The ANDES laboratory: Contributions from Seismology and Geophysics

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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

ALBH East

Displacements (mm)

Hrs with Tremor Activity / 10 days

*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
BFO: Floor Map

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)

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

(Widmer-Schnidrig, 2011)

(Lucien Saviot, 2011)
Global low noise model

BFO contributes to low noise model

Low noise model by Berger, Davis, and Ekström (2004).

-140
-145
-150
-155
-160
-165
-170
-175
-180
-185
-190

PSD / dB re. 1 m² s⁻² Hz⁻¹

frequency / Hz

GSN horizontal components
BFO east component
GSN vertical components
BFO vertical component
Long period signals

Modified after Crossley et al., 1999

Period / s
Superconducting gravimeter
Superconducting gravimeter

(courtesy of Markus Breig, 2015)
Sensitivity: human anomaly....

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

- GR1 BFO SG056 (tidal model removed)
- GR2 BFO SG056 (tidal model removed)

Graph showing time series data with time after 23.06.2017 00:00:00 UT.
Superconducting gravimeters worldwide

IGETS data base containing data from 35 stations
Background free oscillations (Hum of the Earth)

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

(Wielandt und Widmer-Schnidrig, 2002)
Testing Mars-seismometers
Guests from the french space agency (CNES)
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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