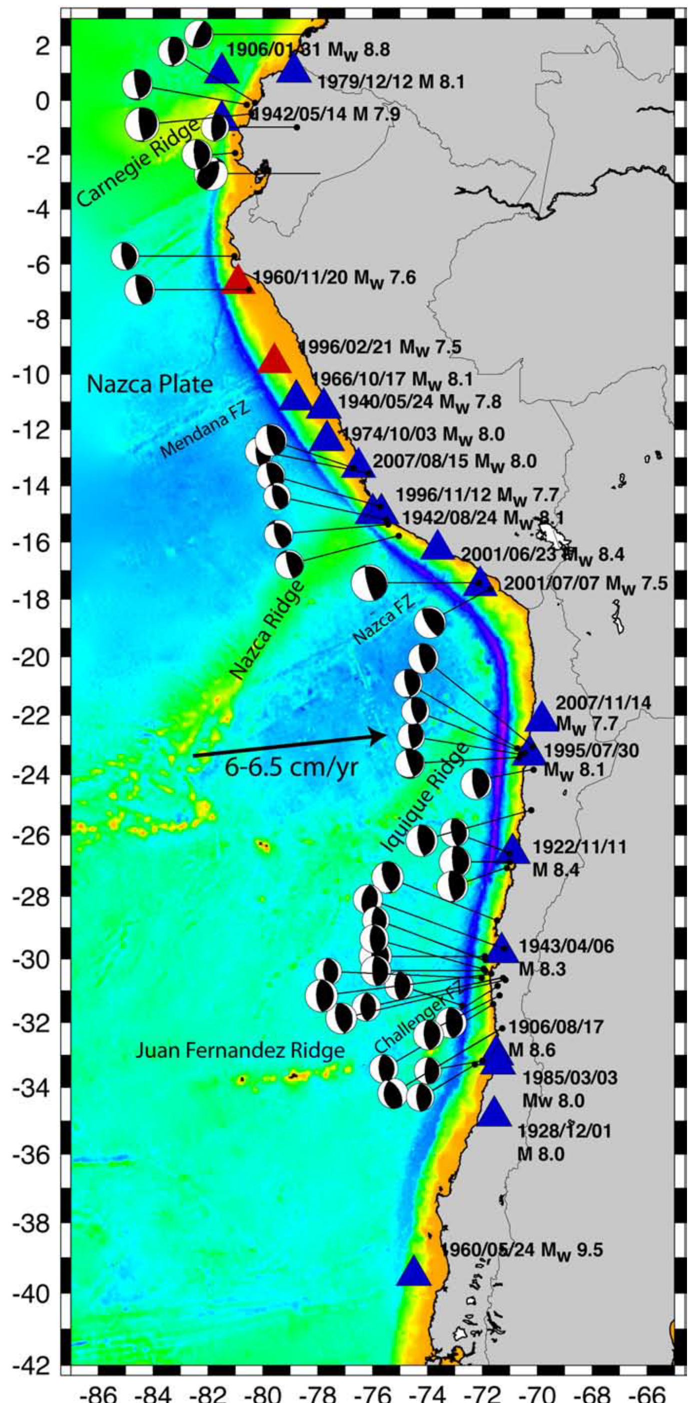
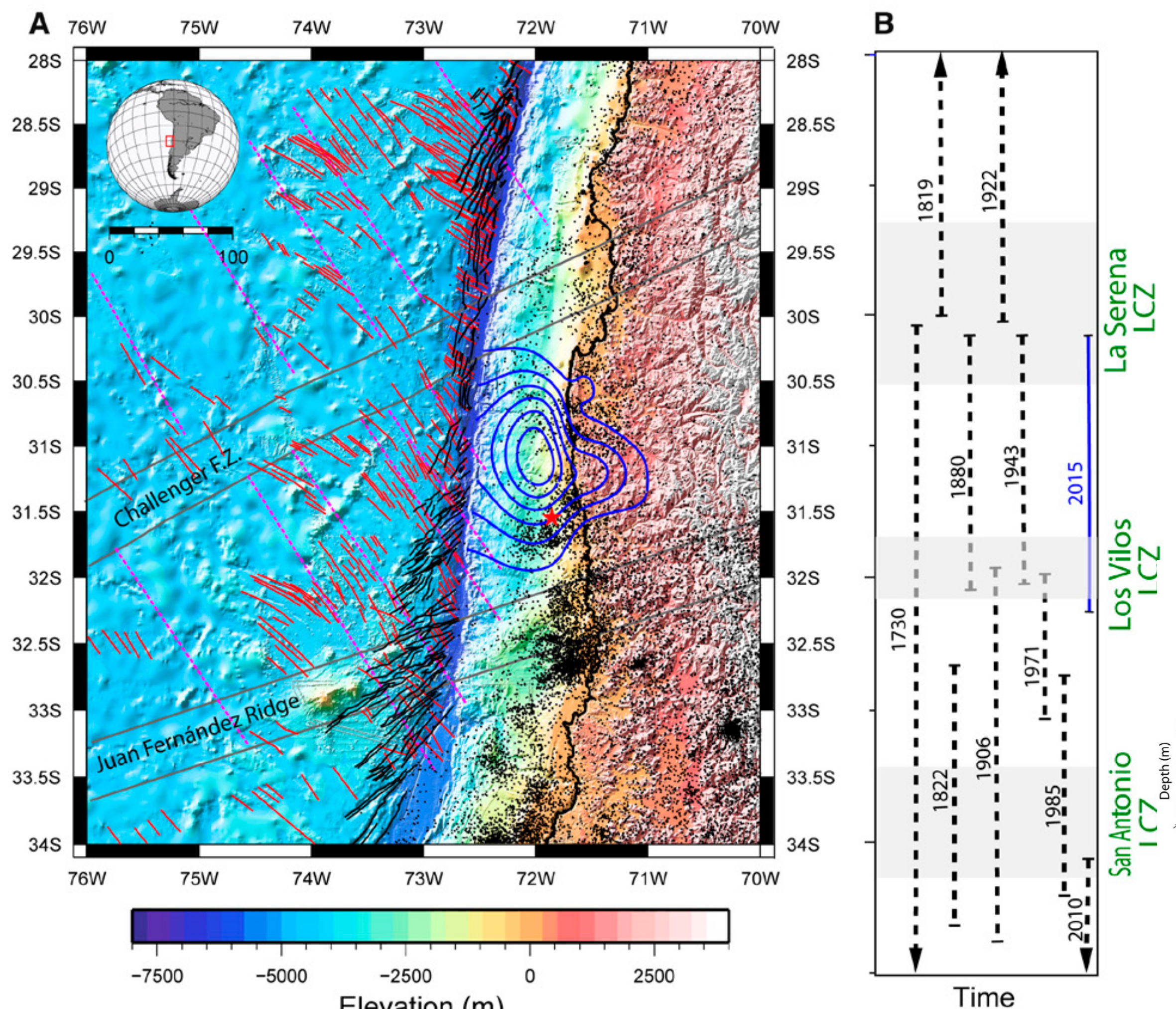


South American Subduction Zone

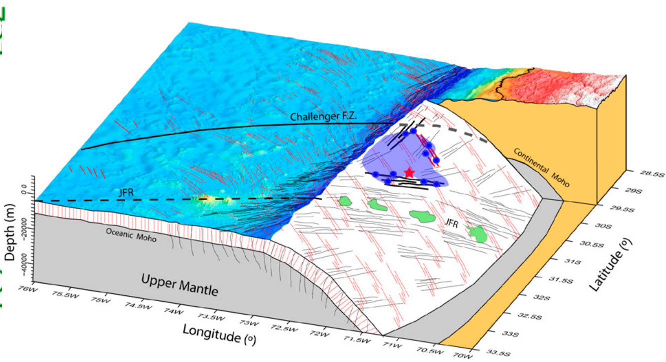
- Ocean-Continent collision
- Nazca plates subducts beneath the South American continent
- 2nd highest mountain range in the world
- Largest ever instrumentally recorded earthquake:
  1960 Valdivia earthquake Mw 9.5

Bilek, 2009

The 2015 Mw 8.3 Illapel earthquake

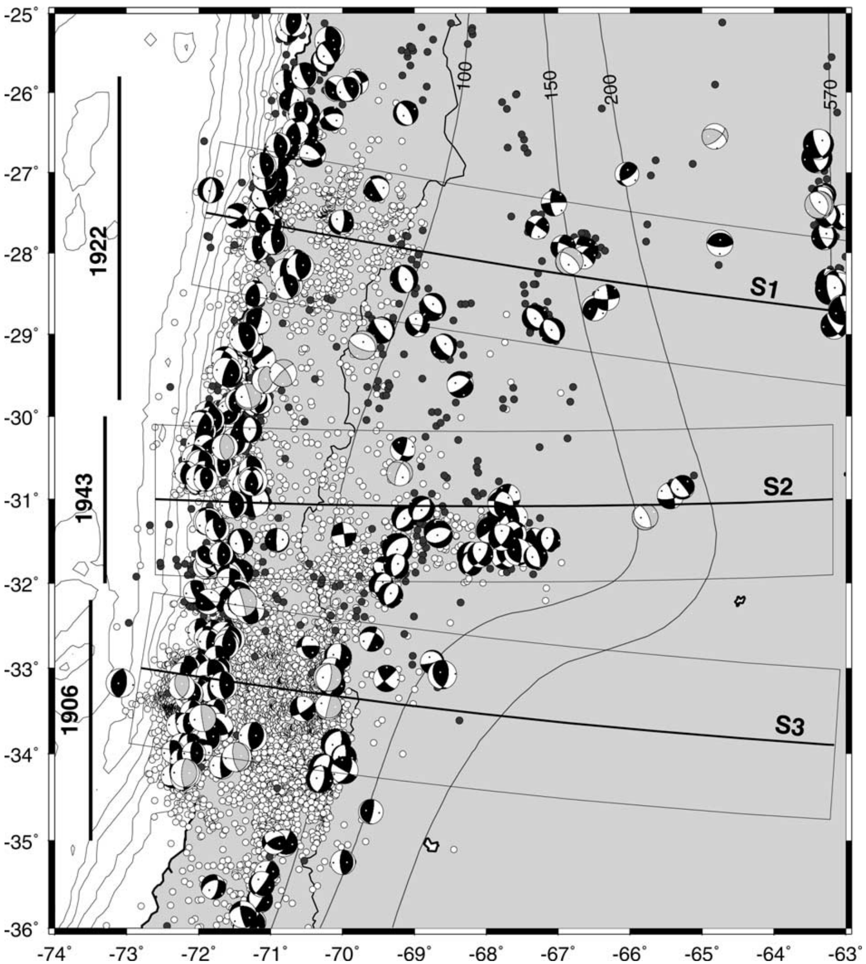


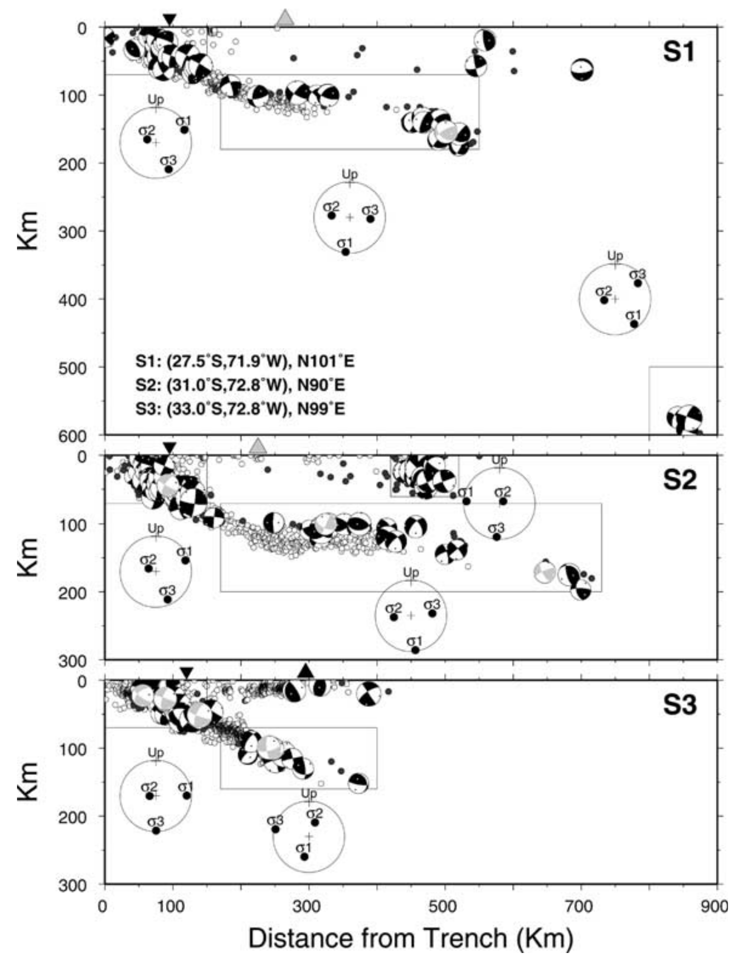
- Good historical record
- Large earthquake occur at “regular’ intervals
- Fracture zones seem to limit the rupture area



Poli et al., 2017

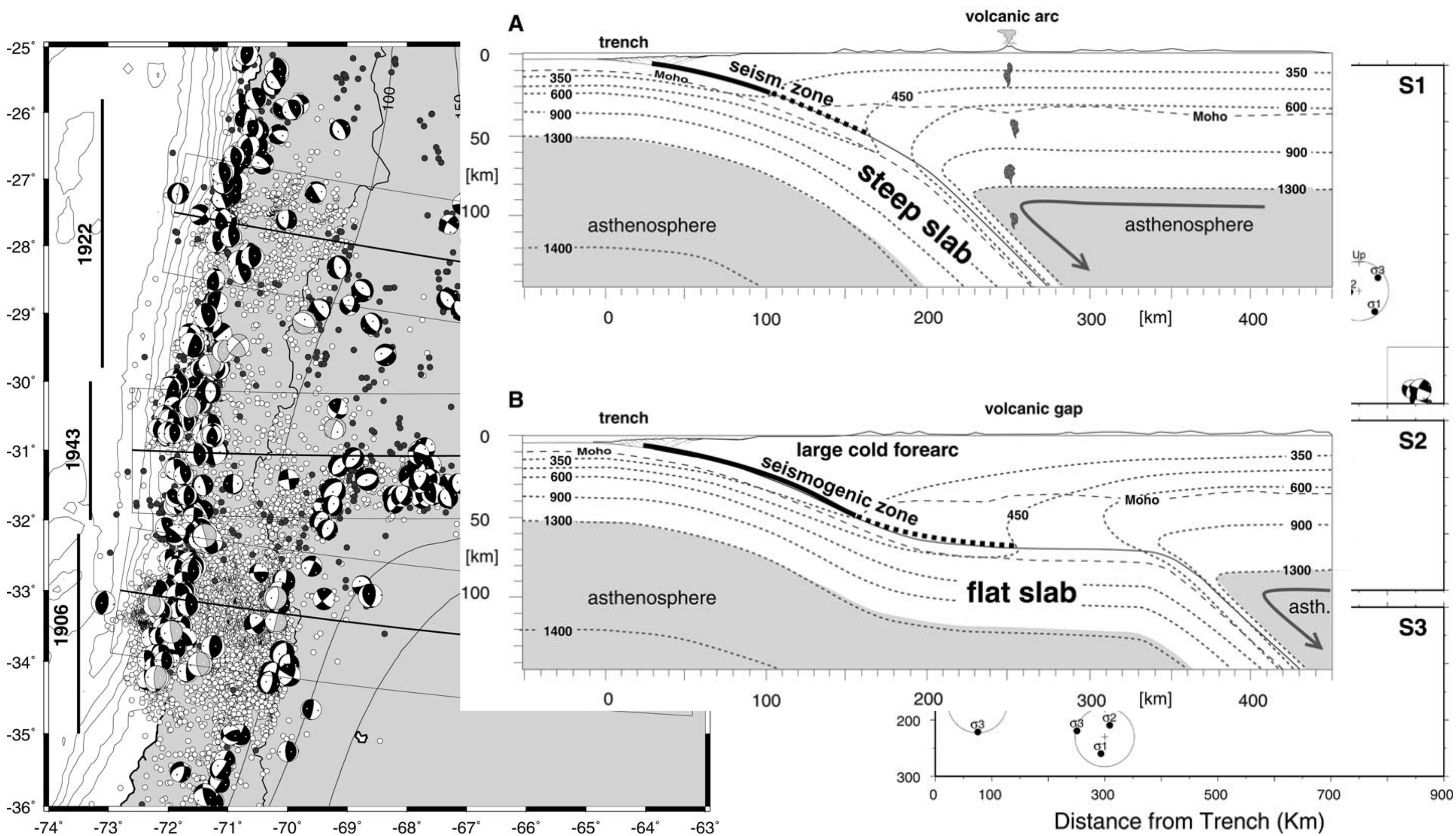
Seismicity cross section: Flat subduction





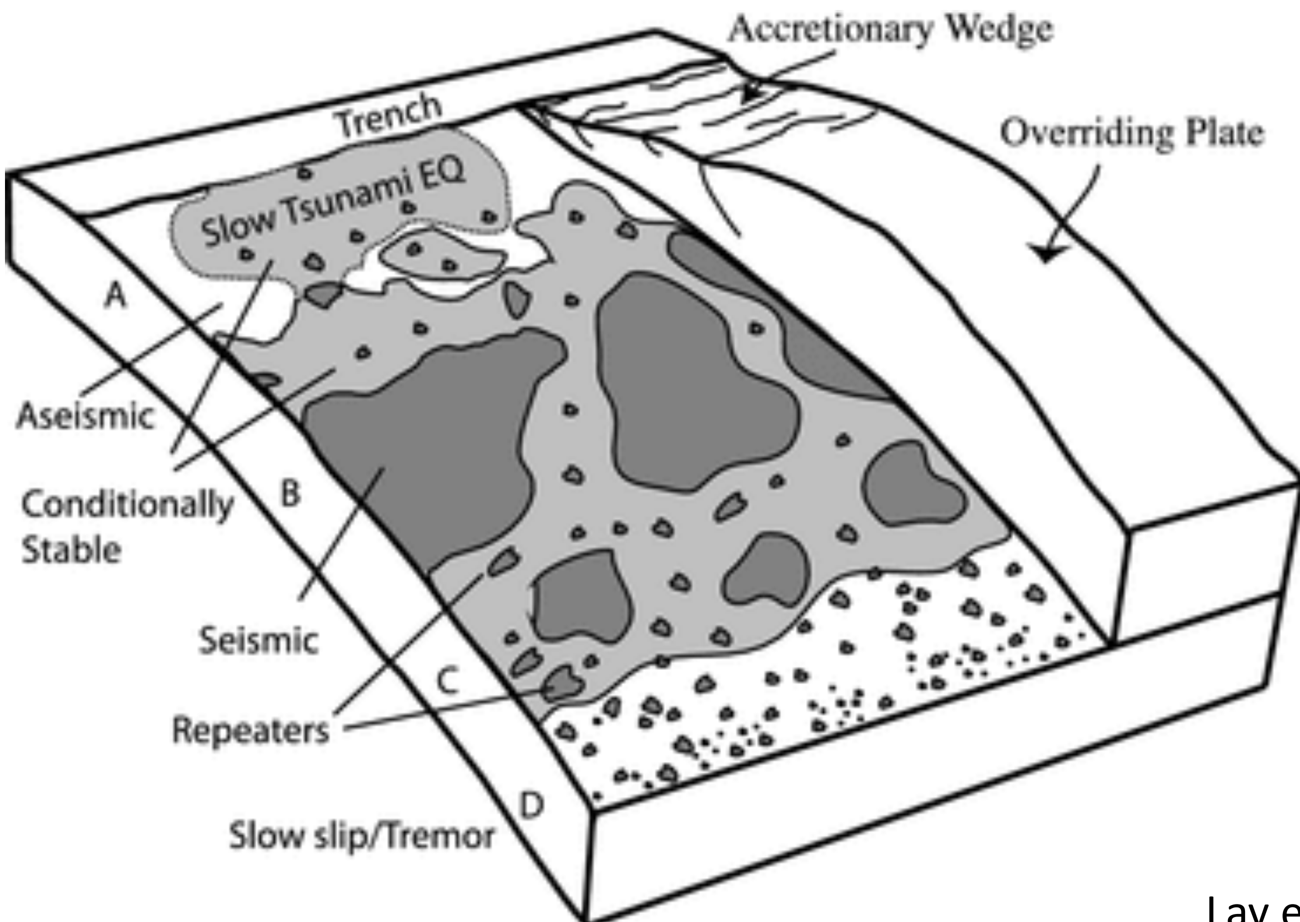
Pardo et al. 2002

Seismicity cross section: Flat subduction



Pardo et al. 2002

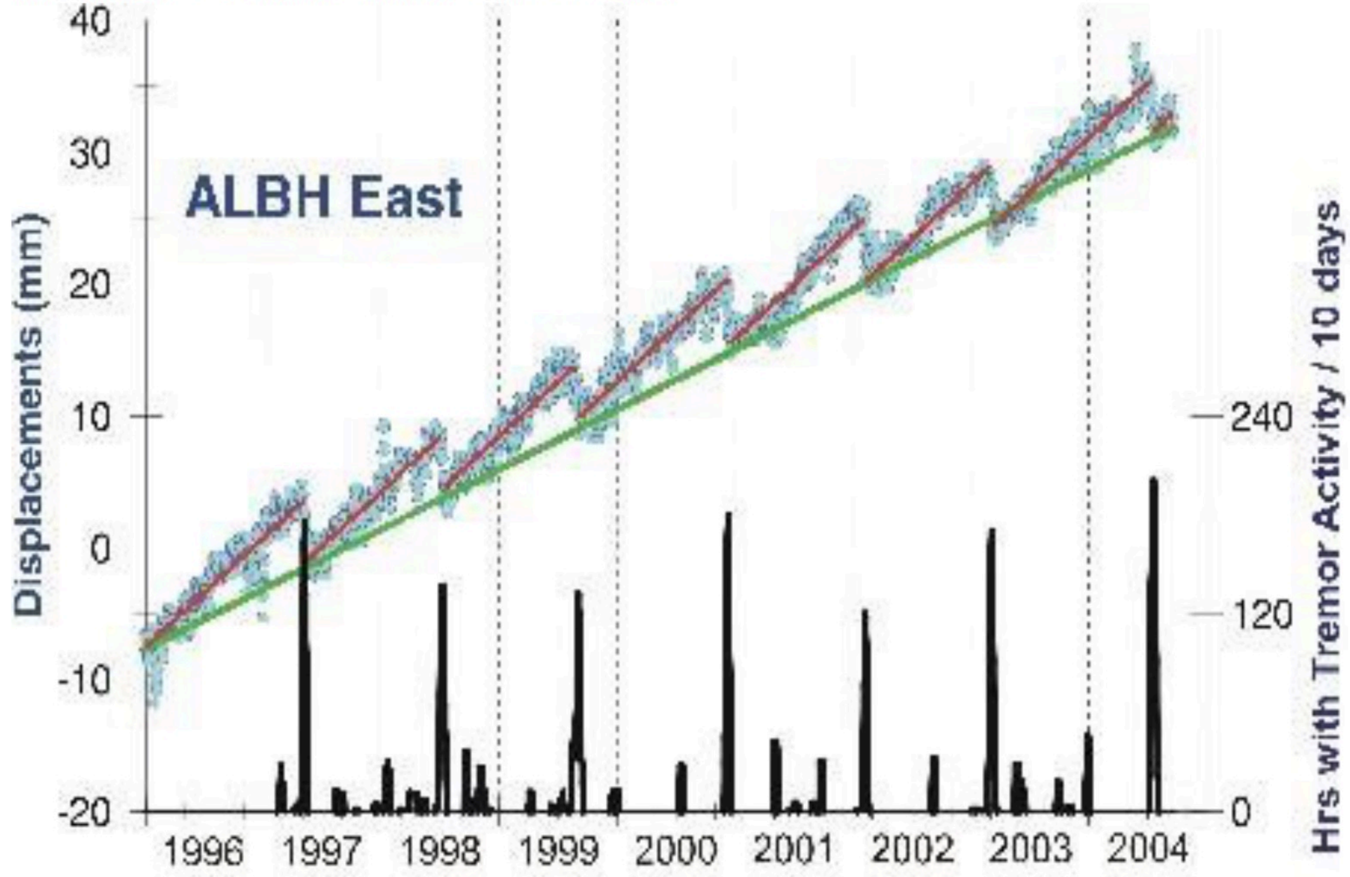
Conceptual model of the subduction zone interface



Lay et al., 2012

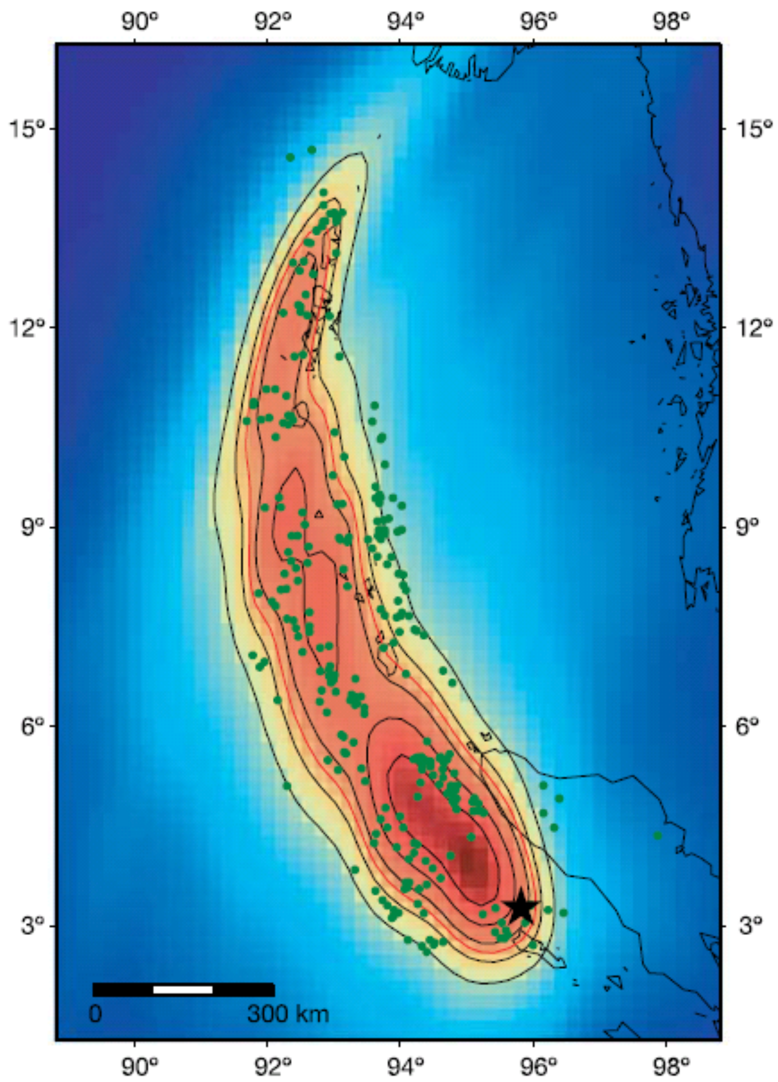
Slow slip events (e.g Cascadia)

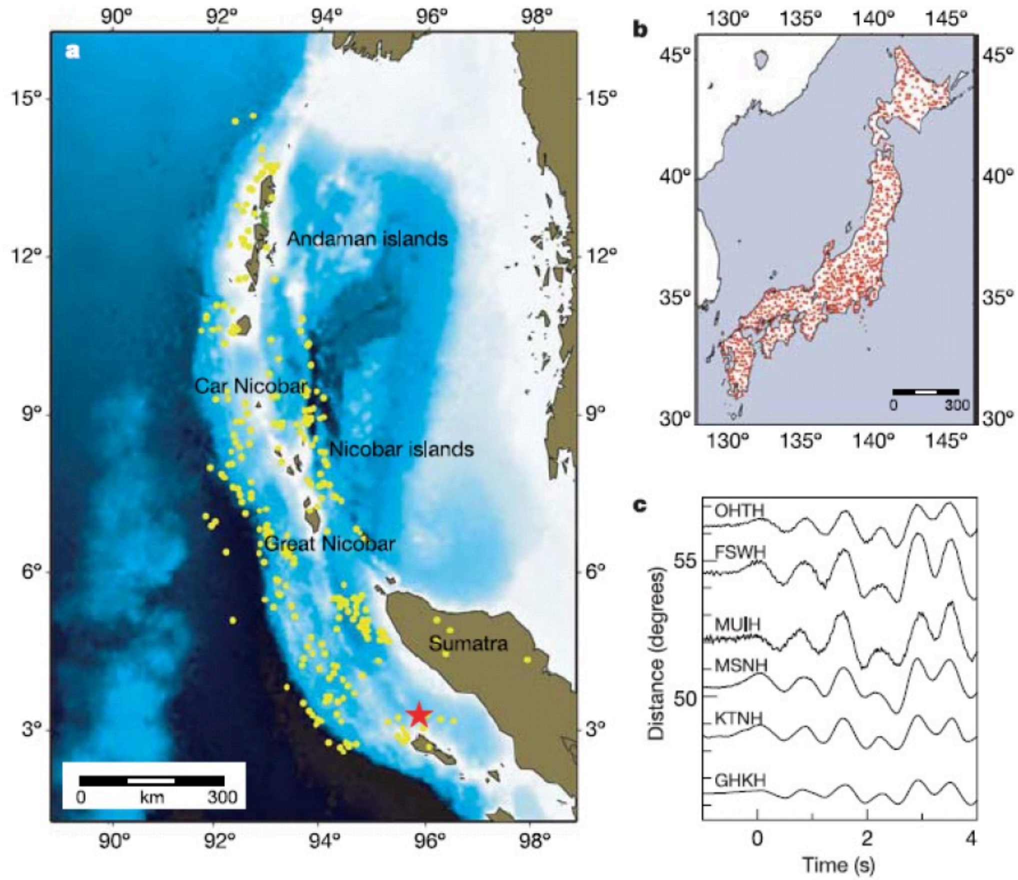
Tremor Counts with GPS Data



*source: http://gsc.nrcan.gc.ca/geodyn/ets_e.php

Rupture front imaging





2004 Sumatra earthquake (Ishii et al, 2005)

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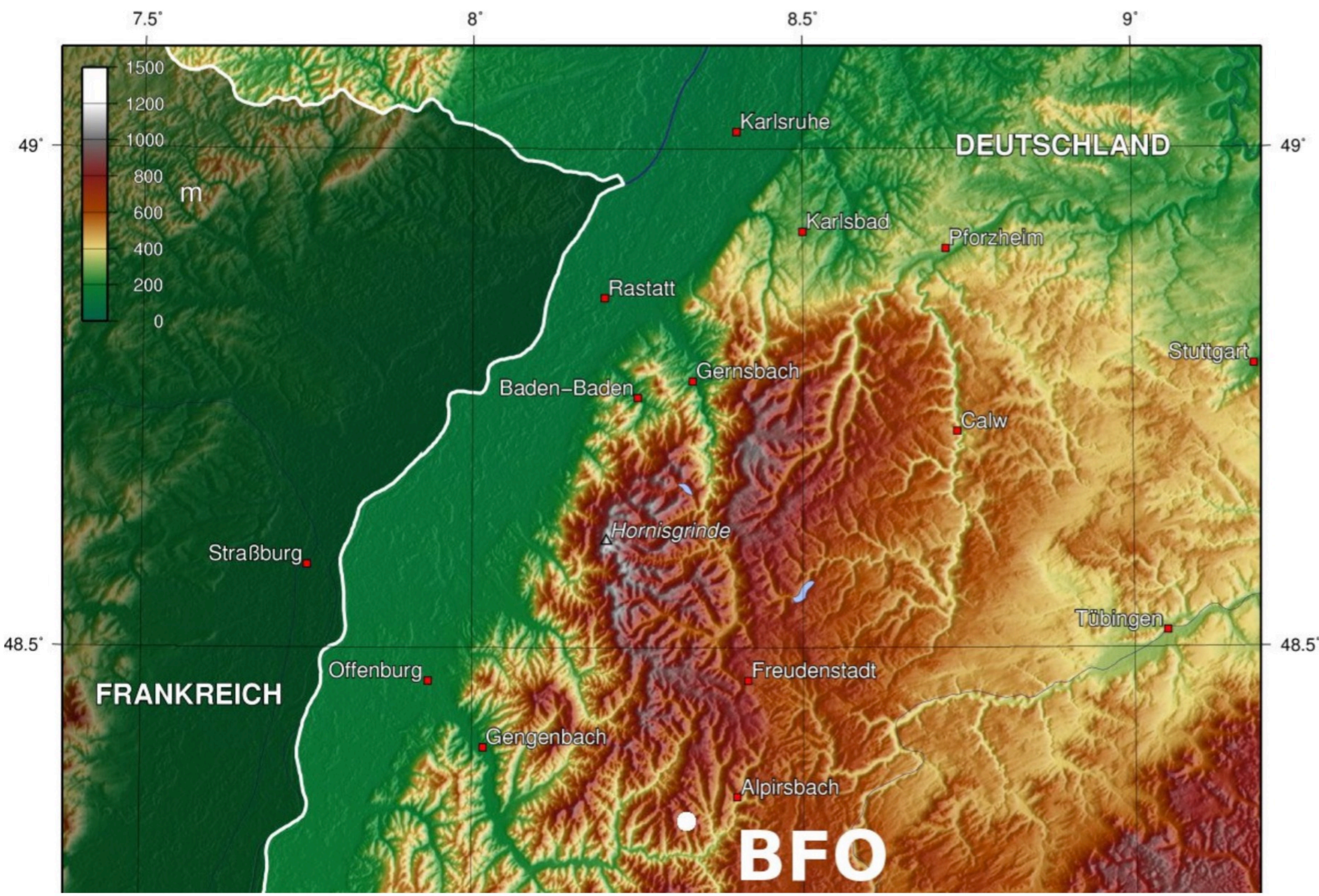
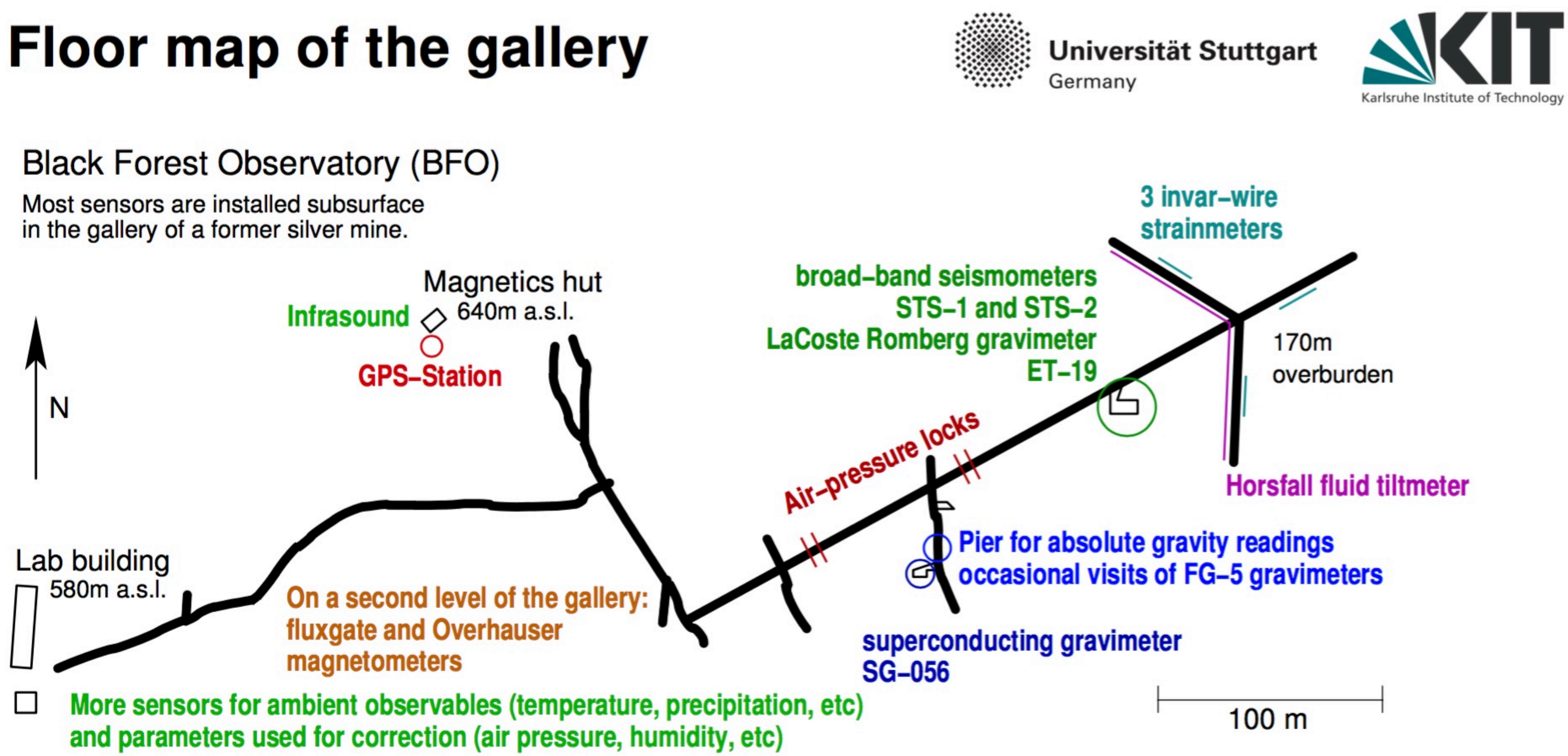
BFO observatory



(courtesy of C. Blood, 2006, wikimedia commons)

BFO: Floor Map



Observables: inertial acceleration, tilt, strain, gravity, magnetic field, position (GPS), ambient pressure, etc.

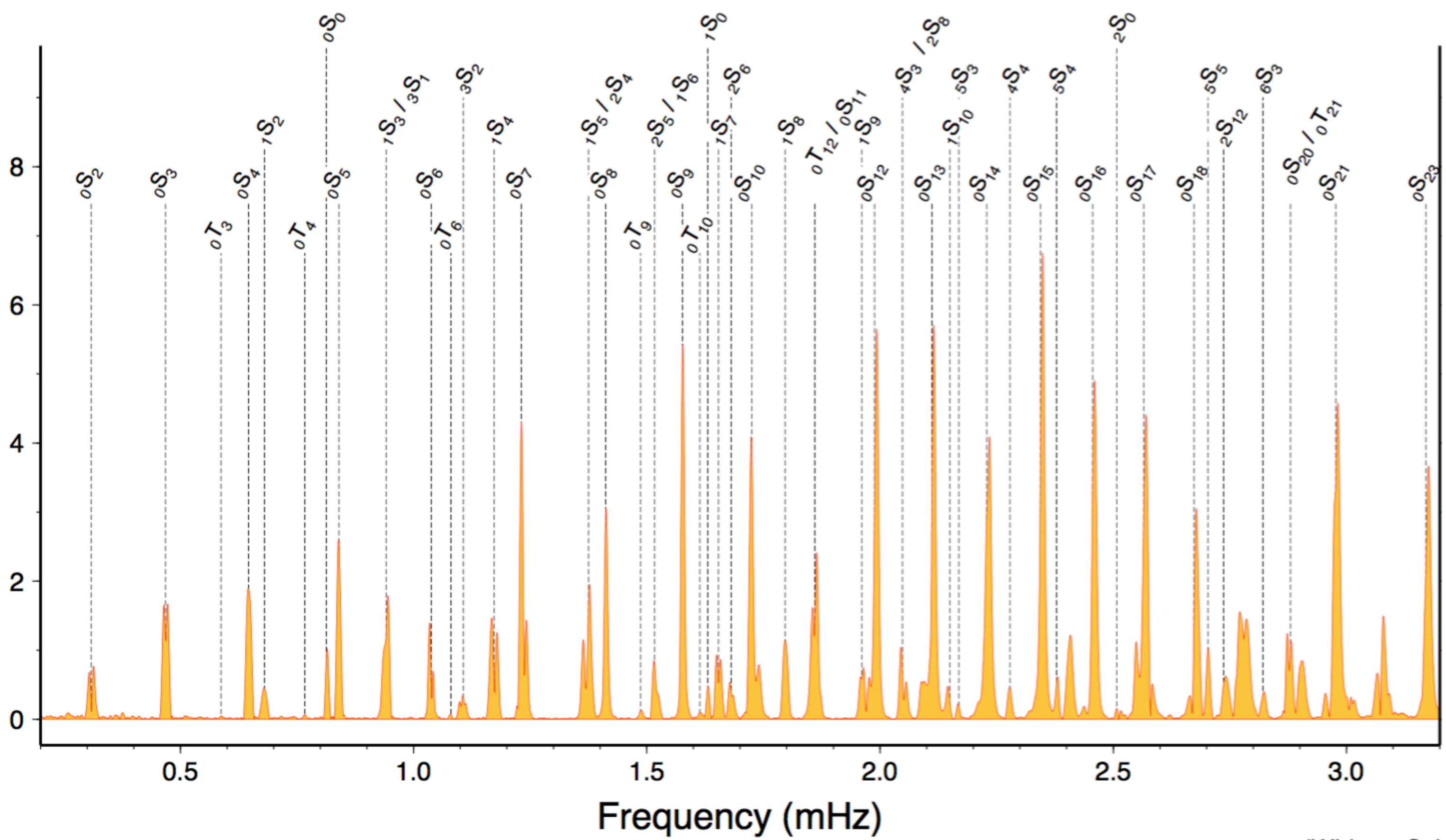
Approx. 30 sensors, 10 data acquisition systems, observatory clocks, computer networks, emergency power supply system, etc.

Tohoku quake (Mw 9.0, 11.3.2011)

Universität Stuttgart
Germany

Karlsruhe Institute of Technology

Sendai event recorded by SG-056 at BFO (100 hrs)



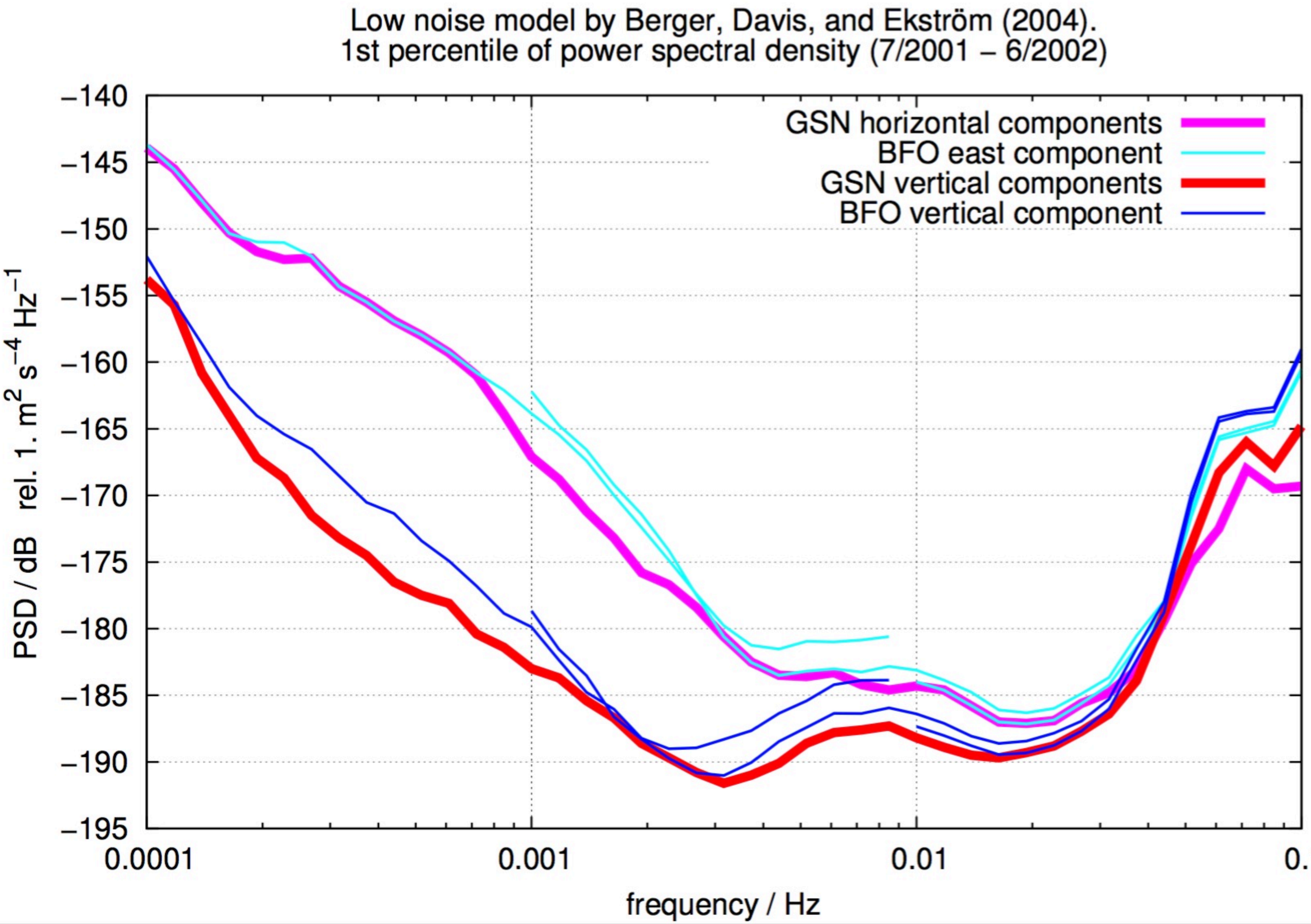
(Widmer-Schnidrig, 2011)

▸ $_1S_1^0$C ▸ $_0S_2^0$ ▸ $_0S_2^2$C,cos ▸ $_0S_3^0$ ▸ $_0S_3^3$cos ▸ $_0S_0^0$ ▸ $_0S_0^0$C ▸ $_0S_8^5$sin ▸ $_0T_2^0$ ▸ $_0T_2^0$C ▸ $_0T_6^6$sin

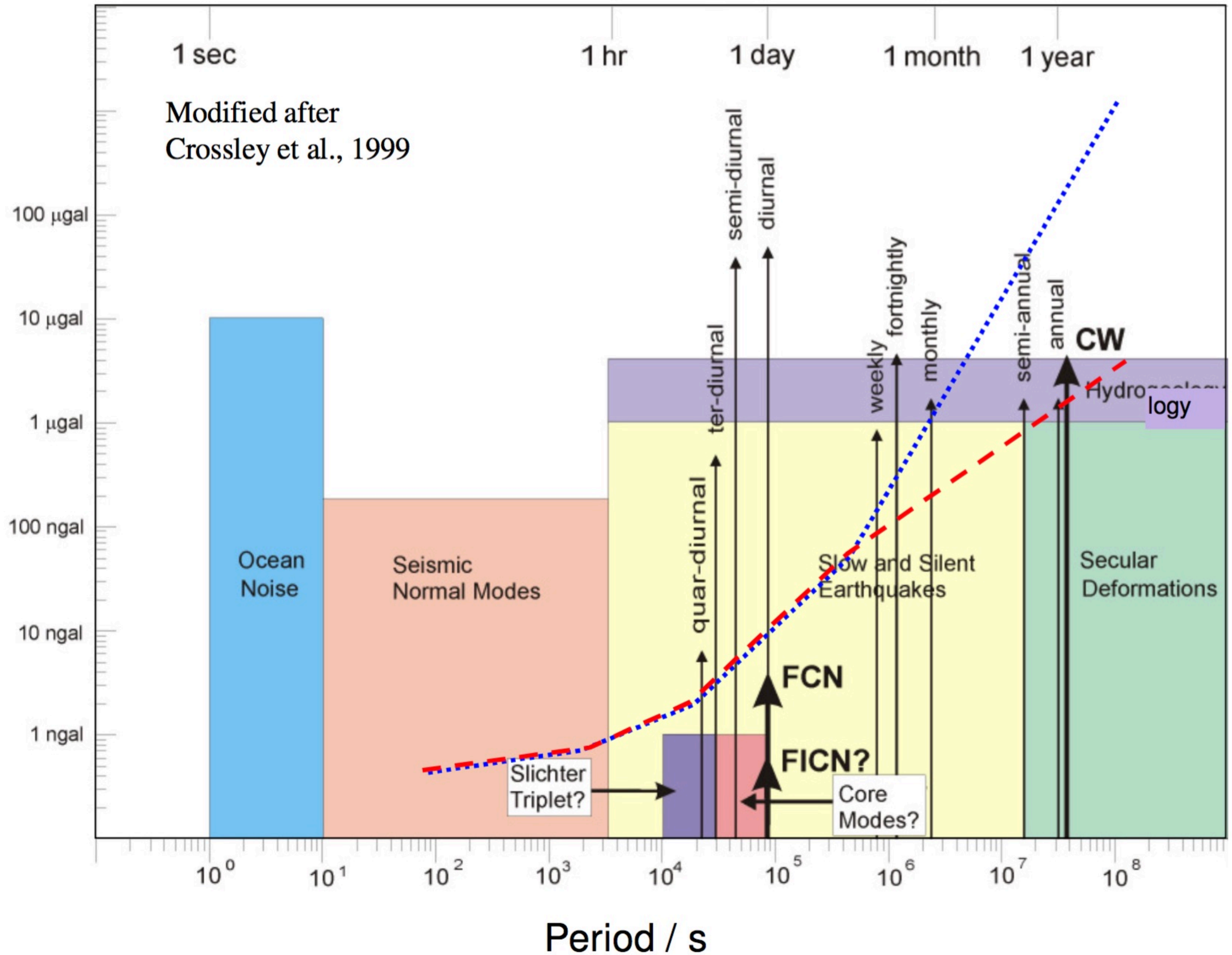
(Lucien Saviot, 2011)

Global low noise model

BFO contributes to low noise model



Long period signals



Superconducting gravimeter

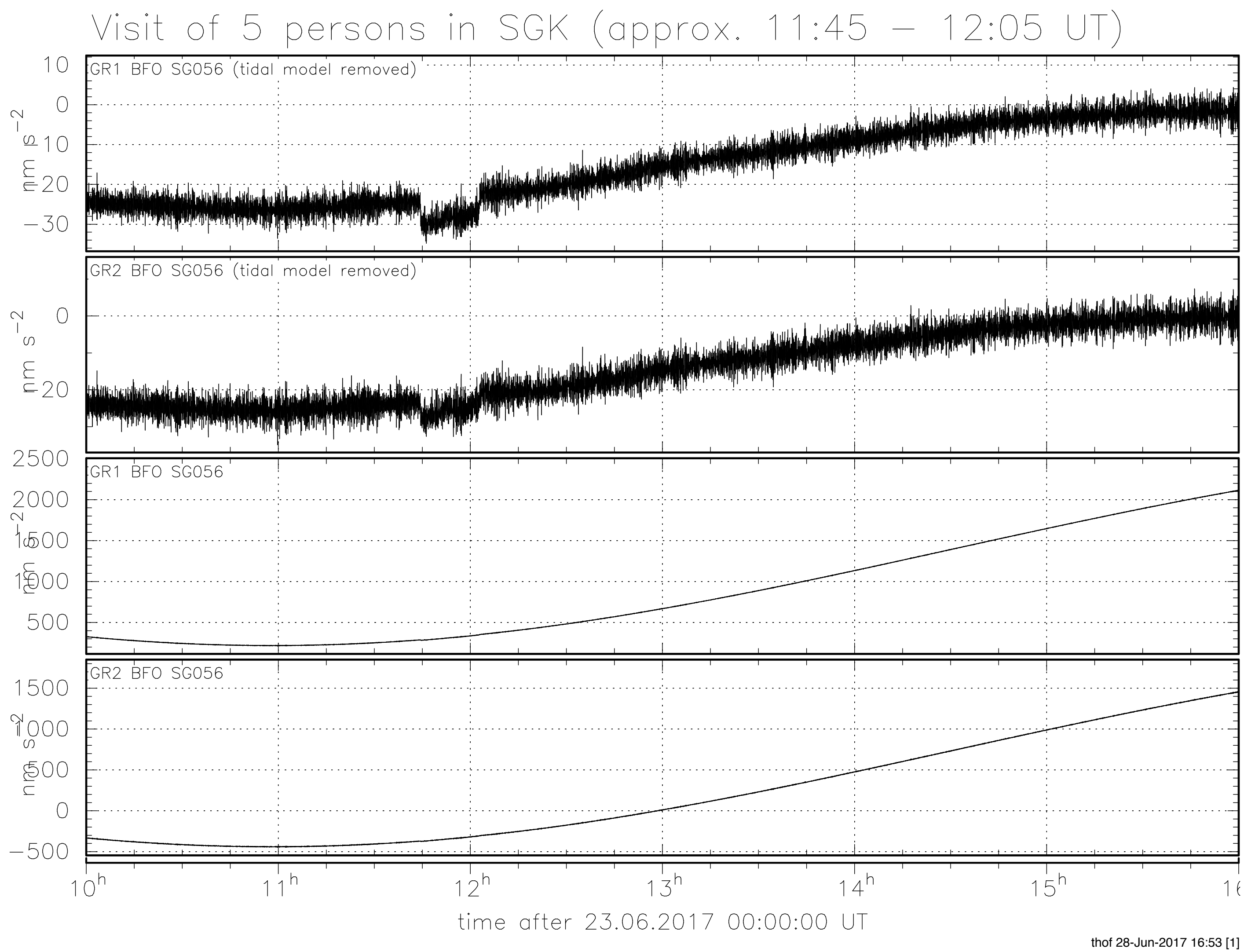
Superconducting gravimeter

Universität Stuttgart
Germany

Karlsruhe Institute of Technology

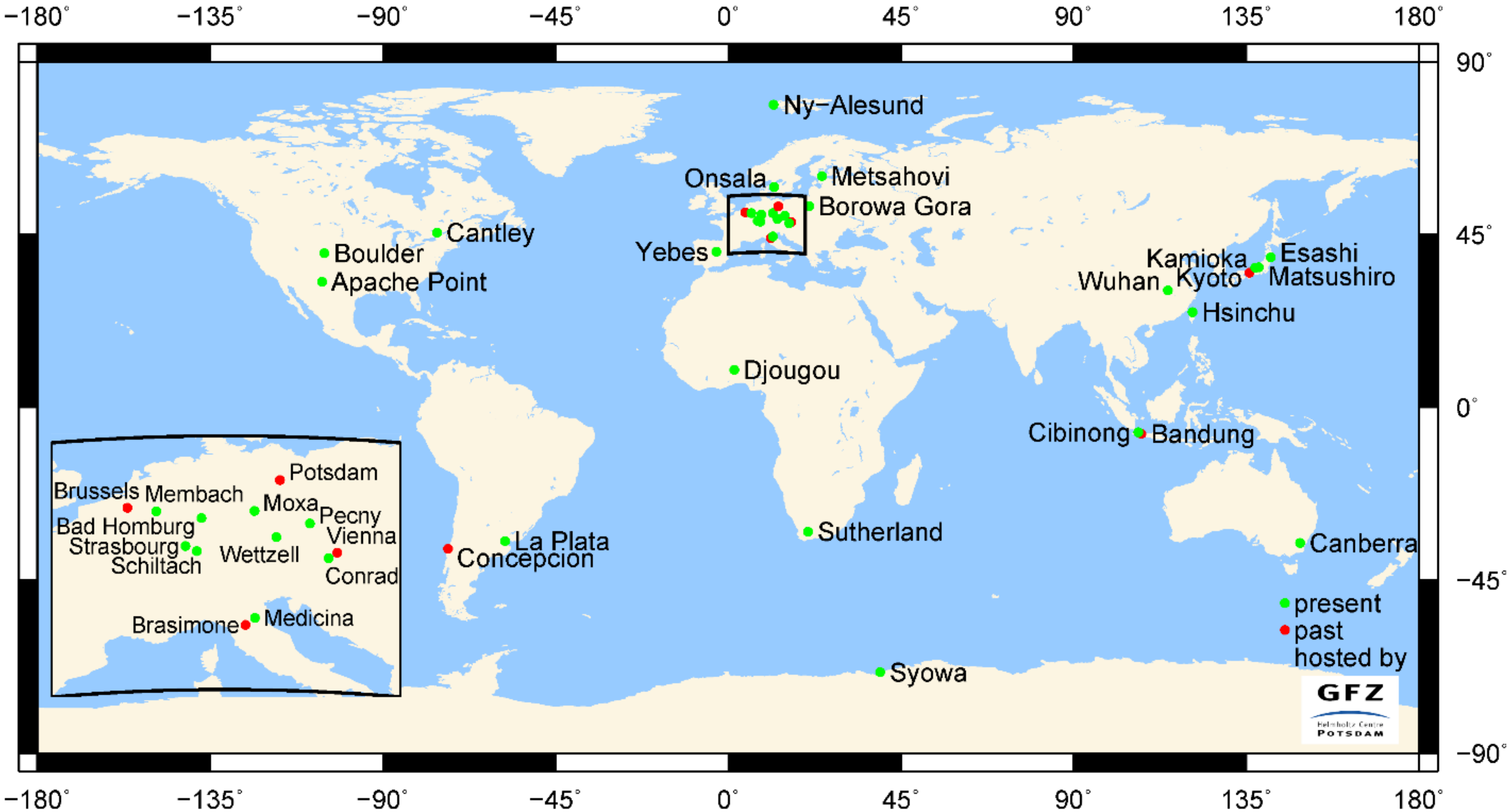
(courtesy of Markus Breig, 2015)

Sensitivity: human anomaly….



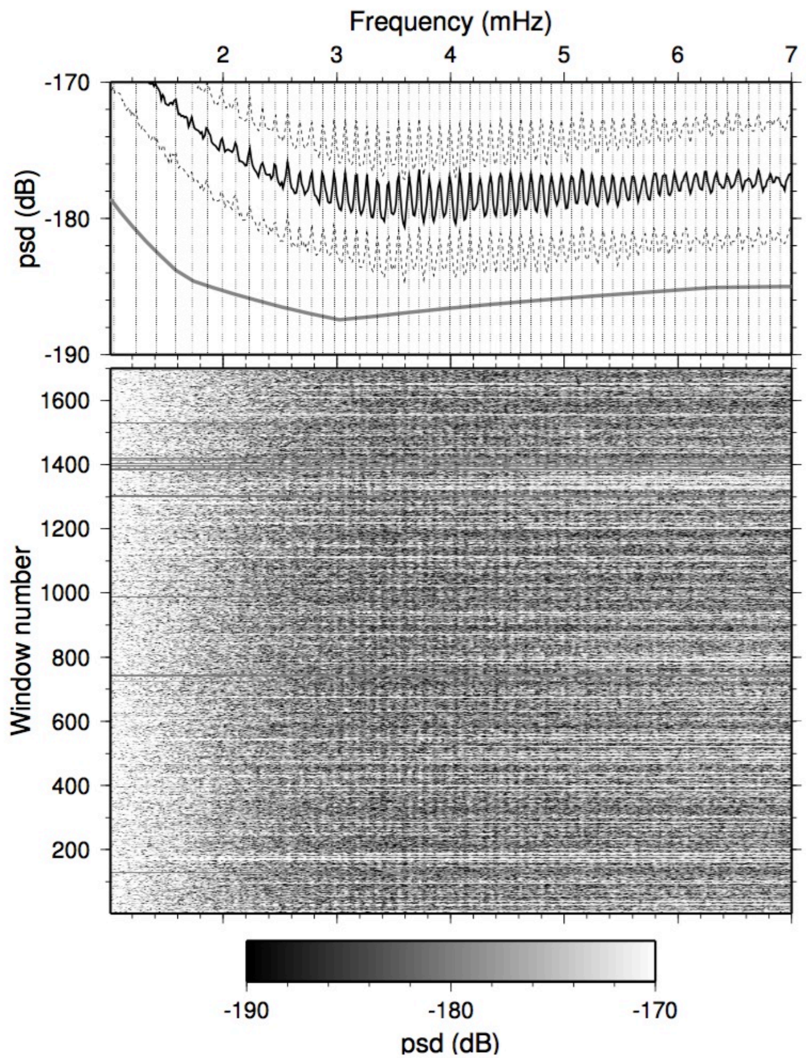
Superconducting gravimeters world wide

IGETS data base containing data from 35 stations



Background free oscillations (Hum of the Earth)

Signalamplitude: $10\,\mathrm{pm\,s^{-2}} = 10^{-12}\,\mathrm{g}$



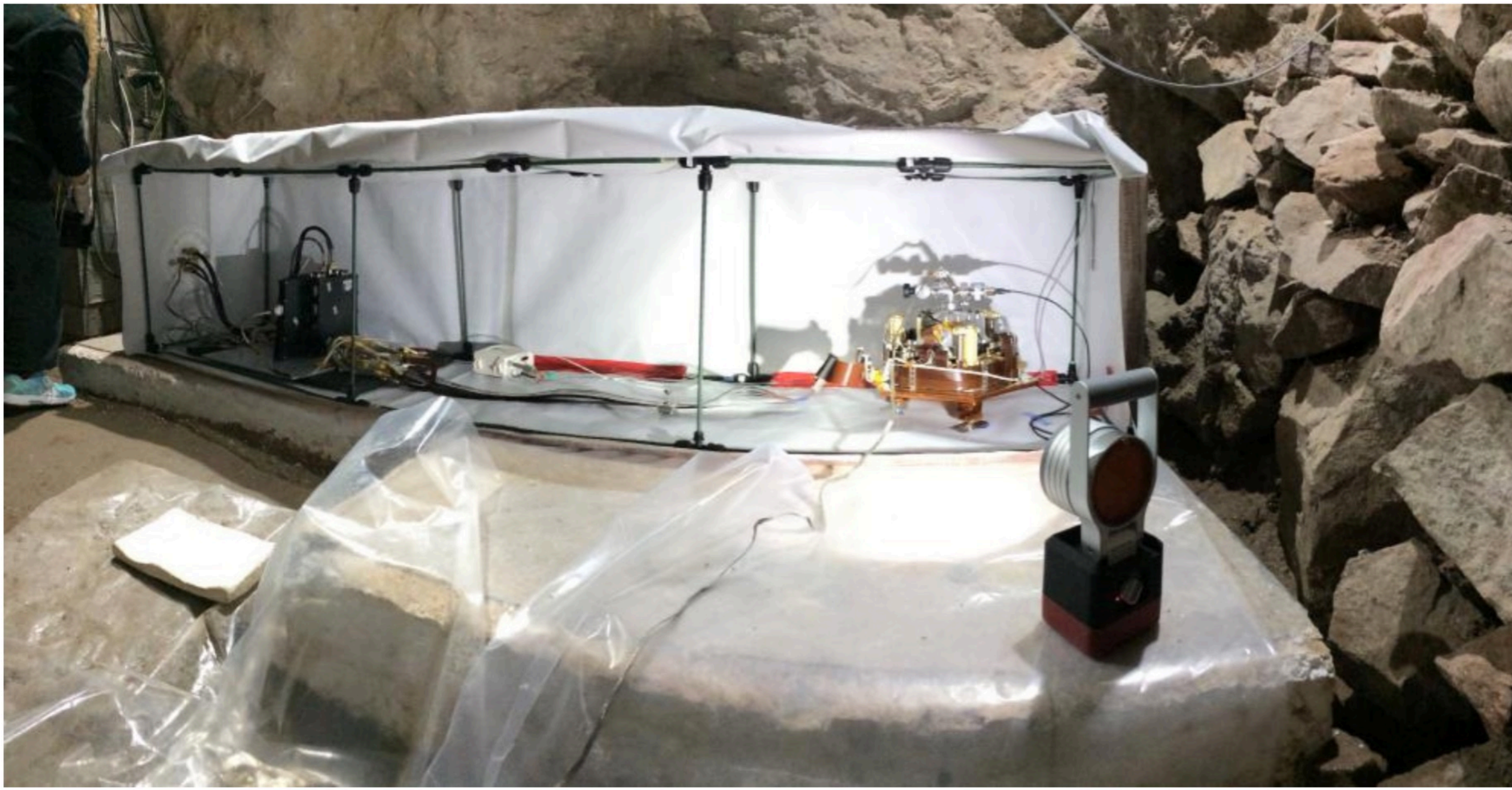
(Wielandt und Widmer-Schnidrig, 2002)

Testing Mars-seismometers

Guests from the french space agency (CNES)

Universität Stuttgart
Germany

KIT
Karlsruhe Institute of Technology



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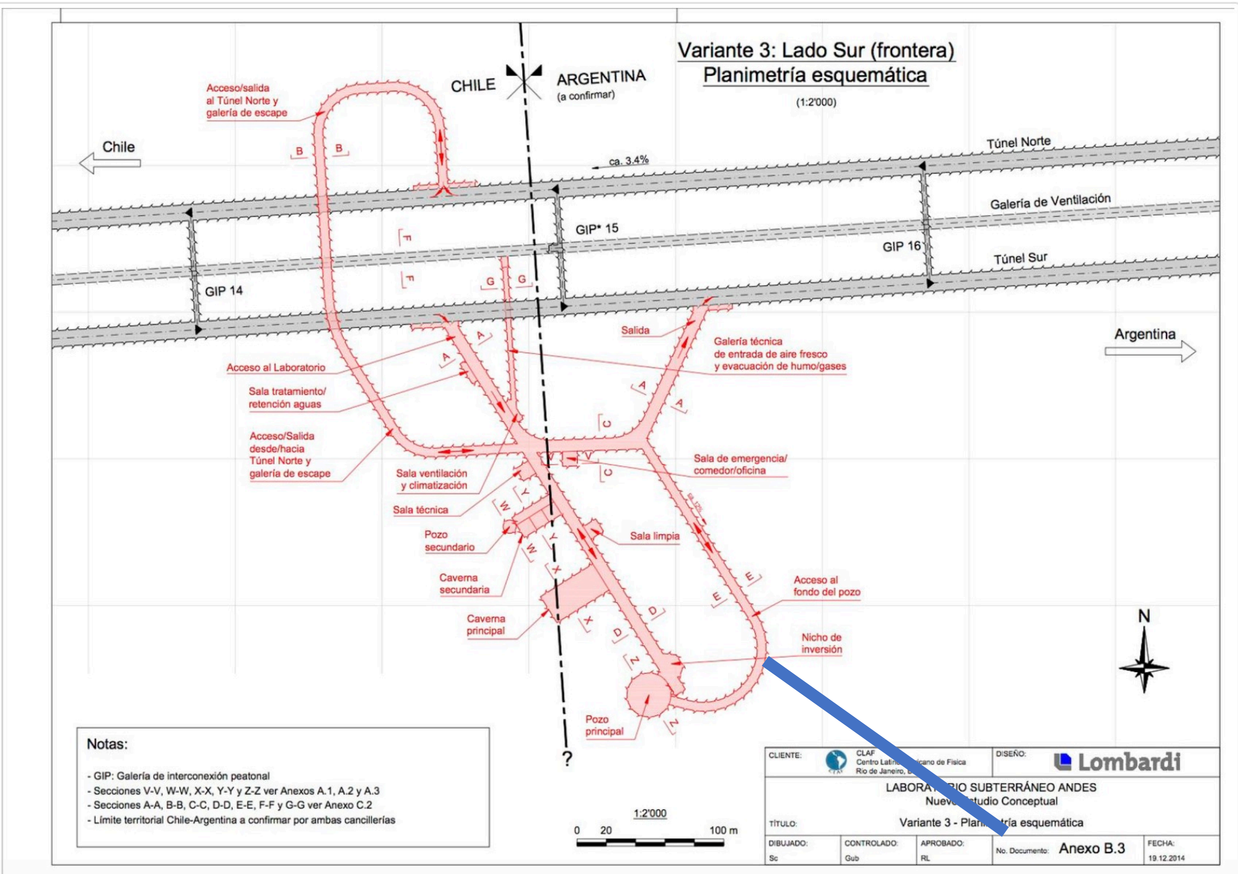
Laboratory design

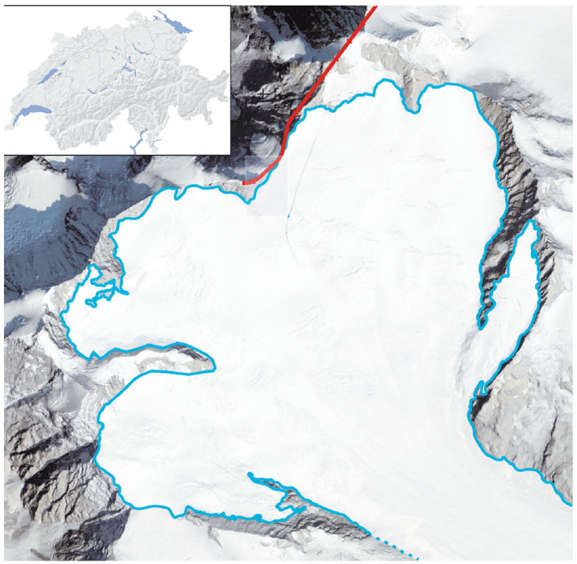


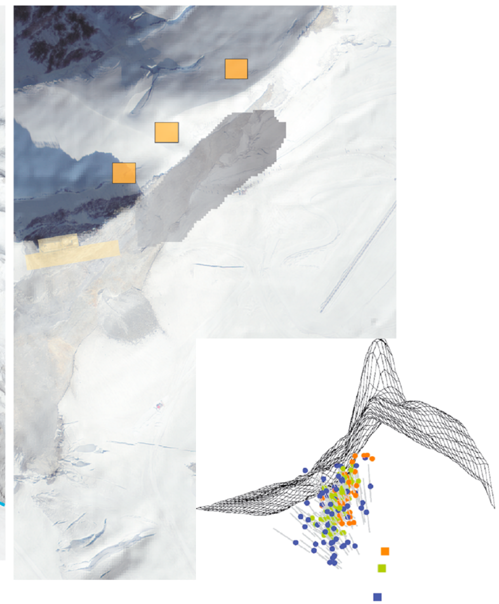
- **Small tunnel (access by foot)**
- **2 airlocks to separate permanent experiments from visiting experiments**
- **No or reduced active ventilation**
- **About 6-8 experiment bays (5x5m and 2-3m high); power supply, optic fibre, GPS time provision**

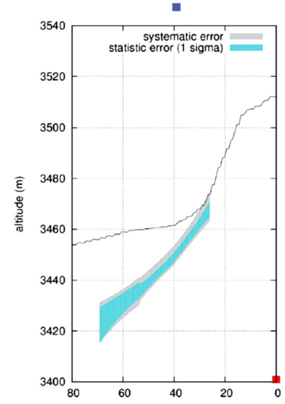
Timeline

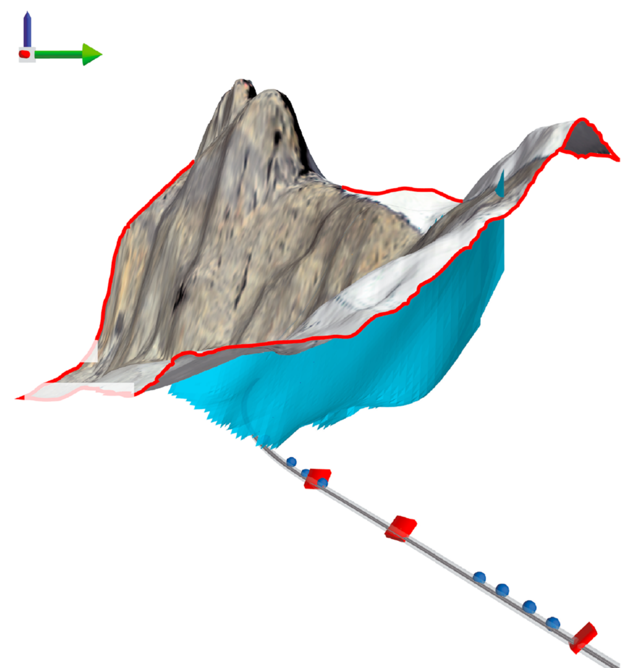
- Deploy a BB seismic array/antenna (2017/18)
  - Structural constrain on crust and upper mantle
  - Establish seismic hazard at surface and explore spectral ordinates
- Install instruments during the tunnel excavation to record seismic acceleration in the tunnel
  - ➔ provide design spectra for the instrumentation of the experiments
- Permanent instrumentation of the lab:
  - Long Period seismometer (STS1)
  - Superconducting gravimeter (best also to have a station in the lab in Chile and Argentina along the transect

First measurement of ice-bedrock interface of alpine glaciers by cosmic muon radiography “Imaging density (contrasts)”









Nishiyama et al., 2017

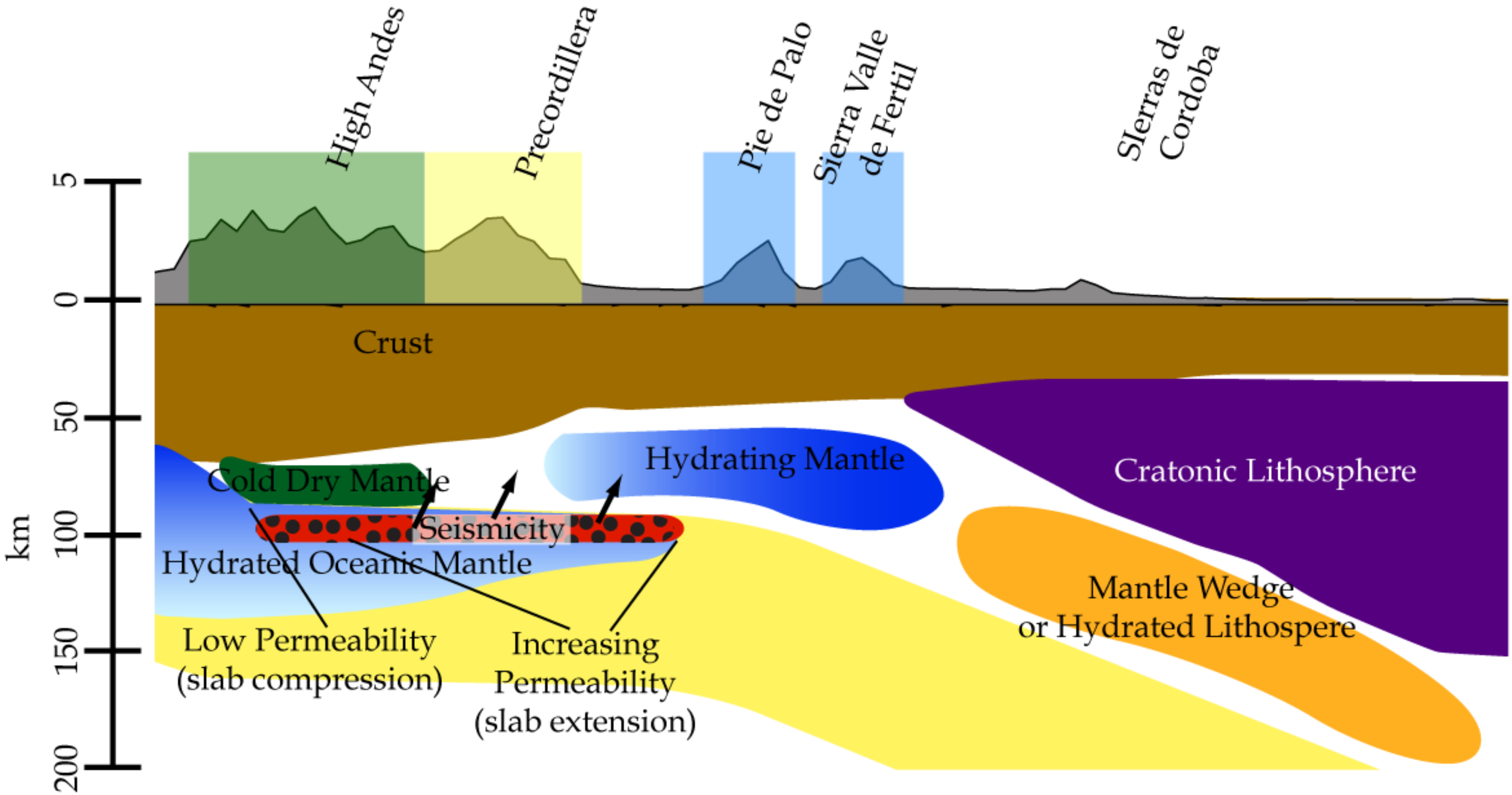

High Andes
Precordillera
Pie de Palo
Sierra Valle de Fertil
SIerras de Cordoba
5
0
50
100
150
200
km
Crust
Cratonic Lithosphere
Hydrating Mantle
Cold Dry Mantle
Seismicity
Hydrated Oceanic Mantle
Mantle Wedge or Hydrated Lithospere
Low Permeability (slab compression)
Increasing Permeability (slab extension)

Figure 17