

# ANDES-GEO: Current design considerations and next steps

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ANDES-GEO consortium



Left: Santiaguito volcano, right: Santa Maria volcano, image taken from El Nuevo Palmar, 10/01/18

# Outline

Seismicity and modes of displacement in a subduction zone environment

Underground observatory:

Black Forest Observatory (BFO)

GeoMat Laboratory

Scope and Current activities

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## Seismicity and modes of displacement in a subduction zone environment

Underground observatory:

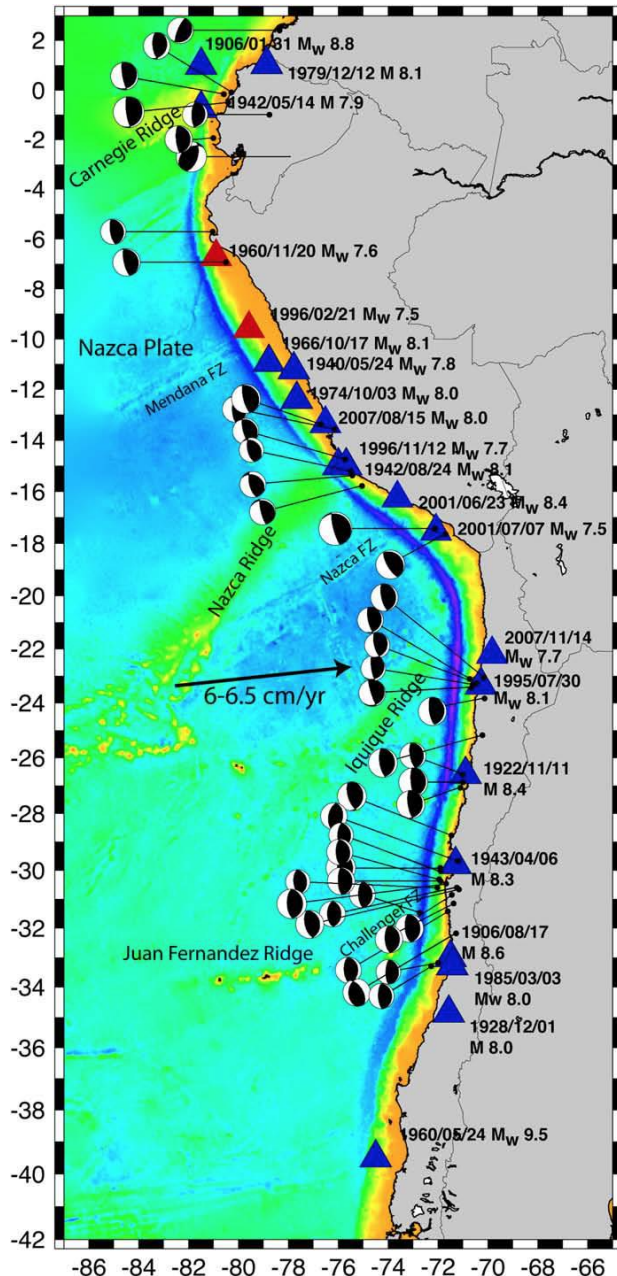
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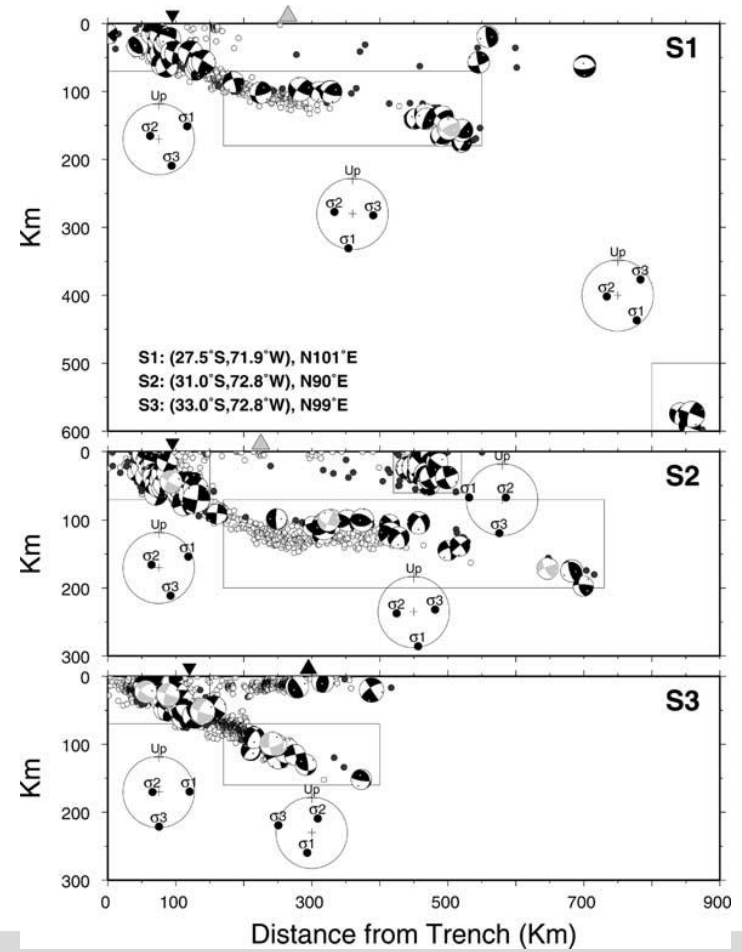
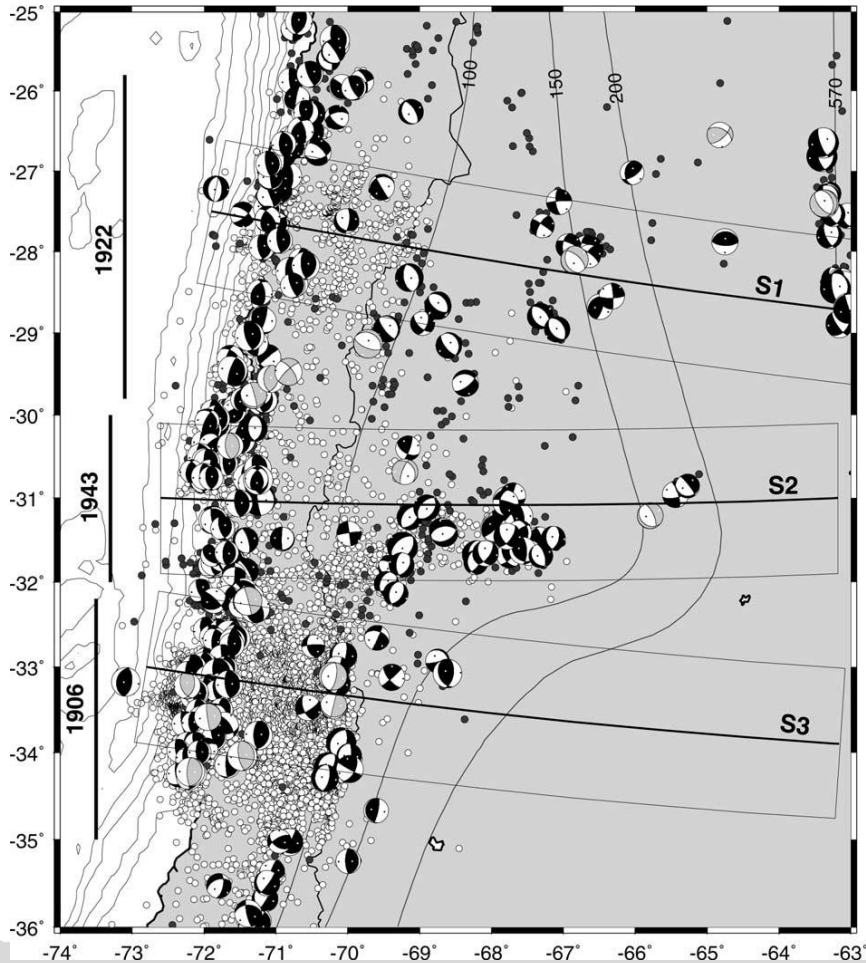
# South American Subduction Zone

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



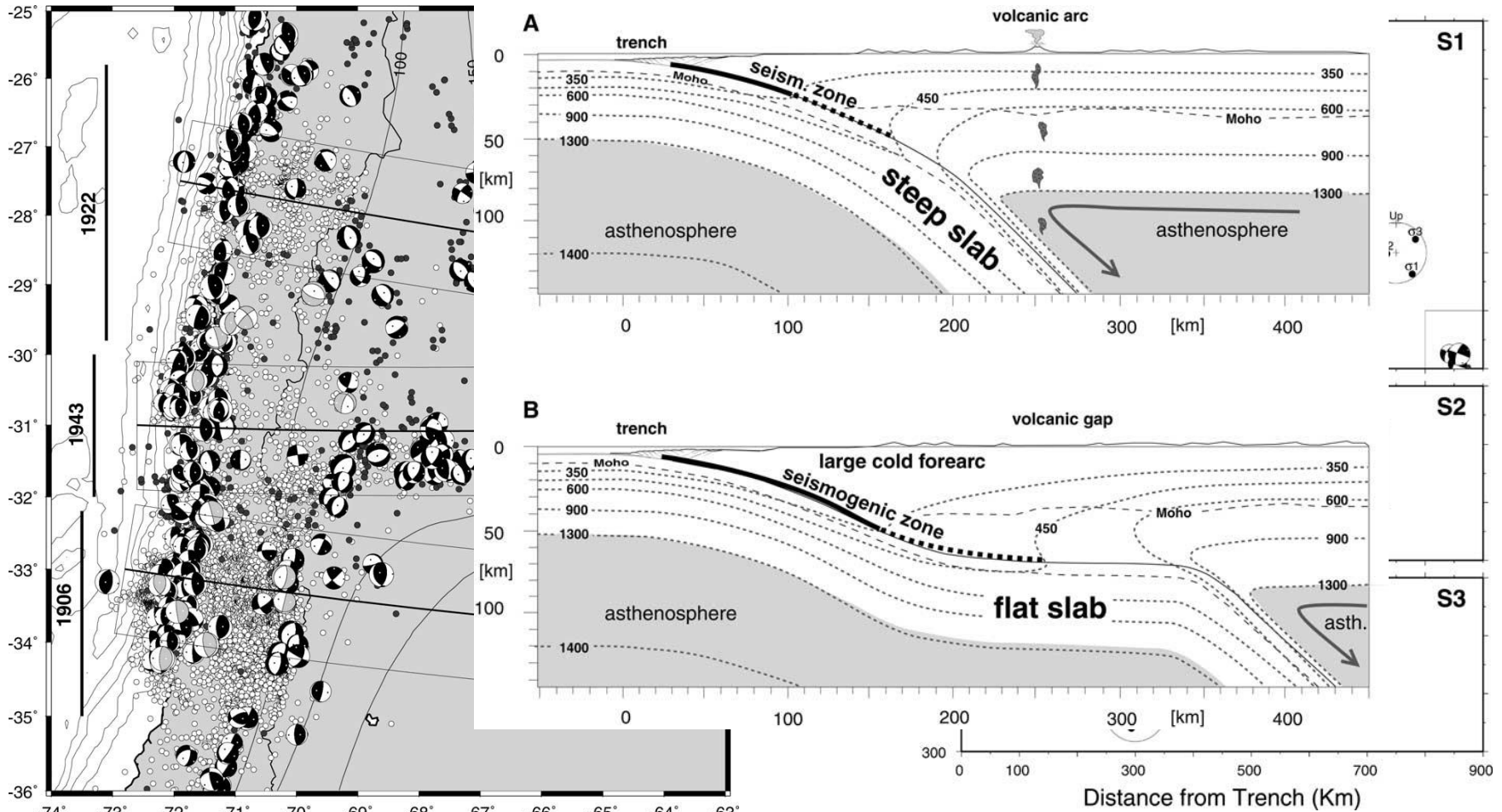
Bilek, 2009

# Seismicity cross section: Flat subduction



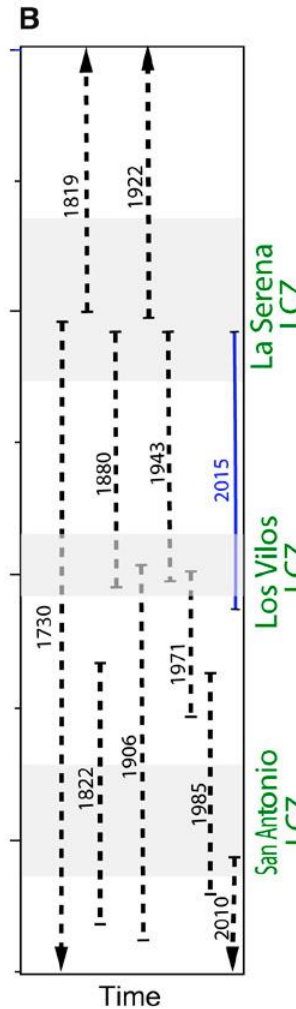
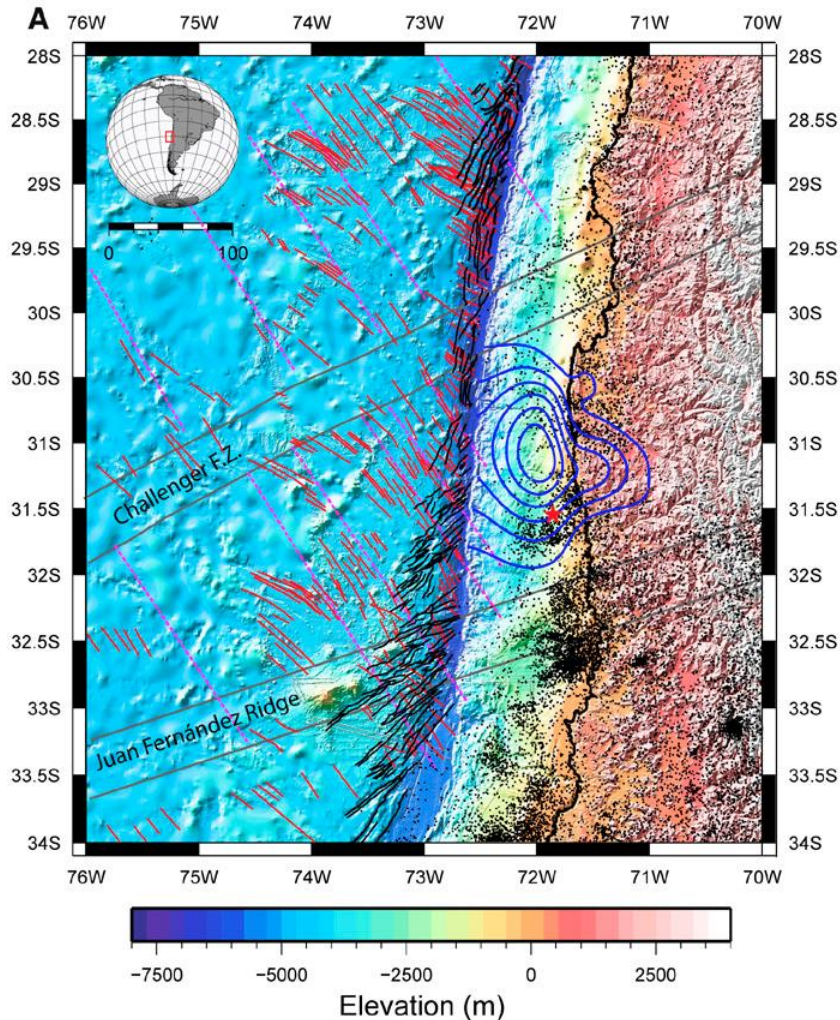


# Seismicity cross section: Flat subduction

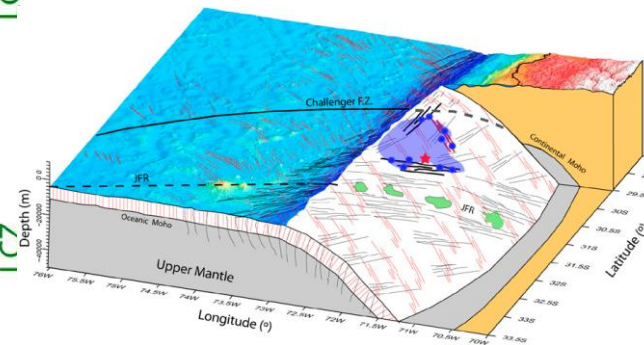


Pardo et al. 2002

# The 2015 Mw 8.3 Illapel earthquake

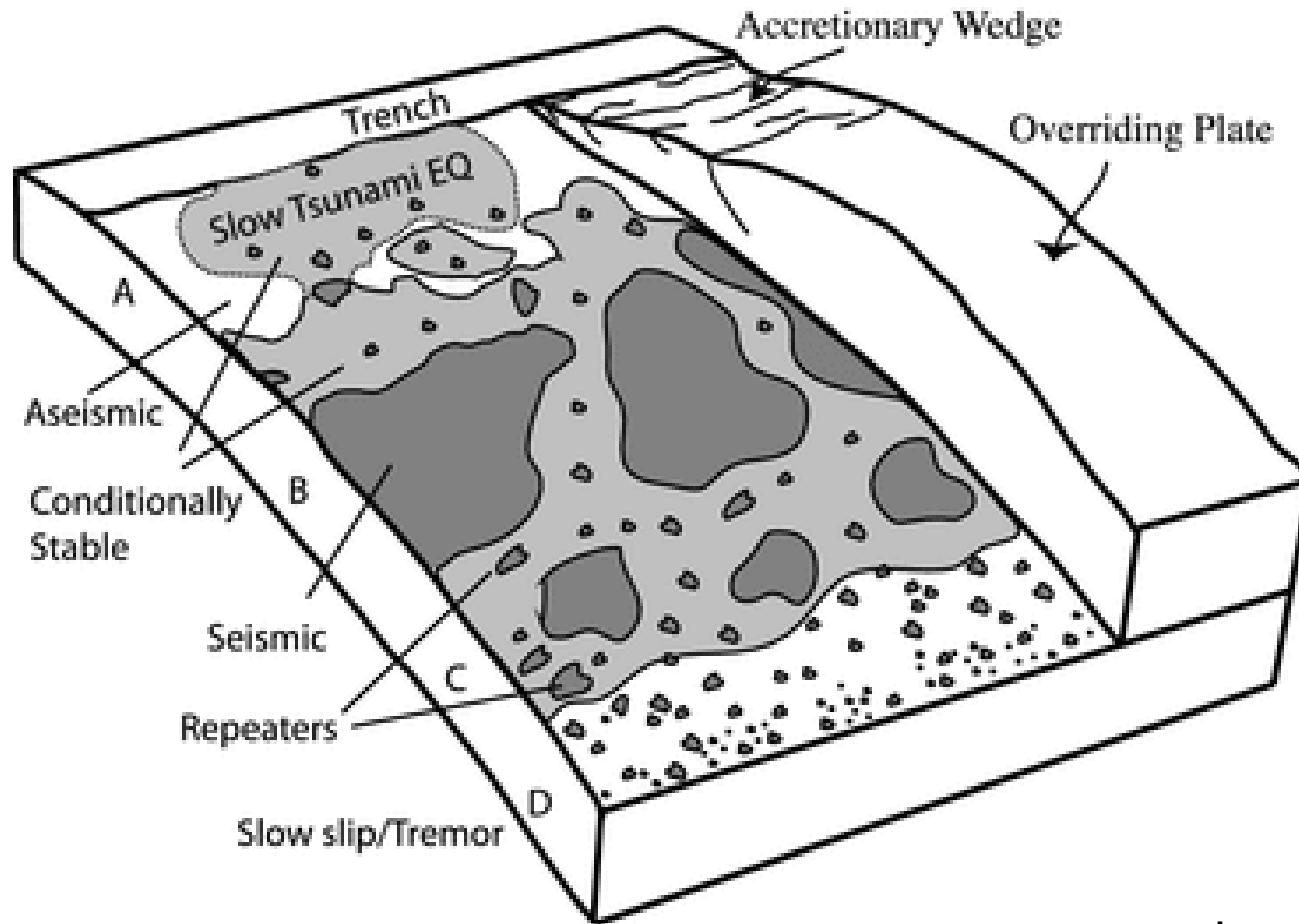


- Good historical record
- Large earthquake occur at “regular” intervals
- Fracture zones seem to limit the rupture area



Poli et al., 2017

# Conceptual model of the subduction zone interface

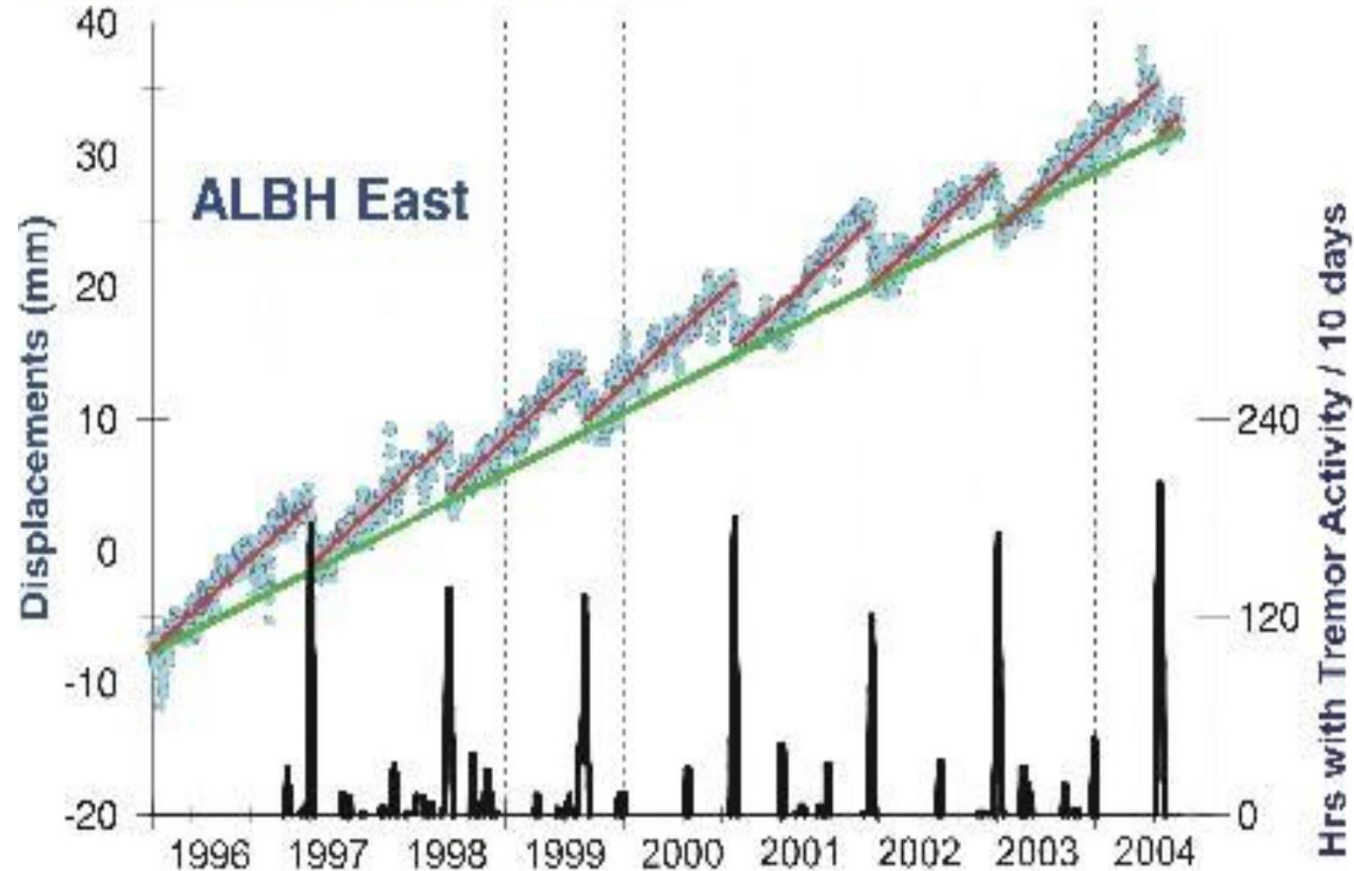


Lay et al., 2012



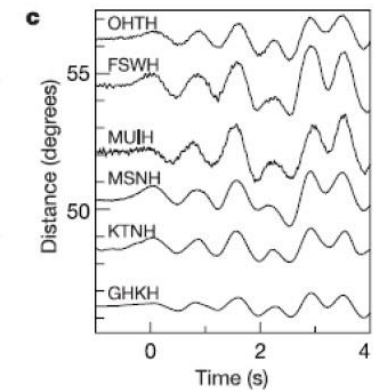
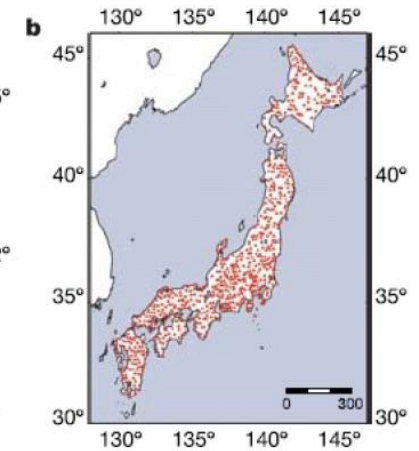
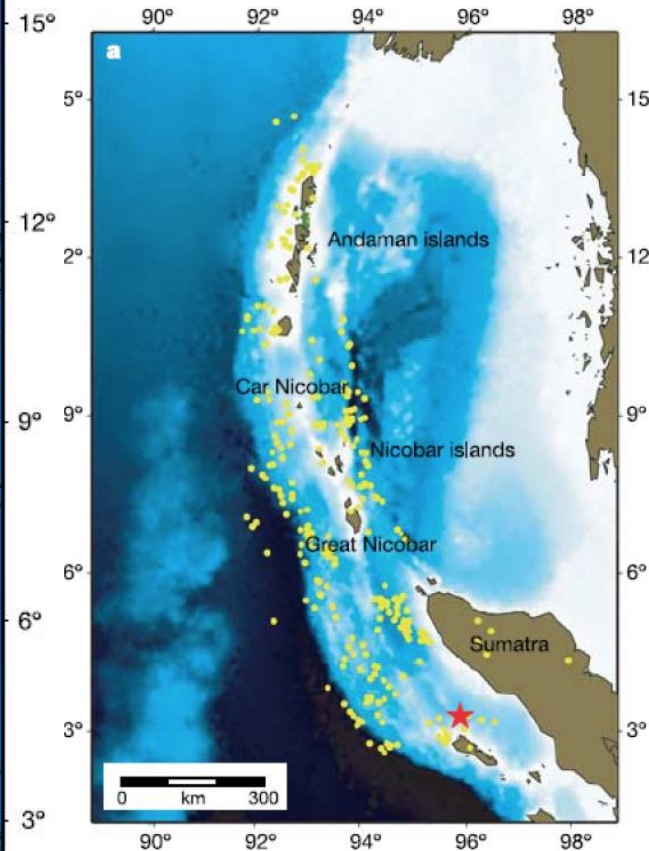
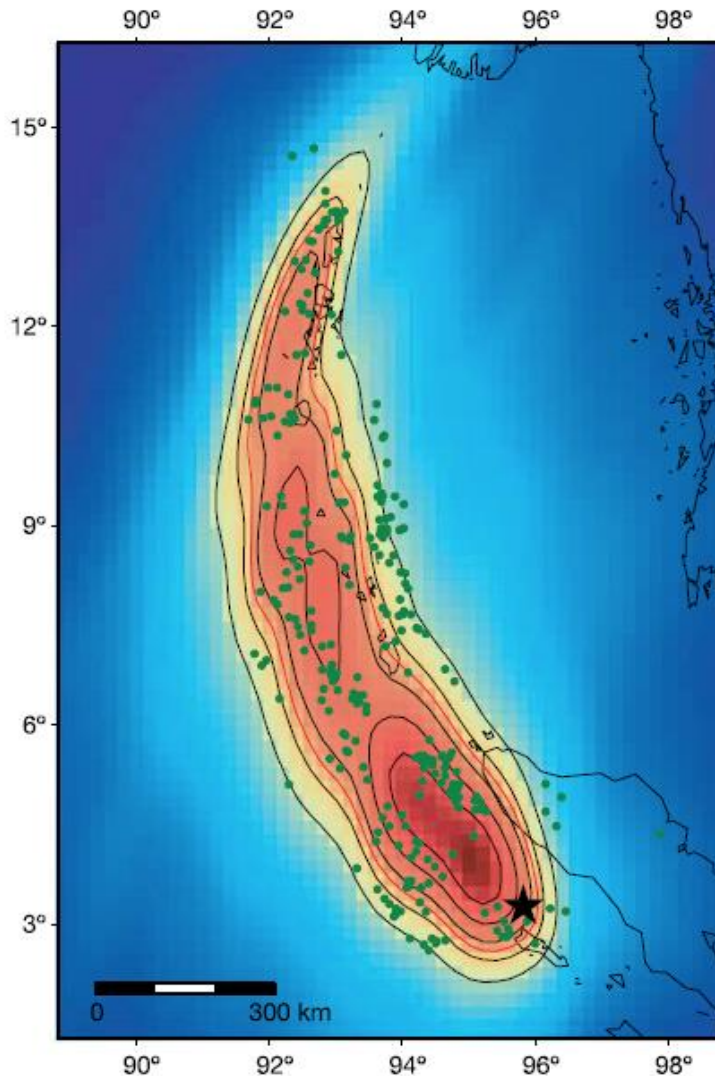
# Slow slip events (e.g Cascadia)

Tremor Counts with GPS Data



\*source: [http://gsc.nrcan.gc.ca/geodyn/ets\\_e.php](http://gsc.nrcan.gc.ca/geodyn/ets_e.php)

# Rupture front imaging



2004 Sumatra earthquake (Ishii et al, 2005)

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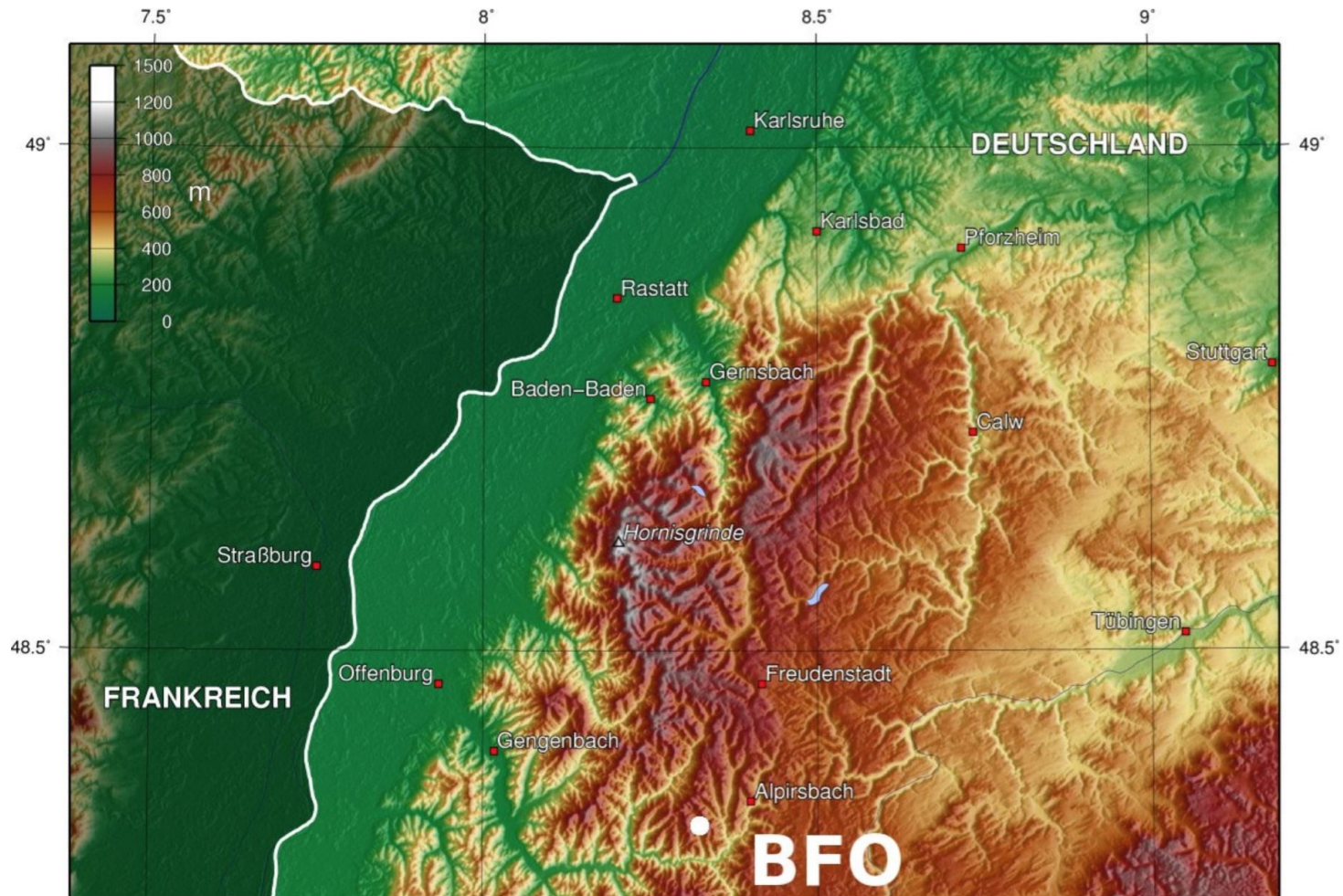
Black Forest Observatory (BFO)

GeoMat Laboratory

Scope and Current activities



# BFO observatory



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

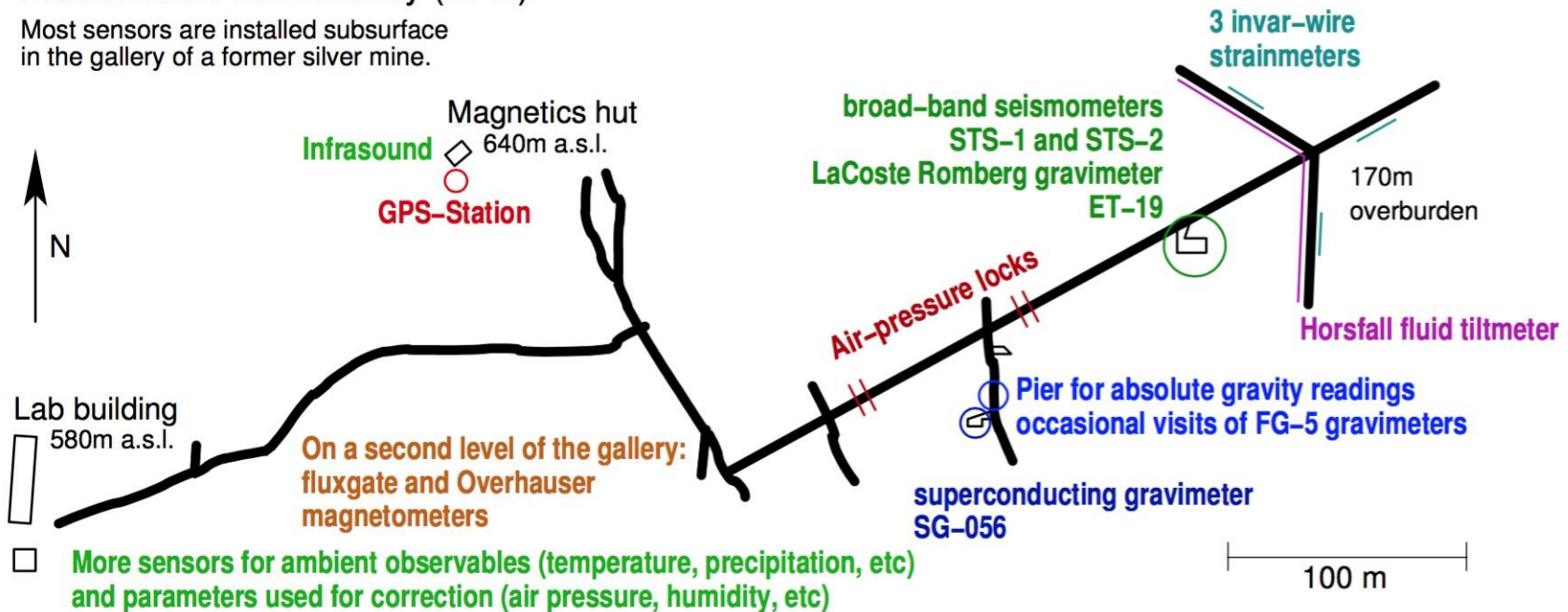


# Floor map of the gallery



## Black Forest Observatory (BFO)

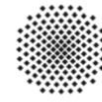
Most sensors are installed subsurface in the gallery of a former silver mine.



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.

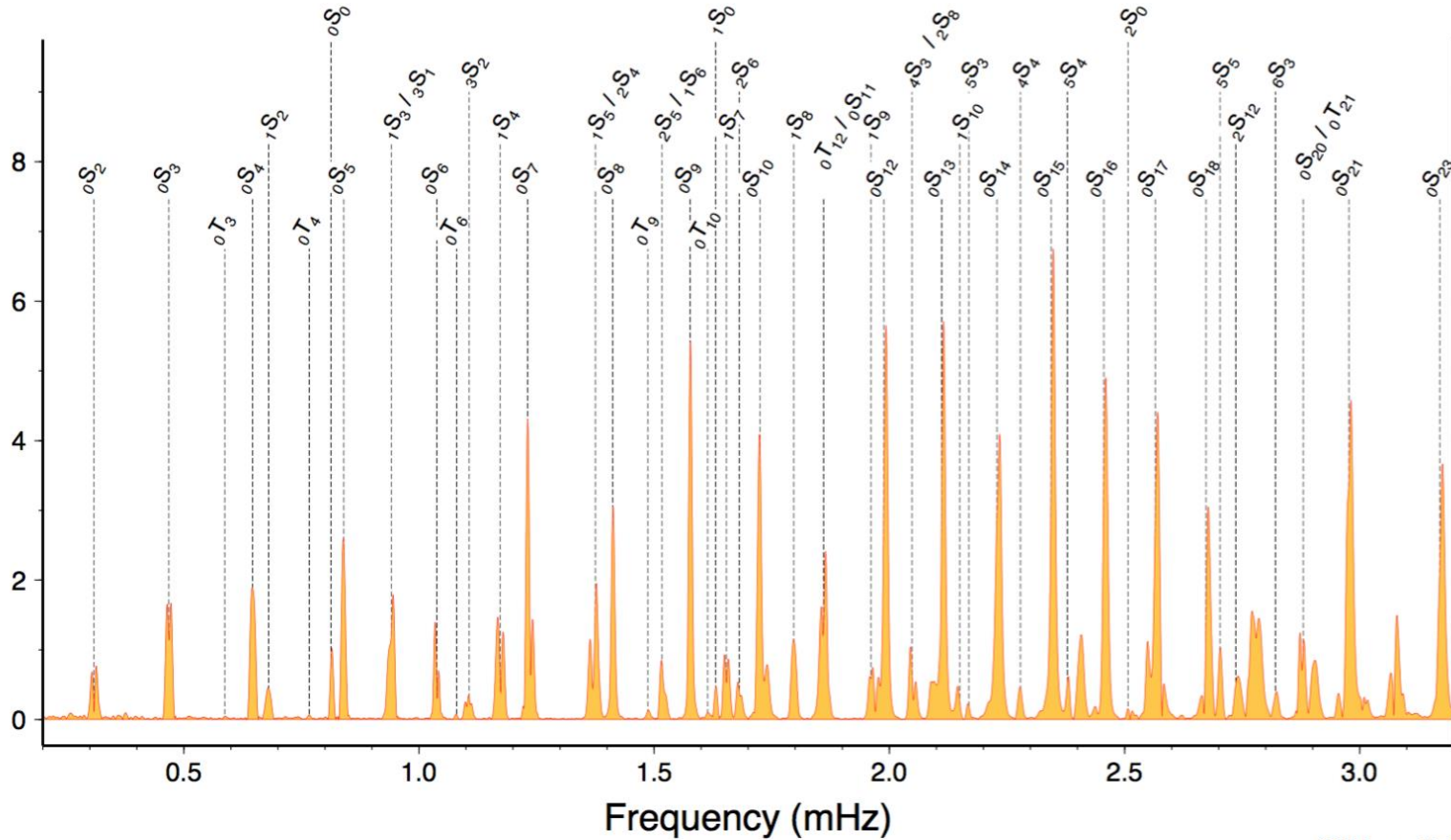
# Tohoku quake (Mw 9.0, 11.3.2011)



Universität Stuttgart  
Germany



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



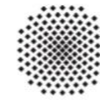
(Widmer-Schnidrig, 2011)

- ${}^1S_1^0C$
- ${}^0S_2^0$
- ${}^0S_2^2C, \cos$
- ${}^0S_3^0$
- ${}^0S_3^3 \cos$
- ${}^0S_0^0$
- ${}^0S_0^0C$
- ${}^0S_8^5 \sin$
- ${}^0T_2^0$
- ${}^0T_2^0C$
- ${}^0T_6^6 \sin$

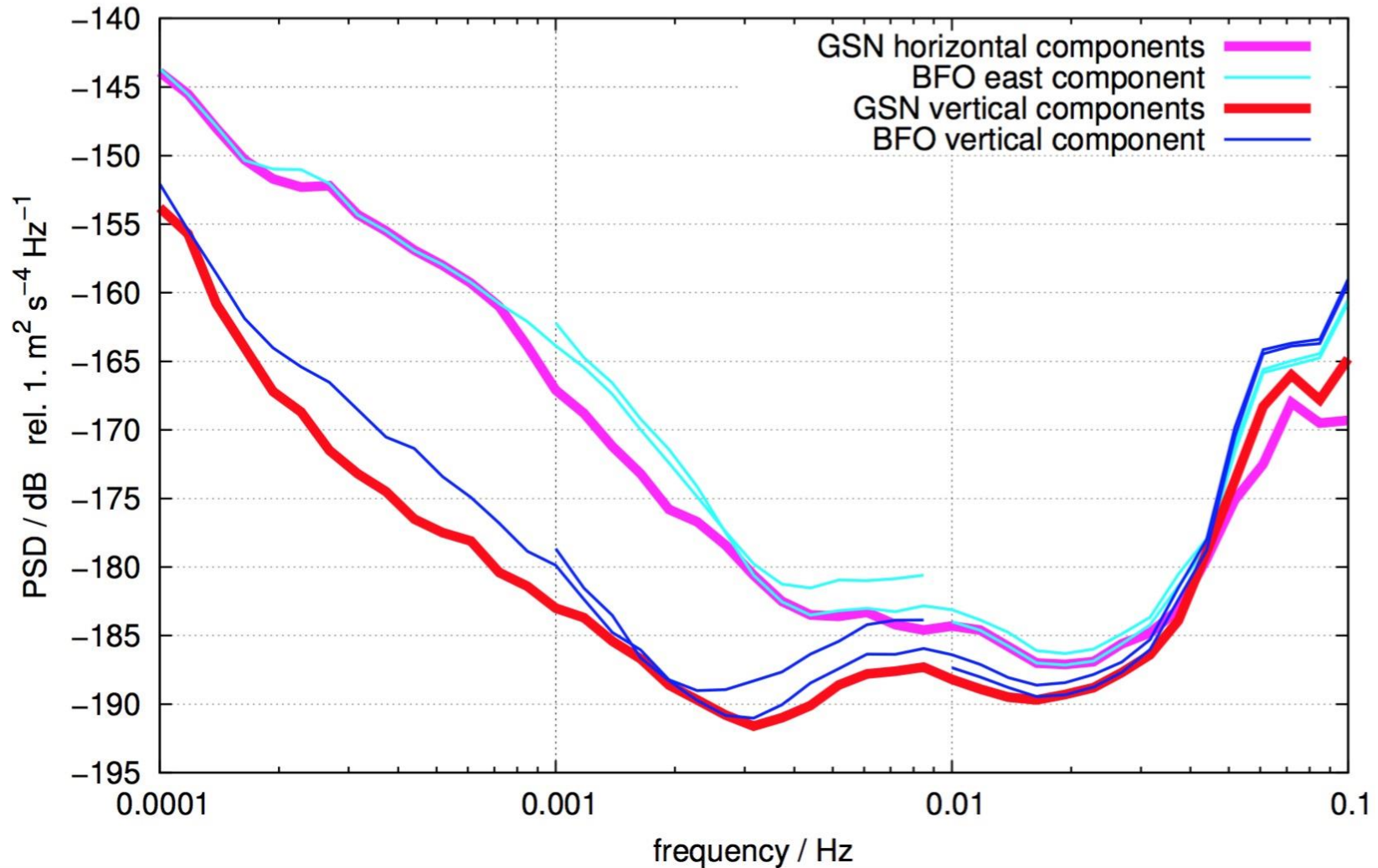
(Lucien Saviot, 2011)

# Global low noise model

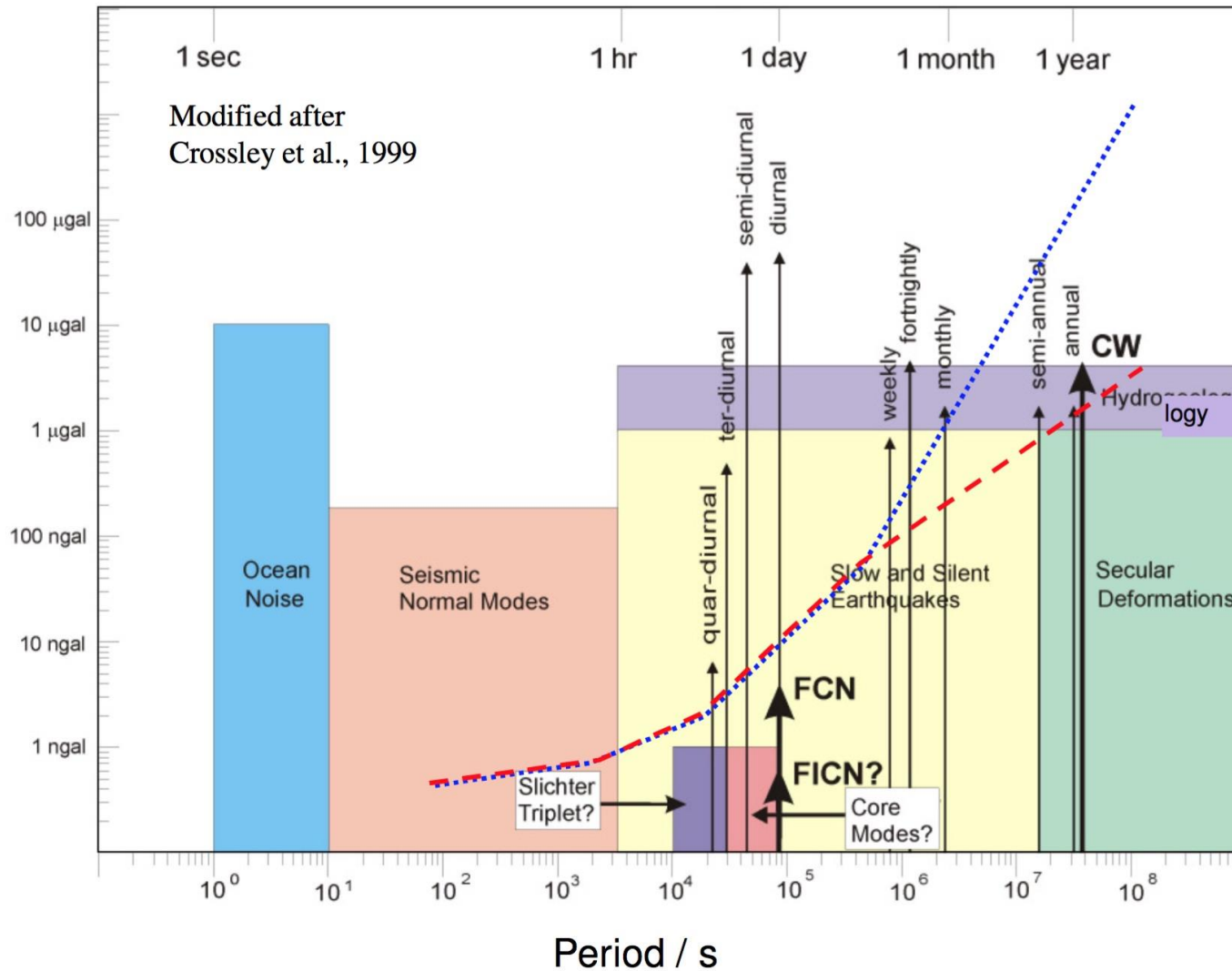
## BFO contributes to low noise model



Low noise model by Berger, Davis, and Ekström (2004).  
1st percentile of power spectral density (7/2001 – 6/2002)



# Long period signals

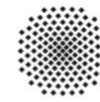




# Superconducting gravimeter



# Superconducting gravimeter



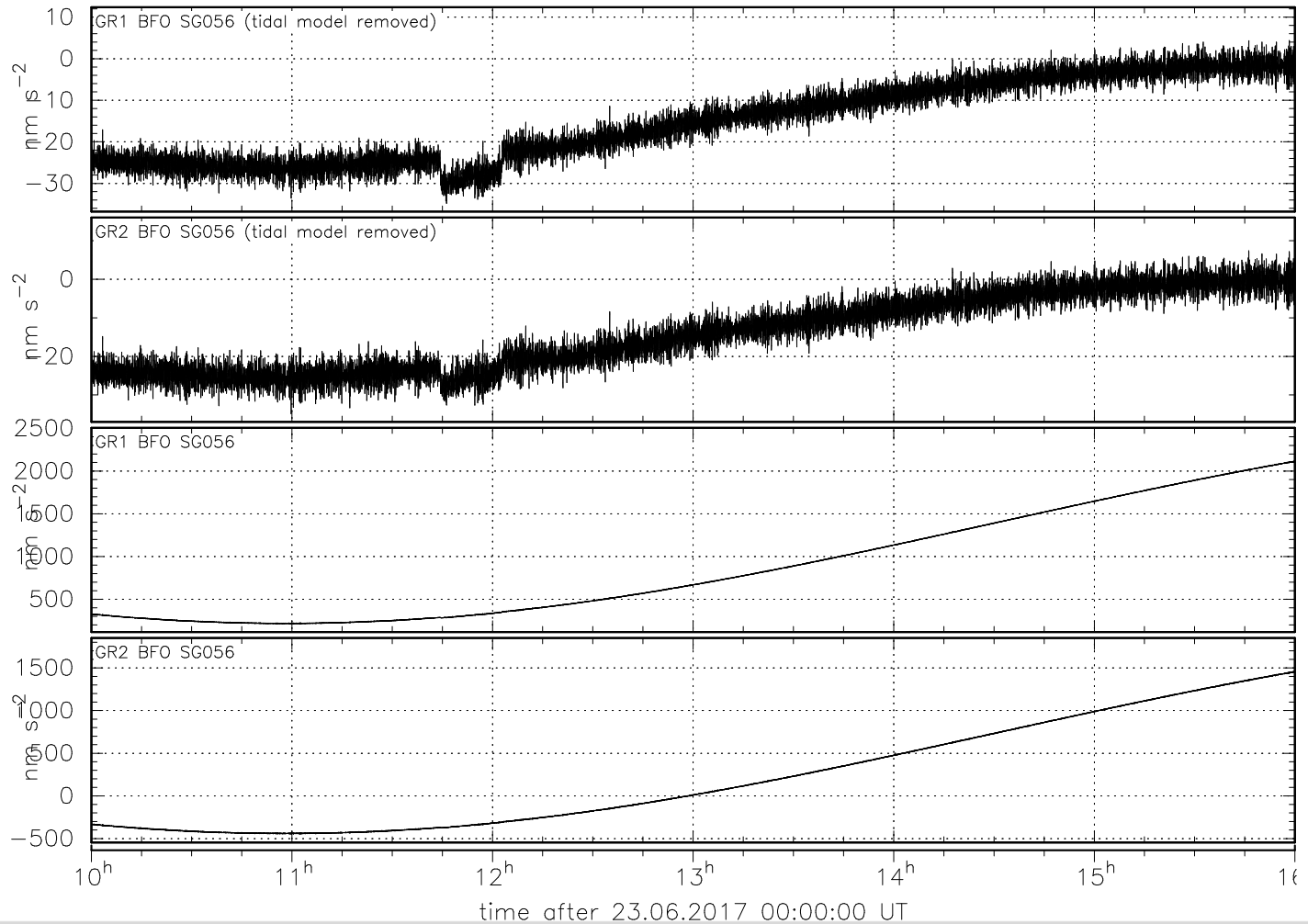
Universität Stuttgart  
Germany



(courtesy of Markus Breig, 2015)

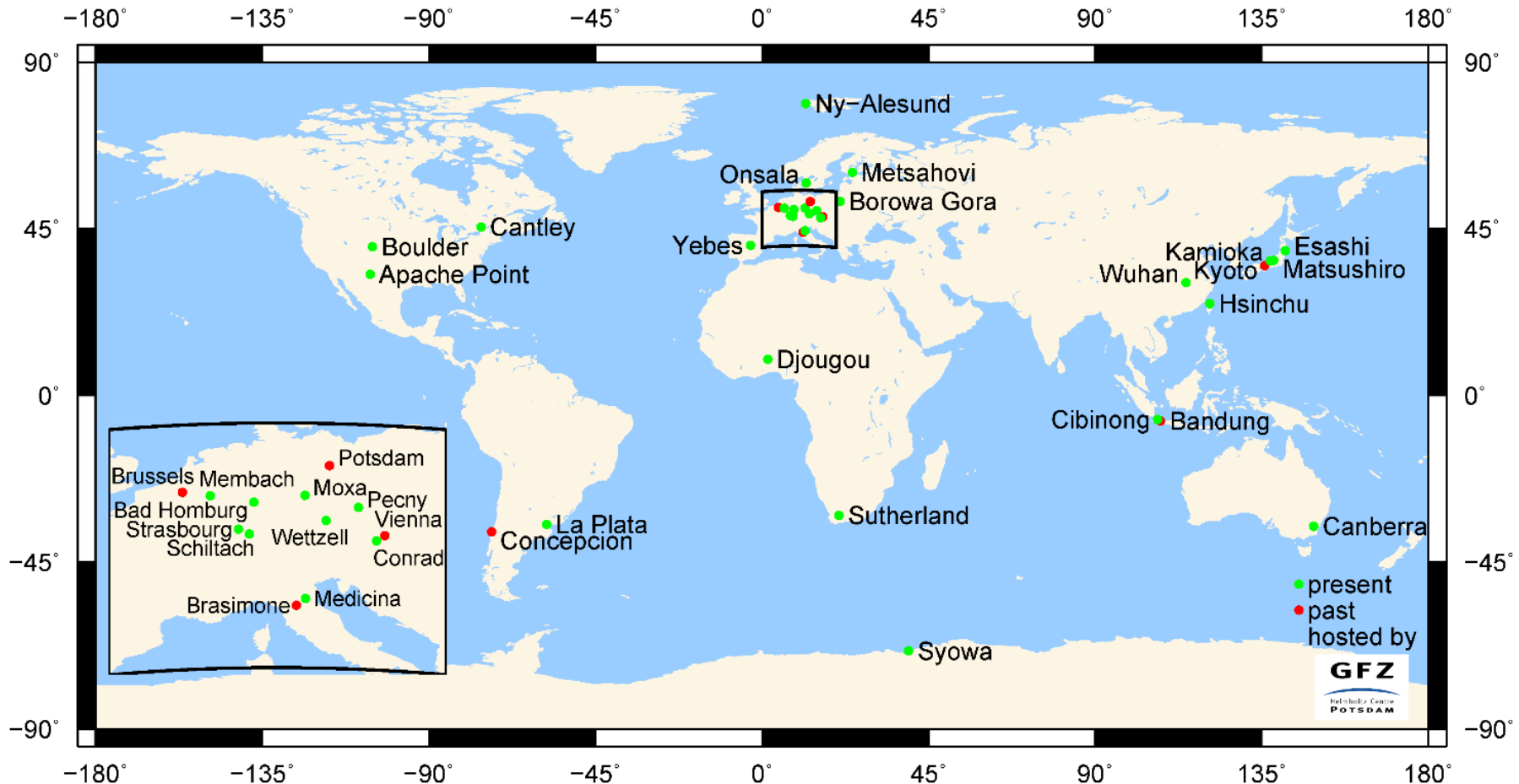
# Sensitivity: human anomaly....

Visit of 5 persons in SGK (approx. 11:45 – 12:05 UT)



# Superconducting gravimeters world wide

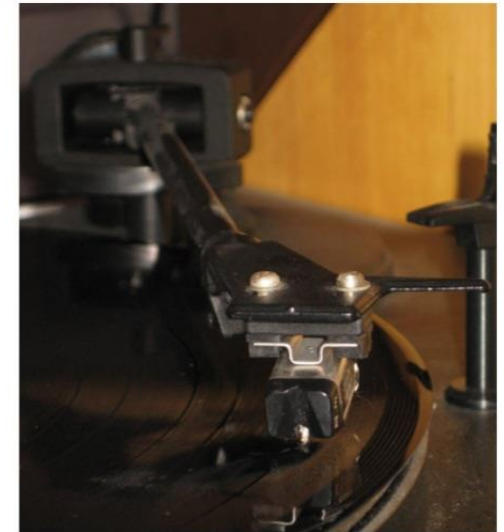
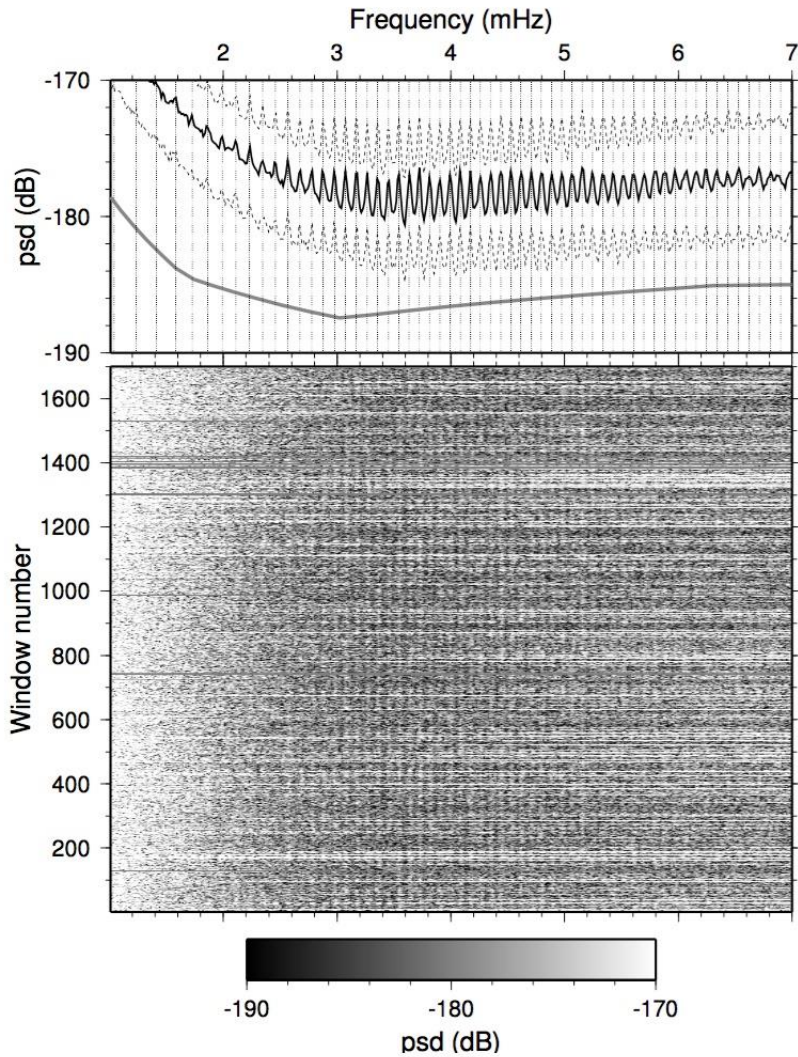
IGETS data base containing data from 35 stations





# Hintergrundeigenschwingungen (Hum)

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



(Wielandt und Widmer-Schnidrig, 2002)

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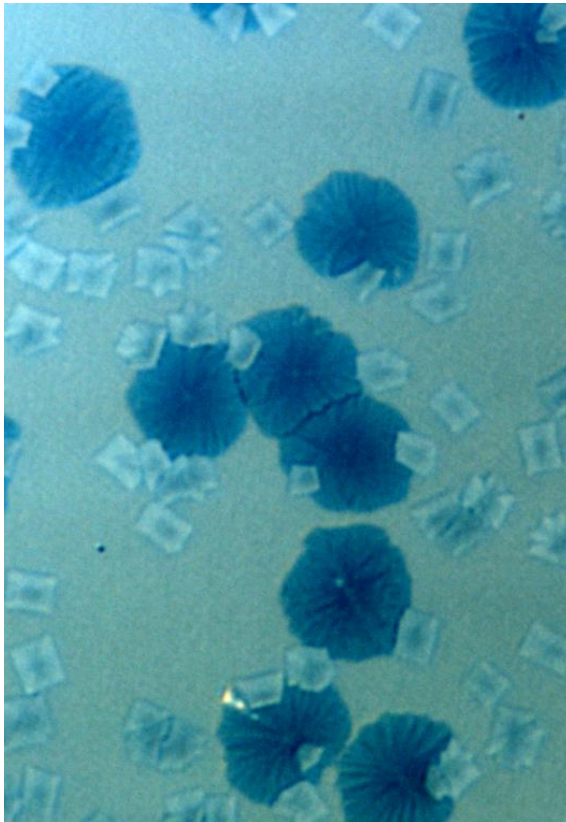
# GeoMat Laboratory: e.g. Geology

## Suggested Projects:

- Controlled crystallization of amorphous thin films without cosmic irradiation
- Long-term monitoring of geogenic gases
- Long-term monitoring of magnetic susceptibility of rocks under in-situ stress
- Long-term rheological and geochemical investigation of host rock integrity in damage zones

# GeoMat Laboratory: e.g. Material Sciences

Fo138



Fo139



Extremely different Forsterite thin films both crystallized 8h at 1098K. Fo139 is completely recrystallized.

Fo139 was stored several month before used for the experiment. (courtesy of Glasmacher, U. Heidelberg)



# GeoMat Laboratory: e.g. Material Sciences

## The Results of the Past Experiments

The crystallization structures are statistically related to:

- the storage time of the thin amorphous films before crystallization experiment.
- and not associated with the  $\text{H}_2\text{O}$  /  $\text{CO}_2$  content. (quantified by IR-spectroscopy).

## The cause?

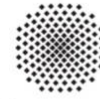
The crystallization structure of the same material is extremely sensitive to the formation of crystal seeds.

Hypothesis: Crystal seeds are related to natural high energy radiation.

Therefore, the different crystallization behavior is to be expected directly connected to the flux of natural high energy radiation.

# Testing Mars-seismometers

Guests from the french space agency (CNES)



Universität Stuttgart  
Germany



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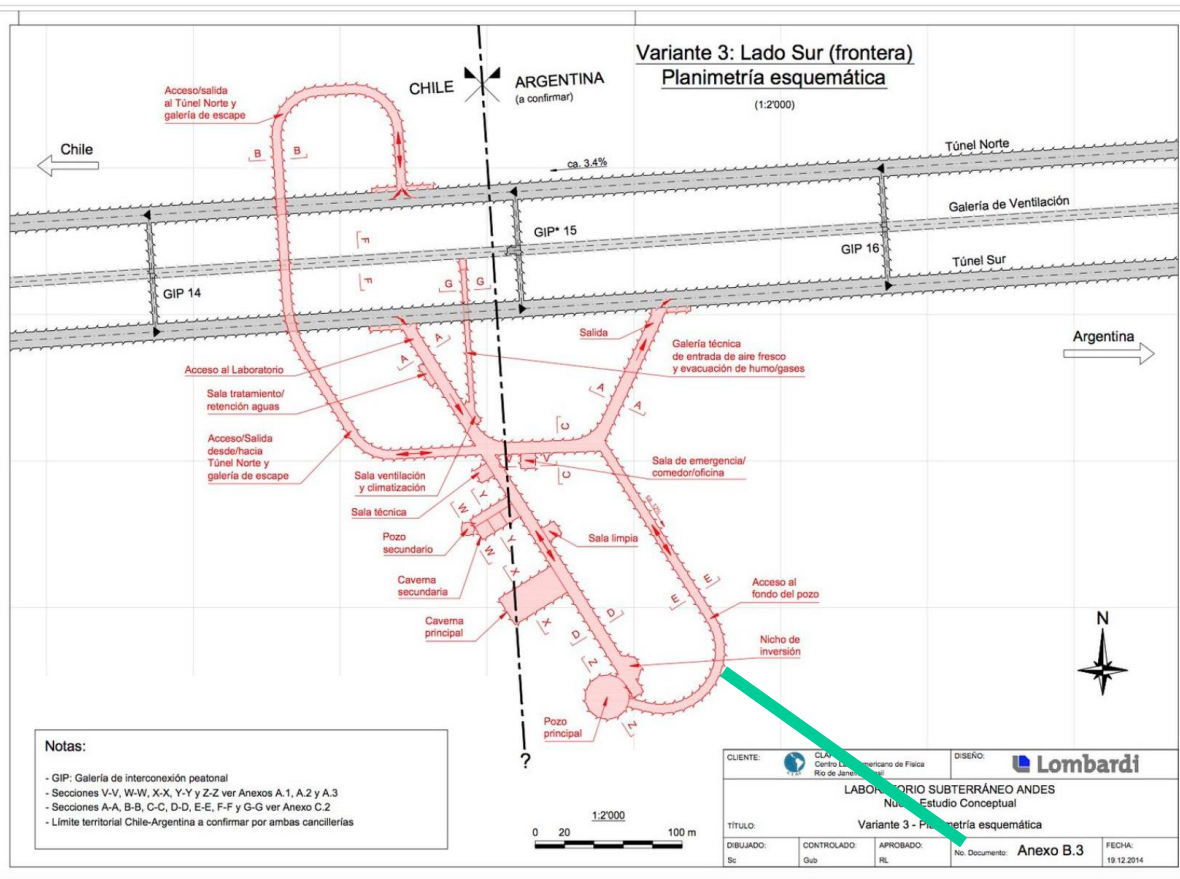
Scope and Current activities

# Scope of the ANDES-GEO lab (preliminary list)

1. Long Term observation of Geophysical parameters
  - Deformation (static to high frequency)
  - Earthquake rupture process
  - Establish a reference observatory for seismology in SA
2. Long term observation of gas and fluid chemistry including isotopes
  - To investigate orogenic processes
  - Processes of mineral deposition
  - Changes to the fluid and gas flux
3. To establish a laboratory for conduction experiments without the influence of cosmic rays and spallation products
  - Crystallisation processes
  - Comparison with experiments under the influence of cosmic rays



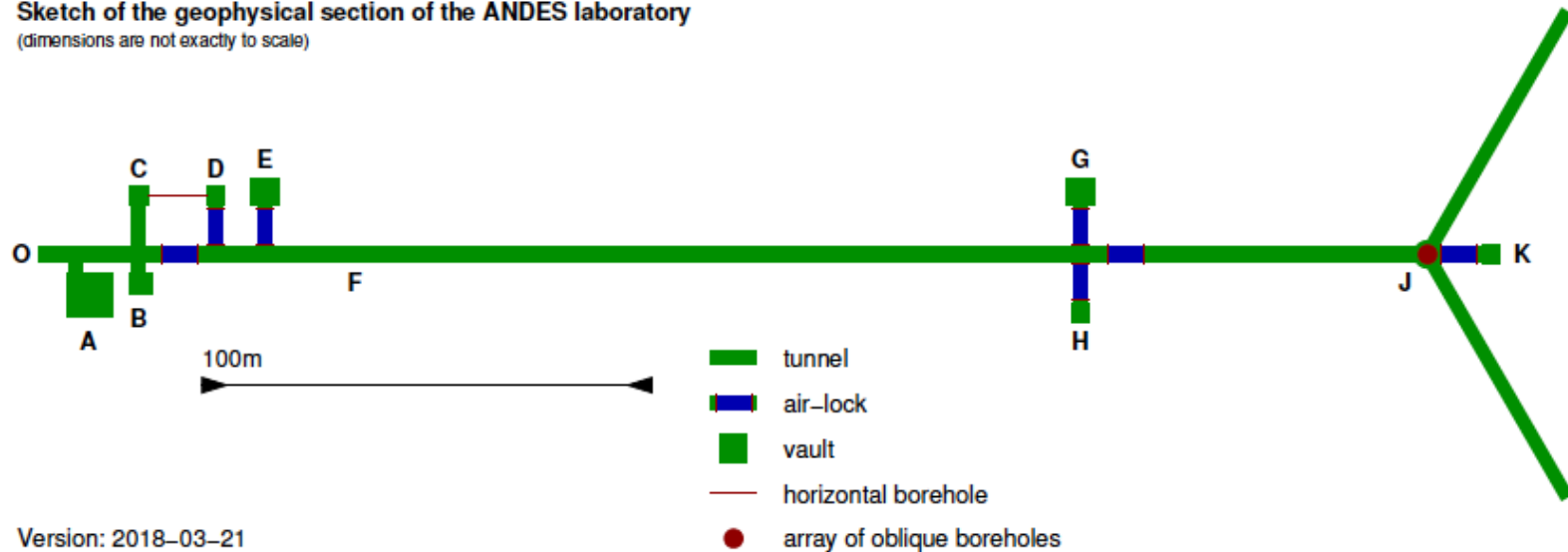
# Proposal 2017



- **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**

# Proposal Spring 2018

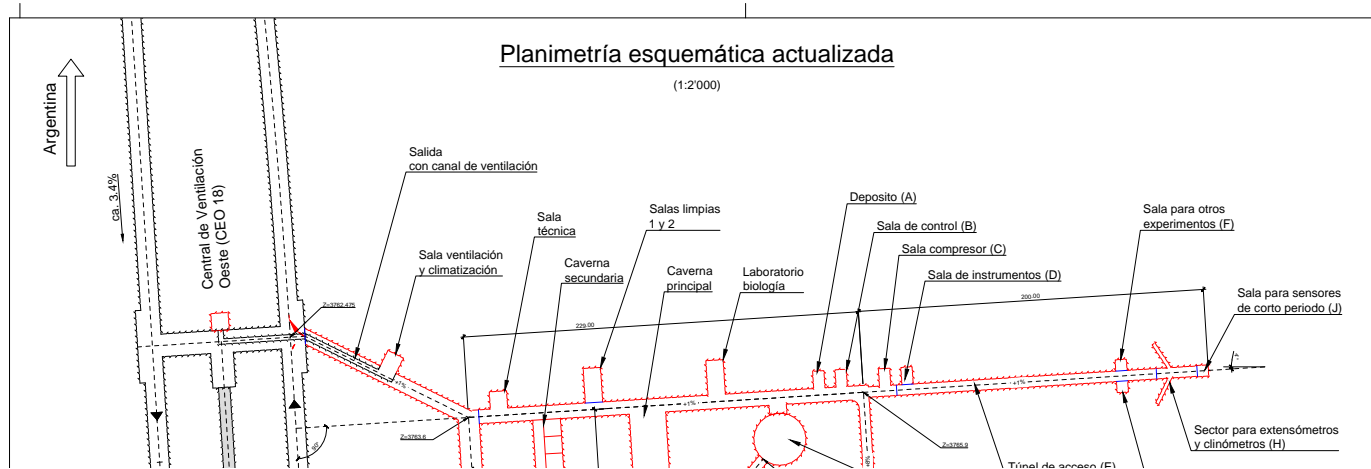
Sketch of the geophysical section of the ANDES laboratory  
(dimensions are not exactly to scale)



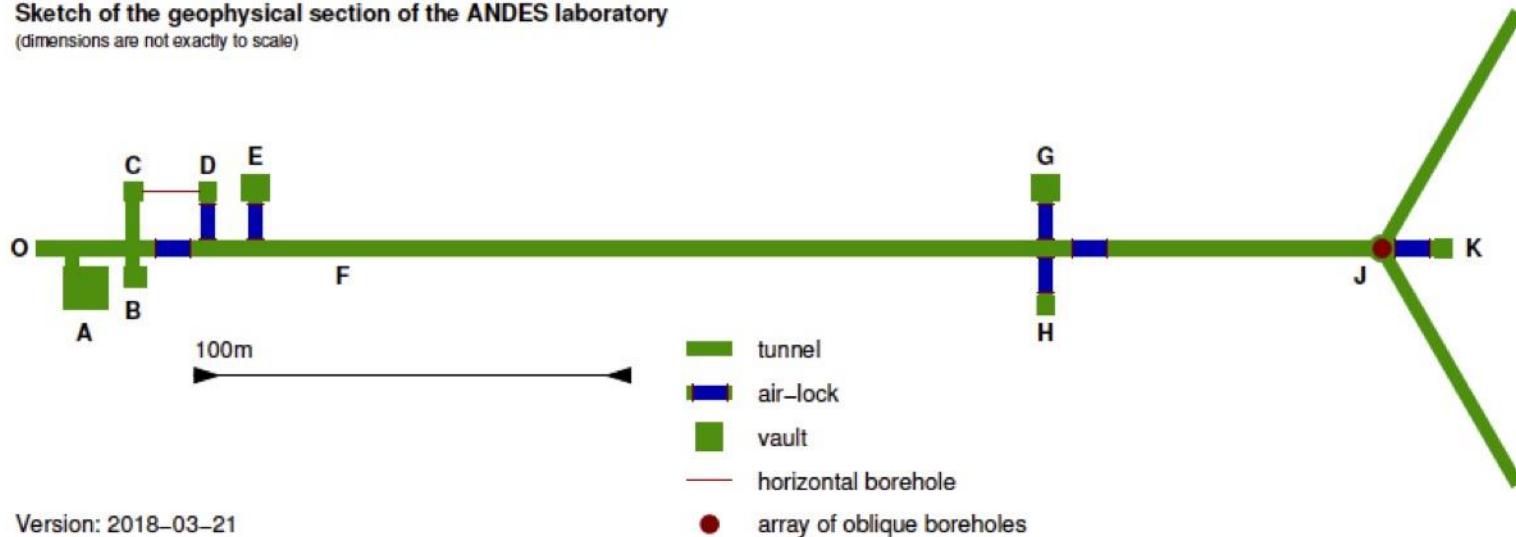
Version: 2018-03-21

Figure 1: Draft of the gallery and the vaults for the geophysical section of the ANDES lab. O: entrance, A: storage, B: operator room, office, workshop, C: compressor for cryocooler (required for SG), D: superconducting gravimeter (SG), E: temporary installations (guest experiments), F: main tunnel (as part of the air-pressure low-pass and access to quiet areas), G: guest experiments and/or ring-laser gyro, H: permanent long-period seismometers, J: strainmeter and long-baseline tiltmeter array-section, K: permanent short-period sensors. The azimuth of the main tunnel is subject to further consideration (see text).

# Summer 2018: Meeting with Lombardi in July



**Sketch of the geophysical section of the ANDES laboratory**  
(dimensions are not exactly to scale)



Version: 2018-03-21

# Towards ANDES-GEO consortium

## First International ANDES-GEO Workshop

**14-17 November 2018 in San Juan, Argentina**

The purpose of this workshop is to discuss the establishment of a global ANDES Geoscience Consortium based on its potential research activities. Special emphasis will be laid in those first-phase experiments relevant to achieve this aim. Discussions will also encompass the coordination and financial support of the planned research activities.

### ***Topics include:***

Magmatic rocks; Tectonics (Analyses of tectonic features and quantification of the structural evolution); Stress Field Measurement; Seismicity; acoustic emissions; Geophysical experiments; Fluid&Gas Chemistry; Physical Rock parameters; Exhumation history; Geochronology



# Academic committees

## ***Academic Committee***

Dr. Andreas Rietbrock. Karlsruhe Institute of Technology. Geophysical Institute (GPI), Germany.

Dr. Glasmacher A. Ulrich. Heidelberg University. Institute of Earth Sciences, Germany.

Dra. Silvina V. Nacif Suvire. Univer. Nac. de San Juan. Instituto Geofísico-Sismológico Volponi, Argentina.

Dra. Silvana Spagnotto. Univ. Nac. de San Juan. Instituto Geofísico-Sismológico Volponi, Argentina.

Dr. Gabriel Paparo. Istituto di Acustica O. M. Corbino, Roma, Italy

Dr. Gilberto Saccorotti. Istituto Nazionale di Geofisica e Vulcanologia, Pisa, Italy.

Dra. Diana Comte. Facultad de Ciencias Físicas y Matemáticas. Universidad de Chile.

Dr. Sergio Barrientos. Centro Sismológico Nacional de la Univ. de Chile, Chile

## ***Local Organizing Committee***

Dr. Alberto Etchegoyen. ITeDA (CNEA, CONICET, UNSAM), Buenos Aires, Argentina.

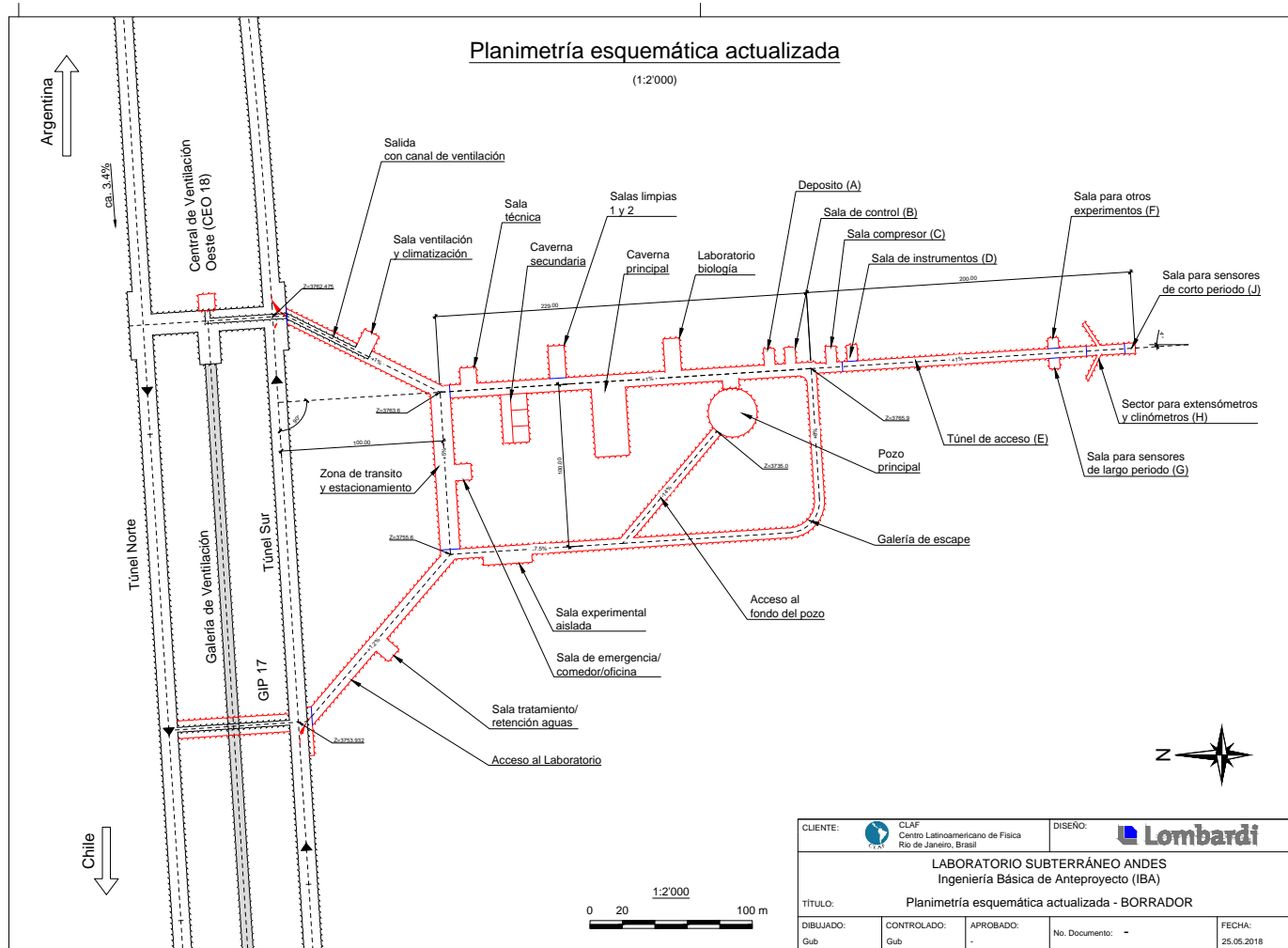
Eng. Andrés Zini. Unidad de Coordinación Túnel de Agua Negra, San Juan, Argentina.

Dr. Claudio Dib. Universidad Técnica Federico Santa María, Valparaíso, Chile.

Dr. Mario E. Gimenez. Secretaría de Ciencia y Técnica, Univ. Nac. de San Juan, Argentina.

Dr. Jorge E. Castro. Secretaría de Investigación y Creación. Fac. de Cs. Exactas, Físicas y Naturales., San Juan, Argentina.

# Summer 2018: Meeting with Lombardi in July



# 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

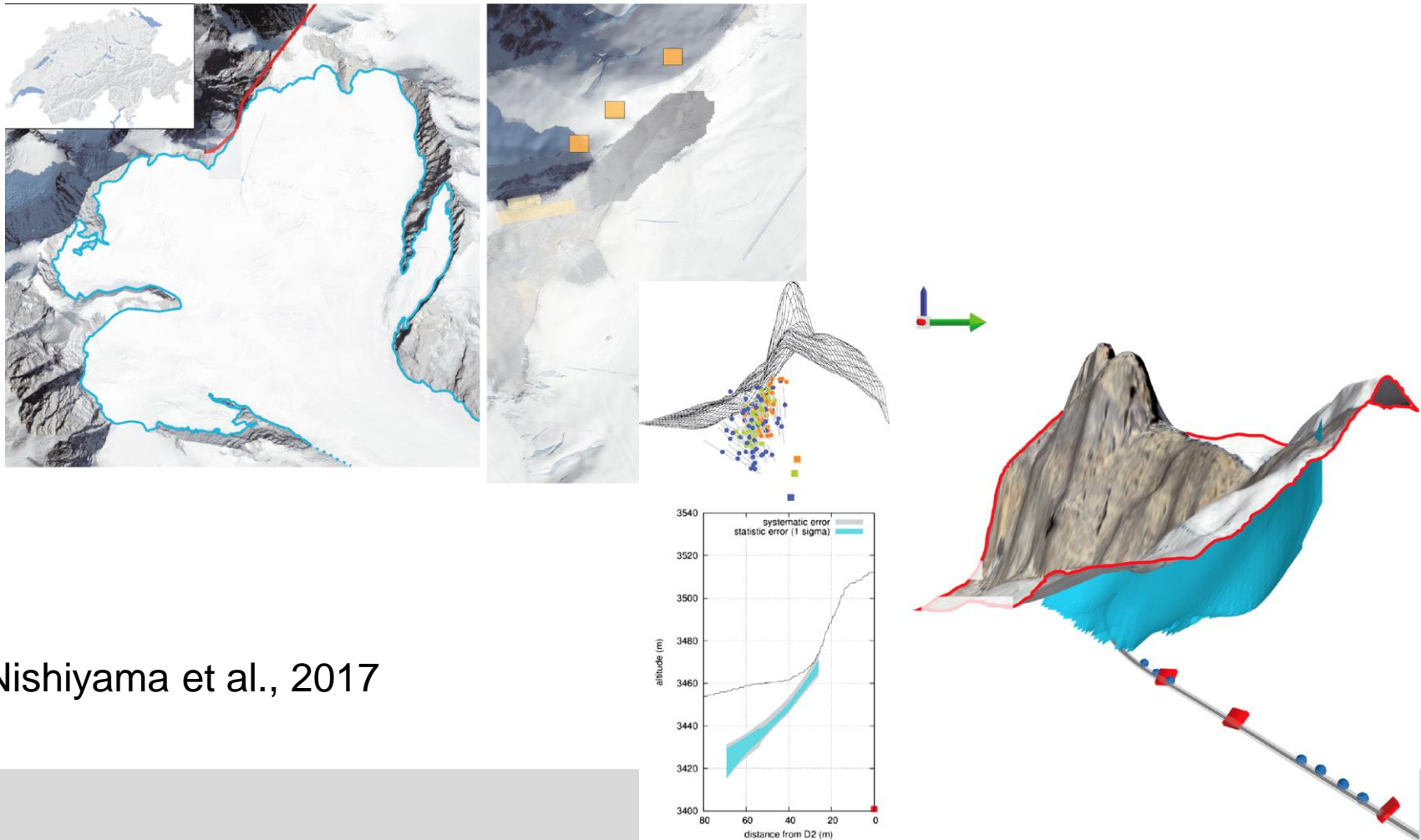
Permanent instrumentation of the lab:

Long Period seismometer (STS1)

Superconducting gravimeter (best also to have a station in the lab in Chile and Argentina along the transect)

# cosmic muon radiography

## “Imaging density (contrasts)”



Nishiyama et al., 2017



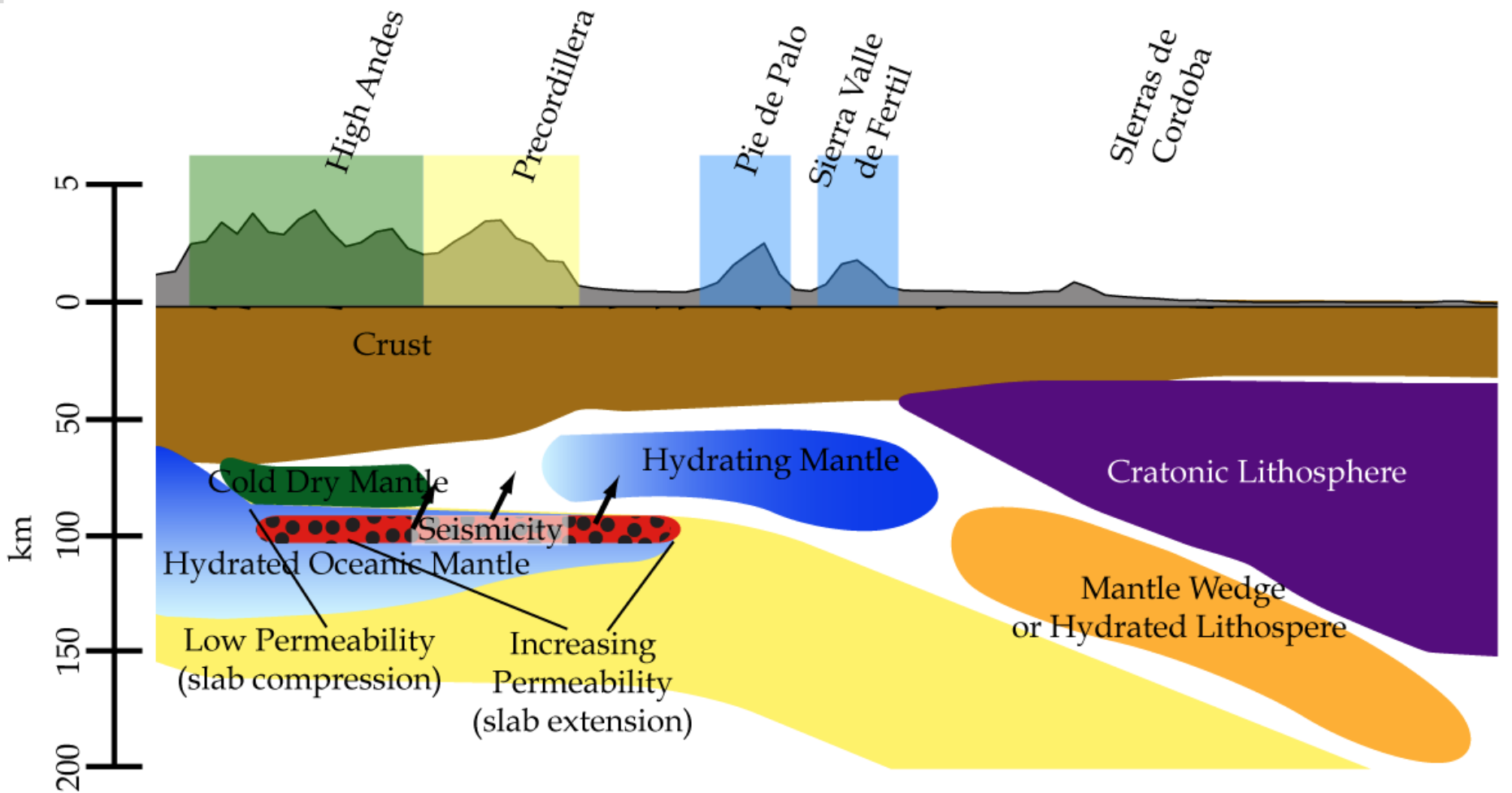


Figure 17