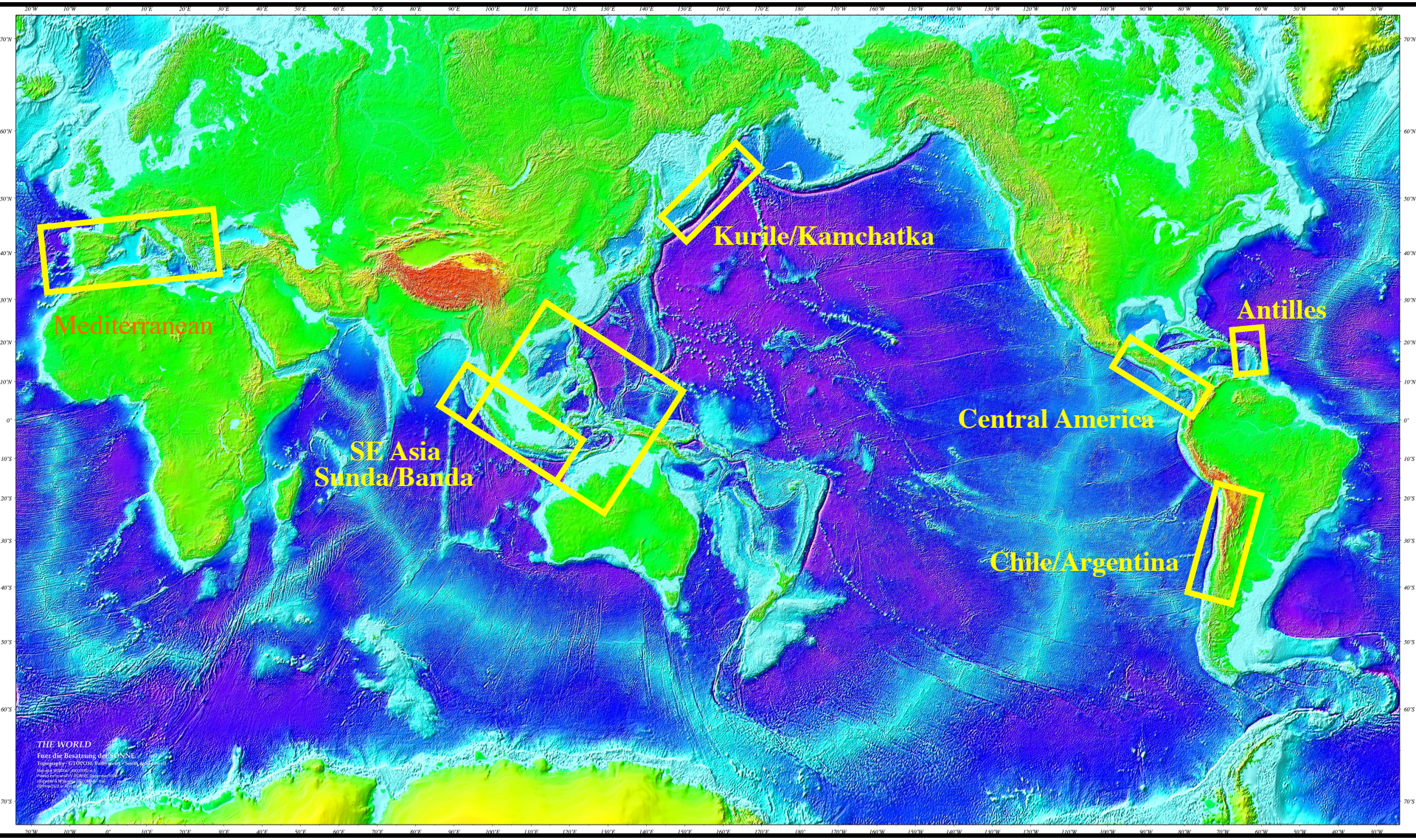
Subduction Zone research: European perspective

Focus on infrastructure, major current-future projects, potential for collaboration and added value for Geoprisms

- Lesser Antilles - Montserrat (UK, Germany, France)
- C. & S. American margin (Chile) - Germany, France, UK, USA, Chile, Costa Rica and other collaborations
- Sumatra-Sunda arc - Germany, UK, France, USA, Japan, Indonesia, Singapore
- Kurils, Kamchatka, Aleutians – Germany, Russia
- Arc processes - UK involvement in international networks
- Europe-African margin, N. Caribbean – Spain
- Experimental facilities – Italy
- Costa Rica (CRiSP) - IODP

Lisa McNeill, University of Southampton, NOCS, UK; Heidrun Kopp, IFM-GEOMAR, Kiel, Germany
Paola Vannucchi, University of Florence, Italy; Cesar Ranero, ICREA Barcelona, Spain

Study Sites

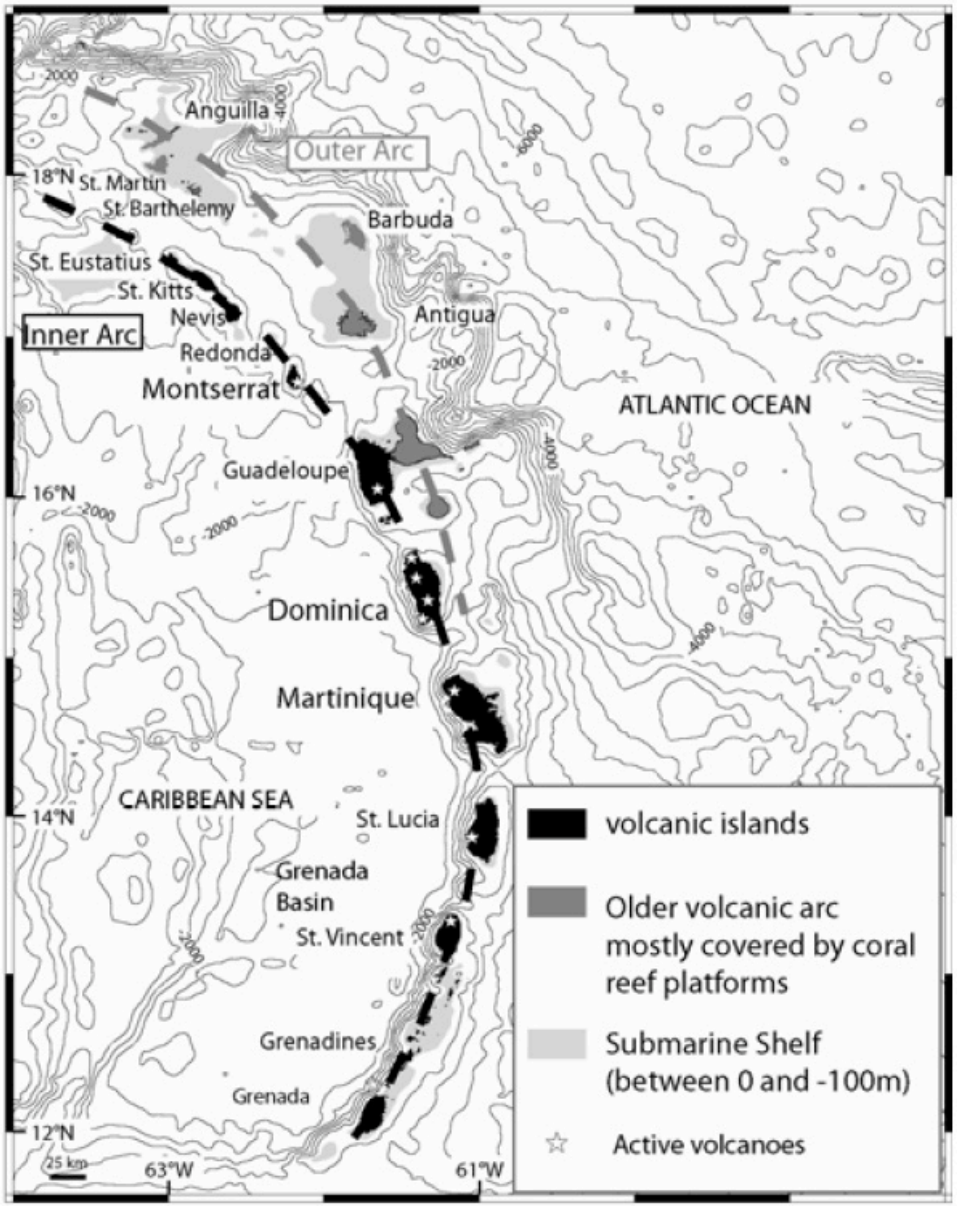

Kurile/Kamchatka
Mediterranean
Antilles
Central America
SE Asia
Sunda/Banda
Chile/Argentina

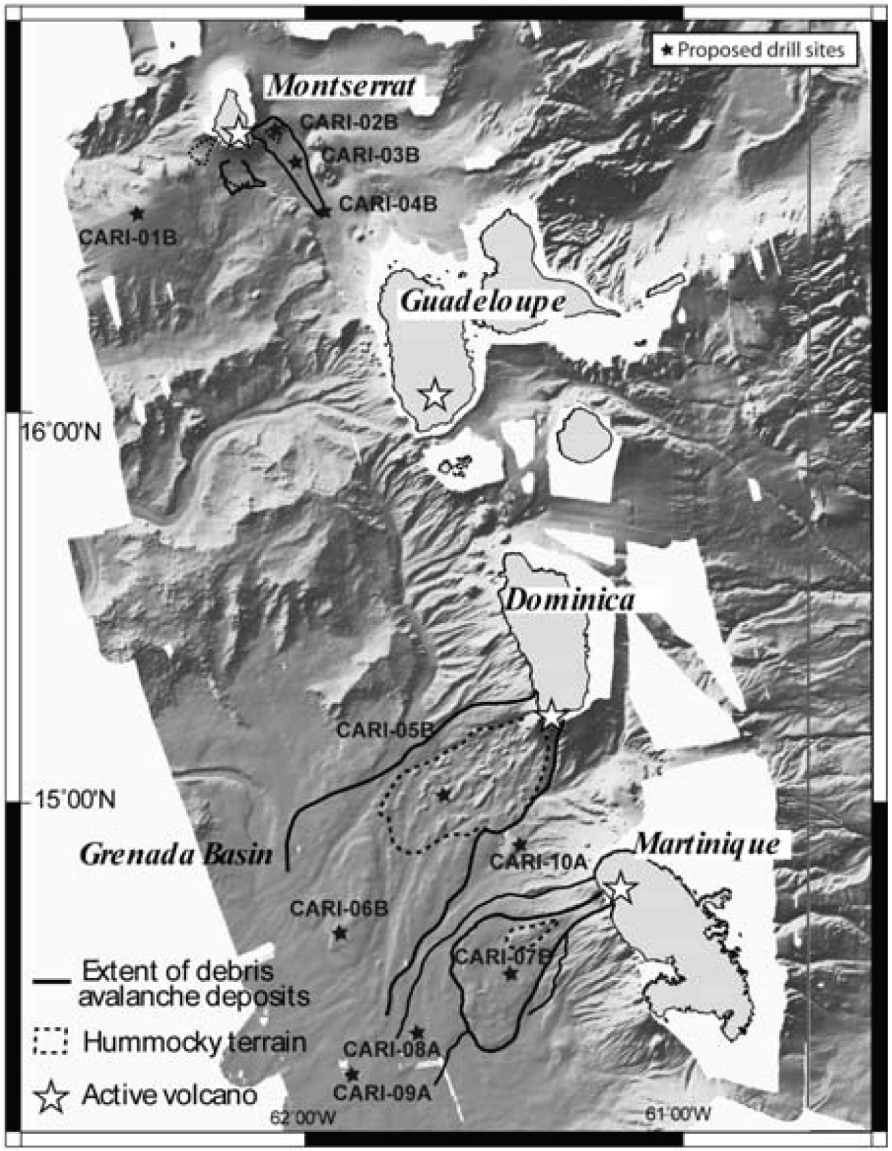
Lesser Antilles

- UK- French focus on Montserrat - island arc structure-evolution, volcanic hazards, eruption and mass flow history
- Proposed IODP expedition (681-Full: Le Friant et al.) - Focus on mass flow, hazards (eruption, flank collapse) and arc evolution.

  Status: Ranked highly by SSP, some potential for scheduling before end of program (first reserve)
- Link to Geoprisms “Integrated surface processes” within subduction zones
- Continued monitoring-infrastructure by MVO (Montserrat Volcano Observatory - permanent seismometers, GPS, tiltmeters, etc)

Sparks, Le Friant, Talling, Palmer, Minshull (Bristol, IPGP, Southampton)

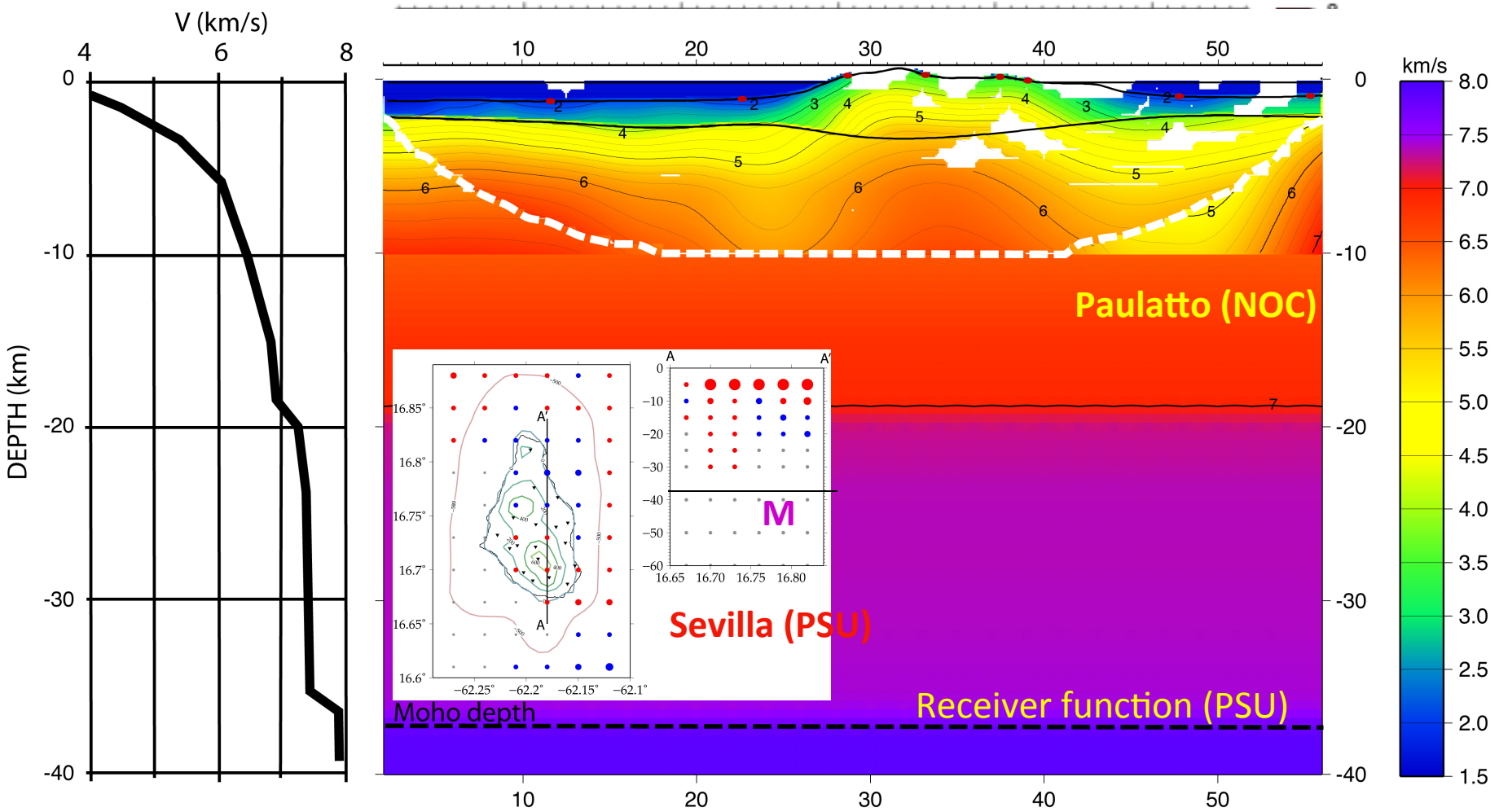




IODP 681 proposed sites

Montserrat, Lesser Antilles - Arc velocity structure

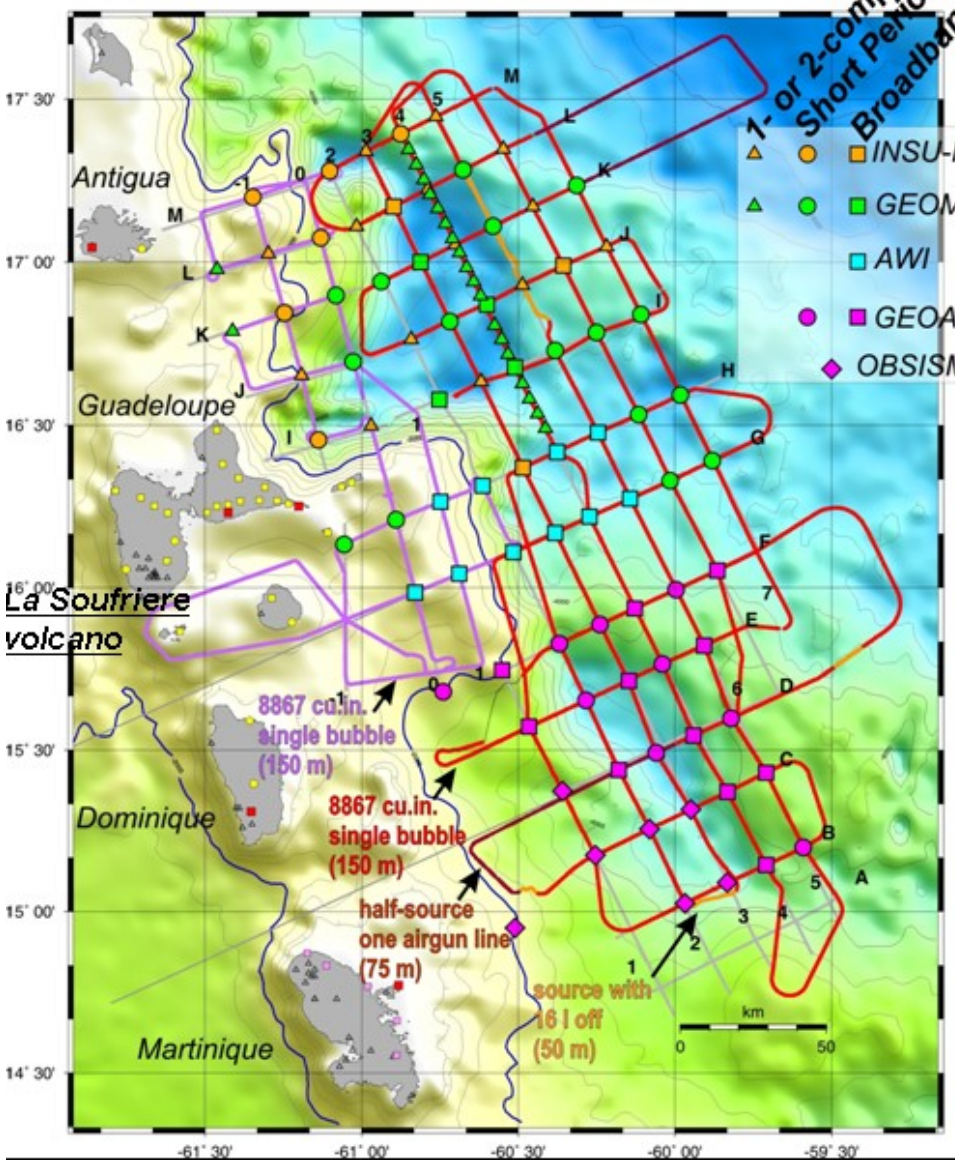
Final model



Recent integrated geophysical data, Montserrat

THALES: Transients in the Hellenic and Antilles

2- SISMANTILLES II *N/O ATALANTE* cruise



Jan. 30 – Feb. 21 2007

N/O ATALANTE cruise LEG 1

(PI: Lebrun)

Dep. of 23 OBSs (INSU/IPGP + 20 OBH GEOMAR)

SHOT :
in water shallower than 2000 m (*5 days*)
~ 7000 shots along 1100 km : **8867 cu.in. single bubble** (*shot interval 60 s, 150 m*)

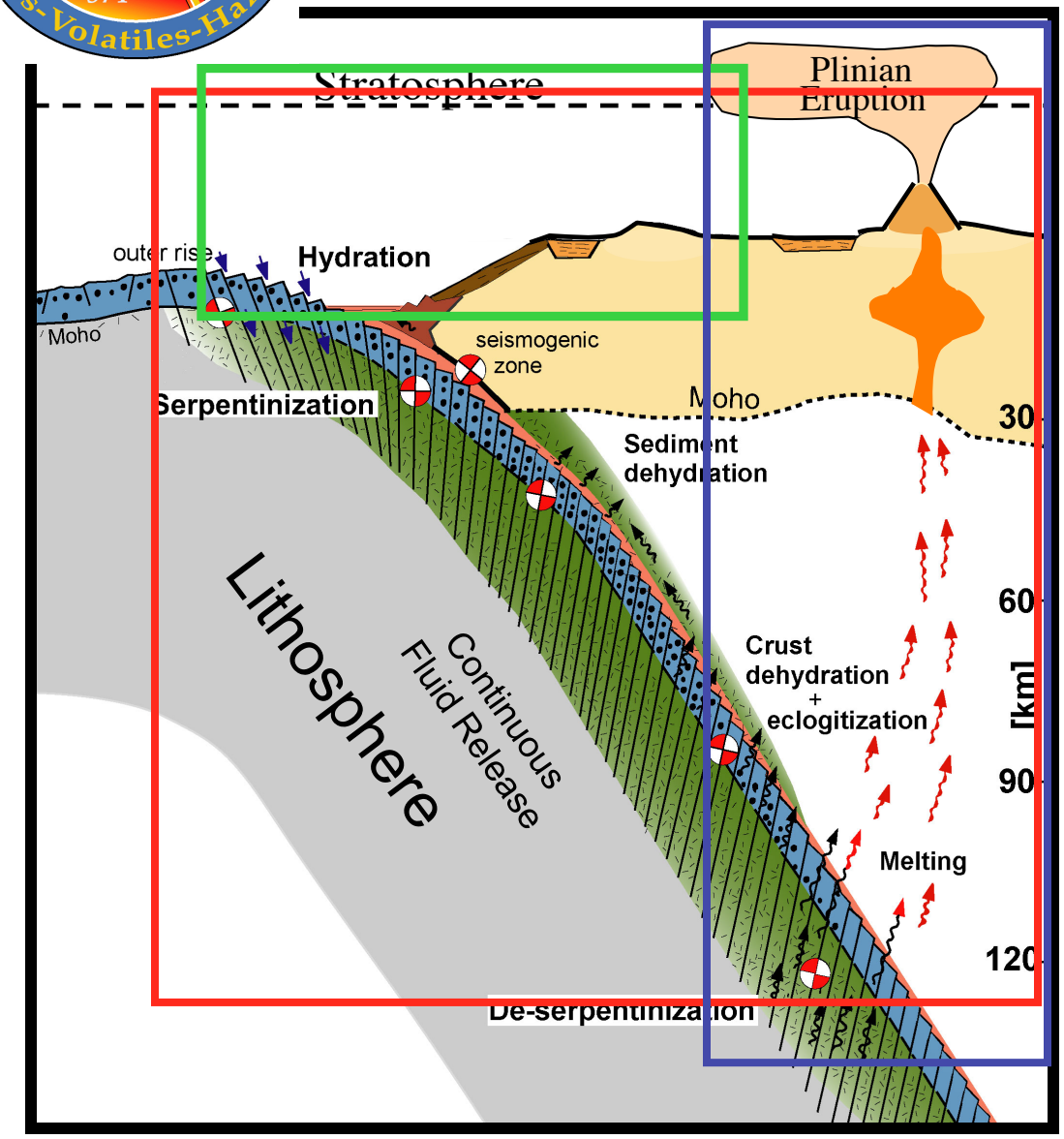
N/O ATALANTE cruise LEG 2

(PI Laigle)

SHOT + 4.5 km long streamer
in water deeper than 2000m (*17 days*)
~ 27 000 shots along 3375 km
=> GRID of 12 dip-lines and 7 strike-lines

Airgun source :
-**8867 cu.in. single bubble** ***(150 m)***
-**half-source**, with one airgun line ***(75 m)***
-**source with the 16 l off** ***(50 m)***

SFB 574: 3 Theme Groups, 10 subprojects



A *Input, Subduction Processes & Structure, Seismogenic Zone*

B *Volatile and Fluid Venting in the Forearc & Incoming Plate*

C *Volatile transfer from Subducting Slab Thru Mantle & Crust into the Atmosphere & Modelling of Climate Effects*

IFM-GEOMAR

C | A | U

Deutsche Forschungsgemeinschaft DFG

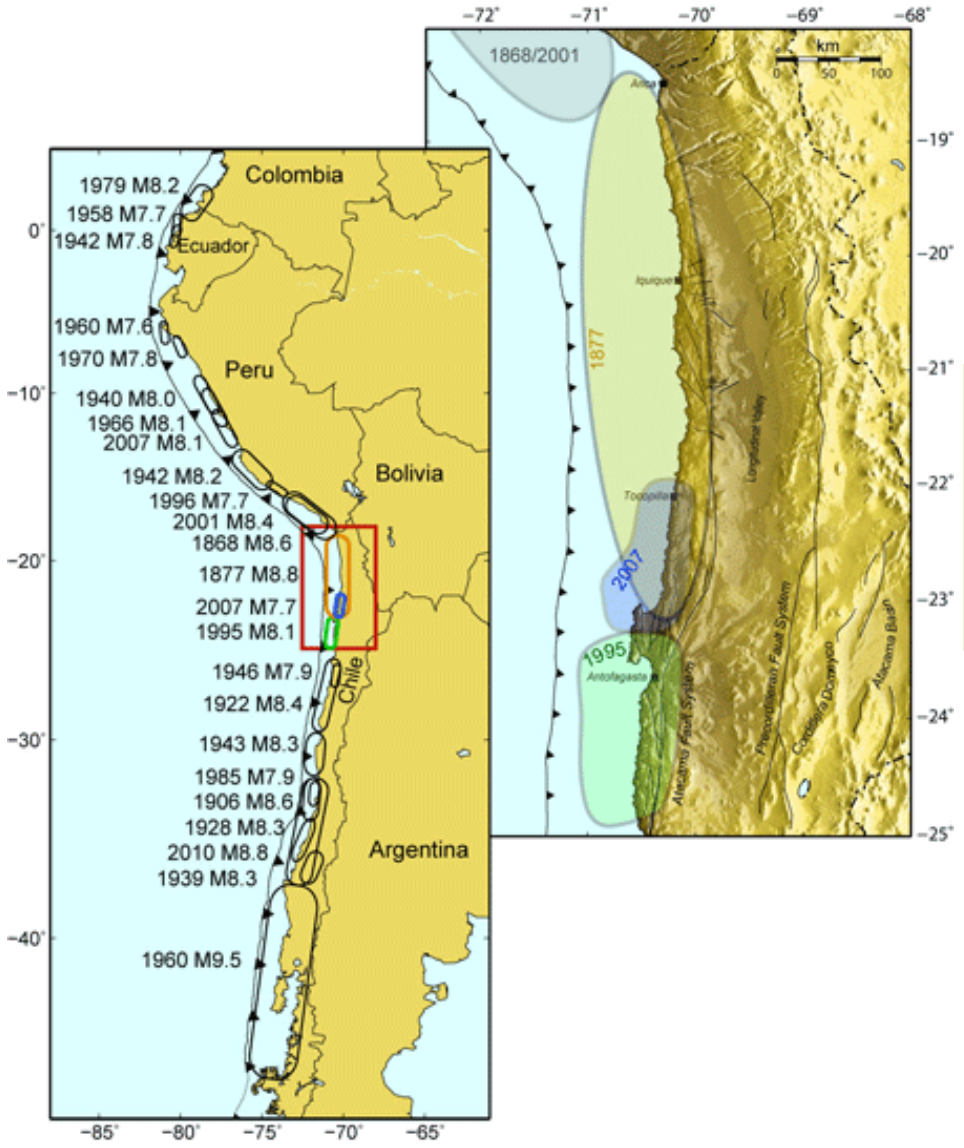
SFB574 Work Areas or Focus Sites:

Central America (Phases I and II)

Central Chile/Argentina (32-42°S) (Phases II and III)

& Global Synthesis

IPOC: Integrated Plate Boundary Observatory Chile



IPOC is a European-South American network of institutions and scientists organizing and operating a distributed system of instruments and projects dedicated to the study of earthquakes and deformation at the continental margin of Chile.

IPOC is a joint project of:

- GFZ German Research Centre for Geosciences
- Institut de Physique du Globe Paris (IPGP), France
- Universidad de Chile, Santiago, Chile
- Universidad Católica del Norte, Antofagasto, Chile

Further affiliated institutions are:

- Ecole Normale Supérieure, Paris, France
- Universität Potsdam, Germany
- Freie Universität Berlin, Germany
- Leibniz Institute for Applied Geophysics
- IFM-GEOMAR, Germany

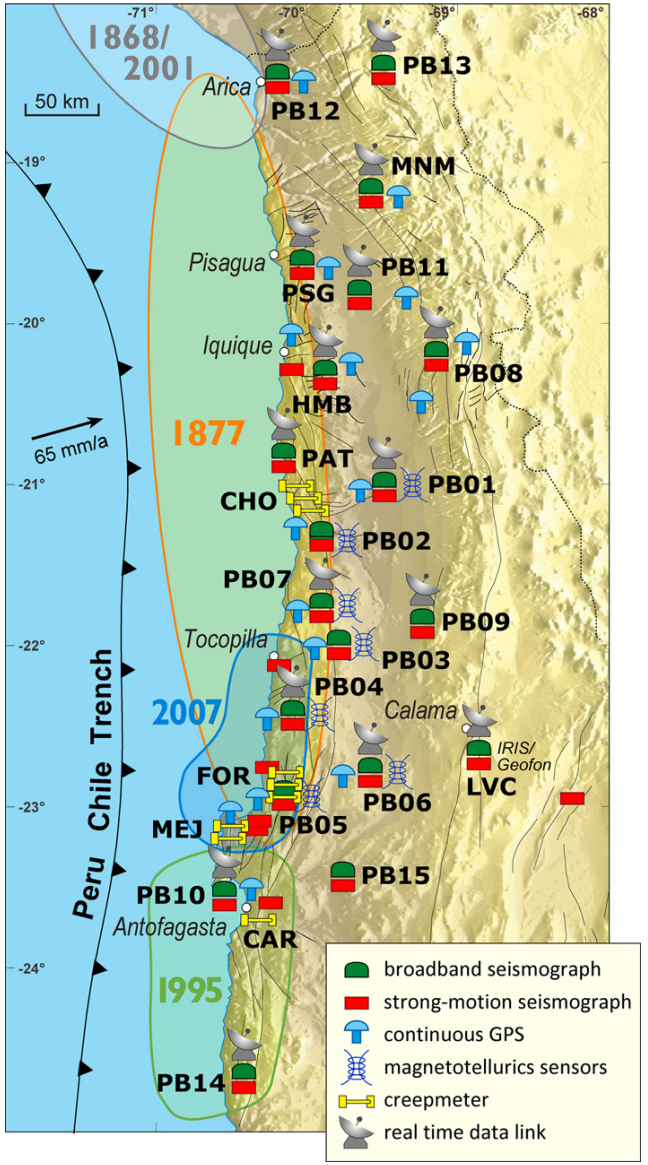
IPOC: Integrated Plate Boundary Observatory Chile

Integrated Plate boundary Observatory Chile

OBSERVATORY

- SEISMOLOGY
- MAGNETOTELLURICS
- CREEPMETER
- TILTMETER
- GPS
- INSAR
- MULTI-PARAMETER STATIONS

In contrast to conventional observatories that monitor an individual signal only, IPOC is designed to capture a large range of different, possibly associated deformation processes.



S. American margin: 2010 Maule, Chile rupture zone

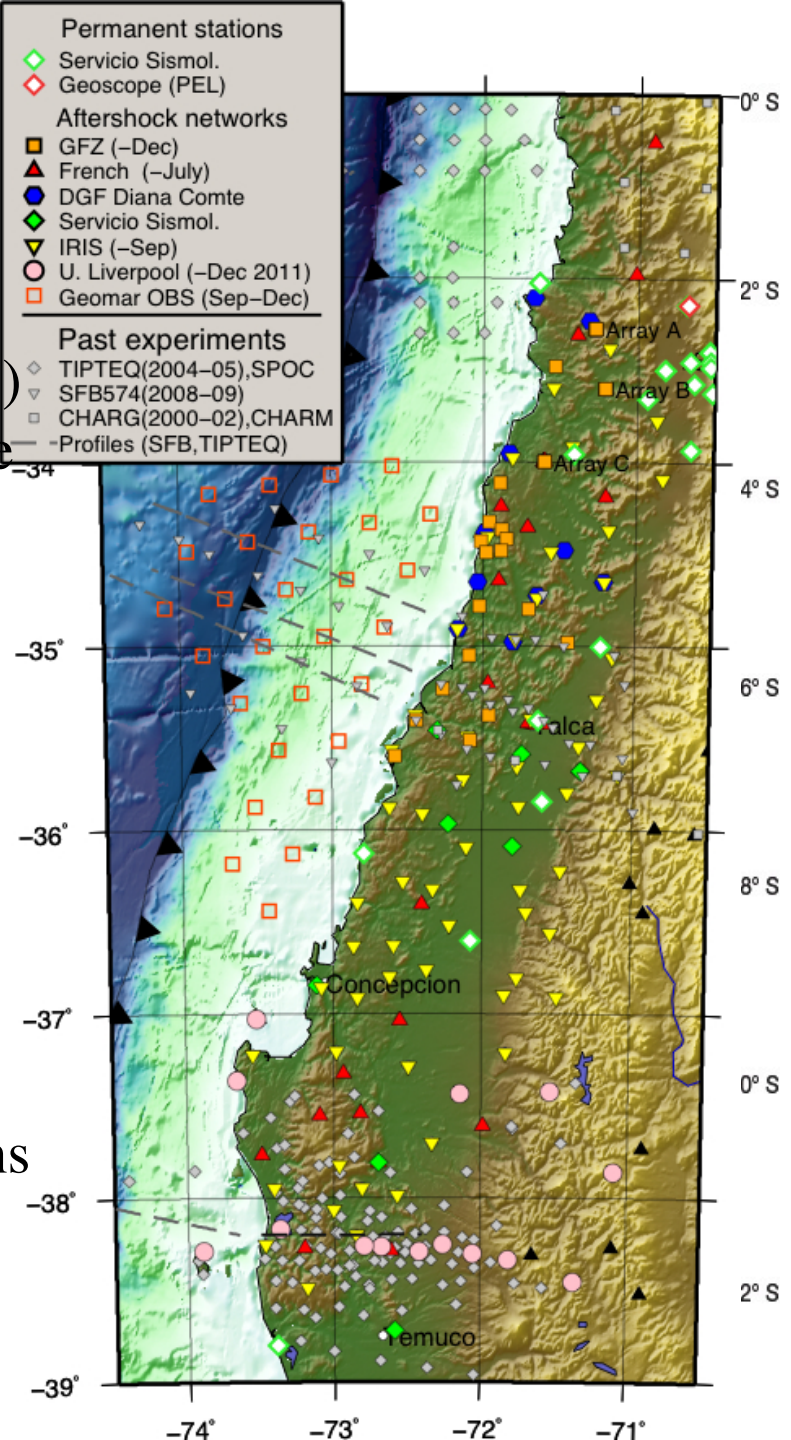
Temporary and permanent onshore (+ OBS) networks following 2010 Maule earthquake

Chile-Germany-UK-USA-France collaborations

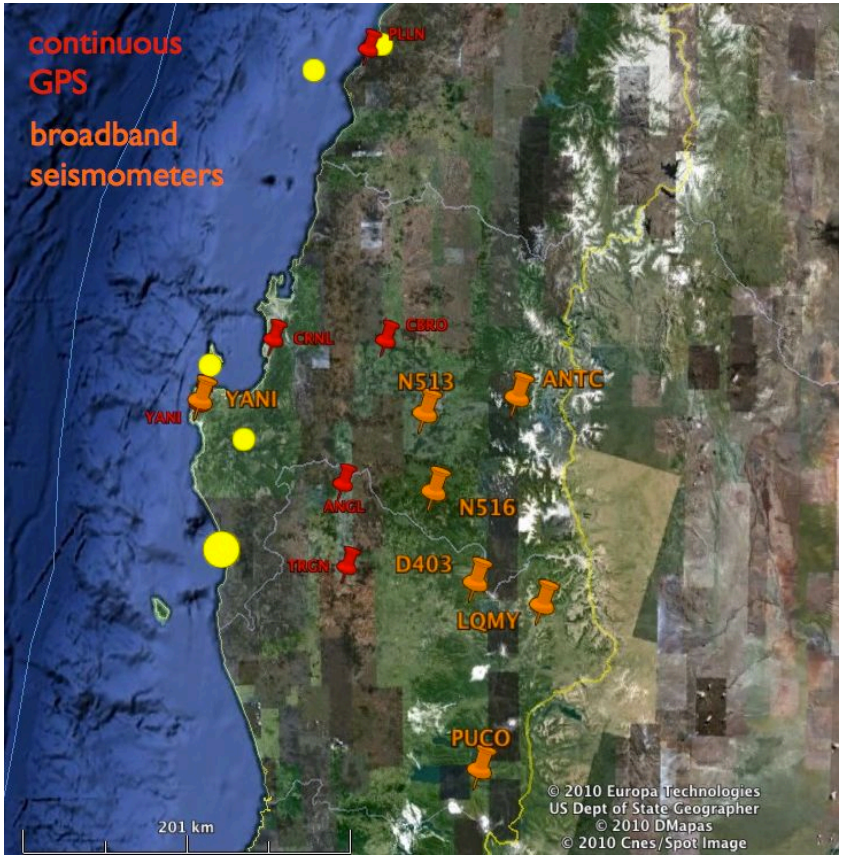
Seismological networks (right)

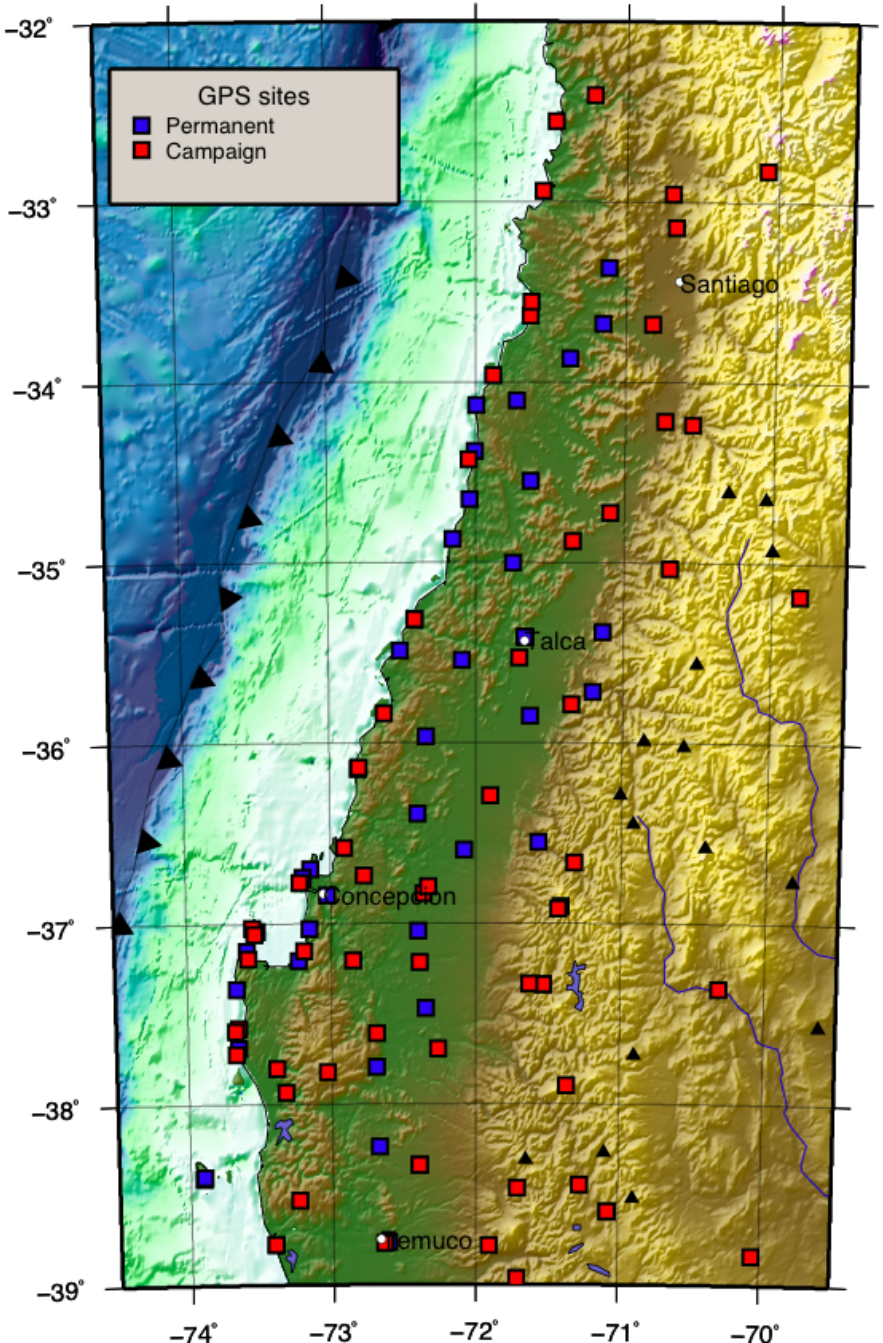
Most stations being decommissioned
Liverpool network (Concepcion) continues until end 2011
Plan for installation of 65 additional stations across Chile

Rietbrock, Tilmann, Ryder (Liverpool-GFZ-Cambridge)

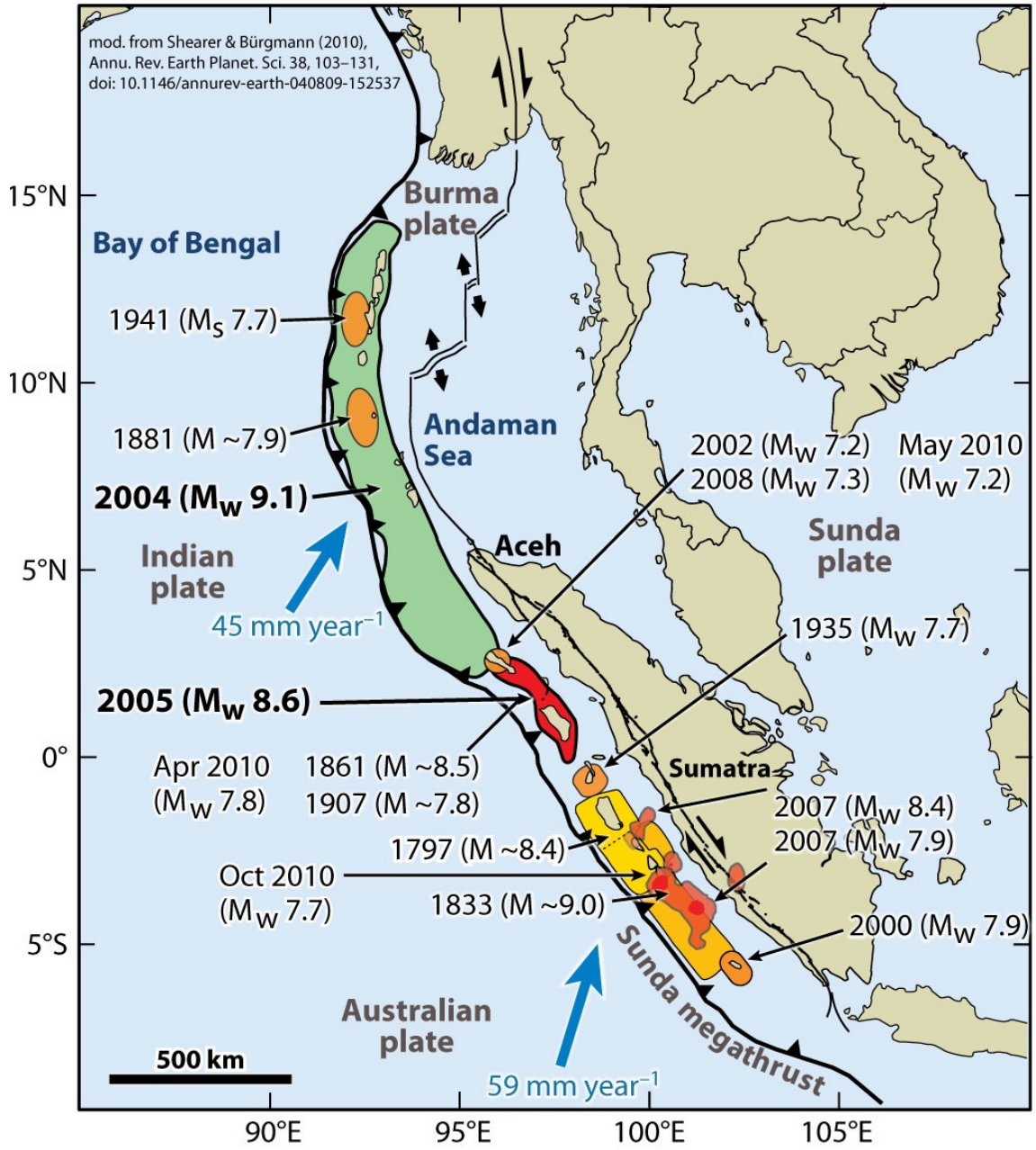


GPS - permanent and campaign networks





Sumatra-Java - Recent data collection

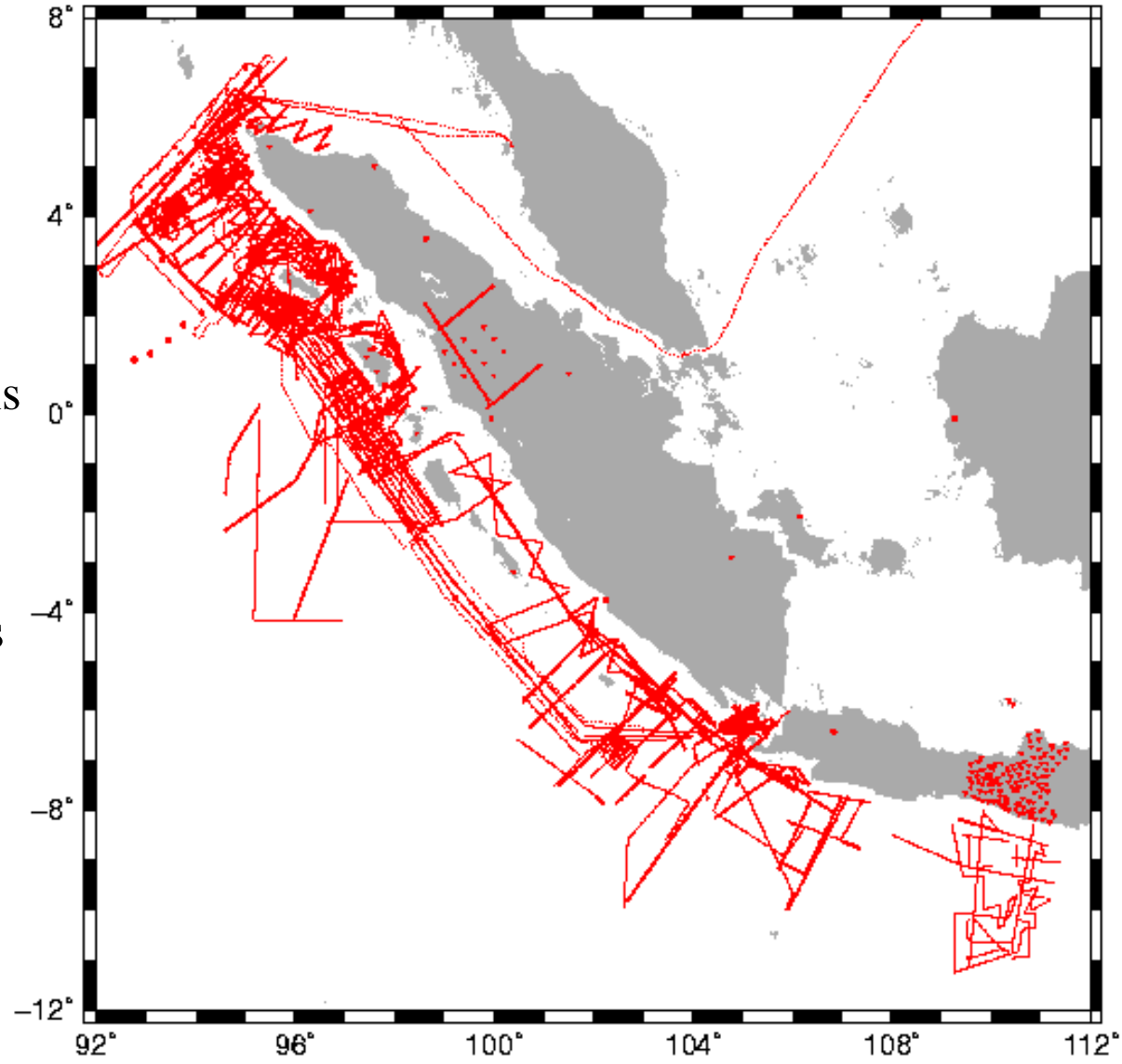


Sumatra-Java - Recent data collection

Extensive marine and terrestrial geophysical and geological data collection 2005-2010

Germany, France, UK, Japan, USA, Indonesia collaborations

Trackline and station data shown (not 100% complete) focuses on marine geophysics and onshore seismological campaigns. Note: does not include data from Indian part of 2004 rupture zone



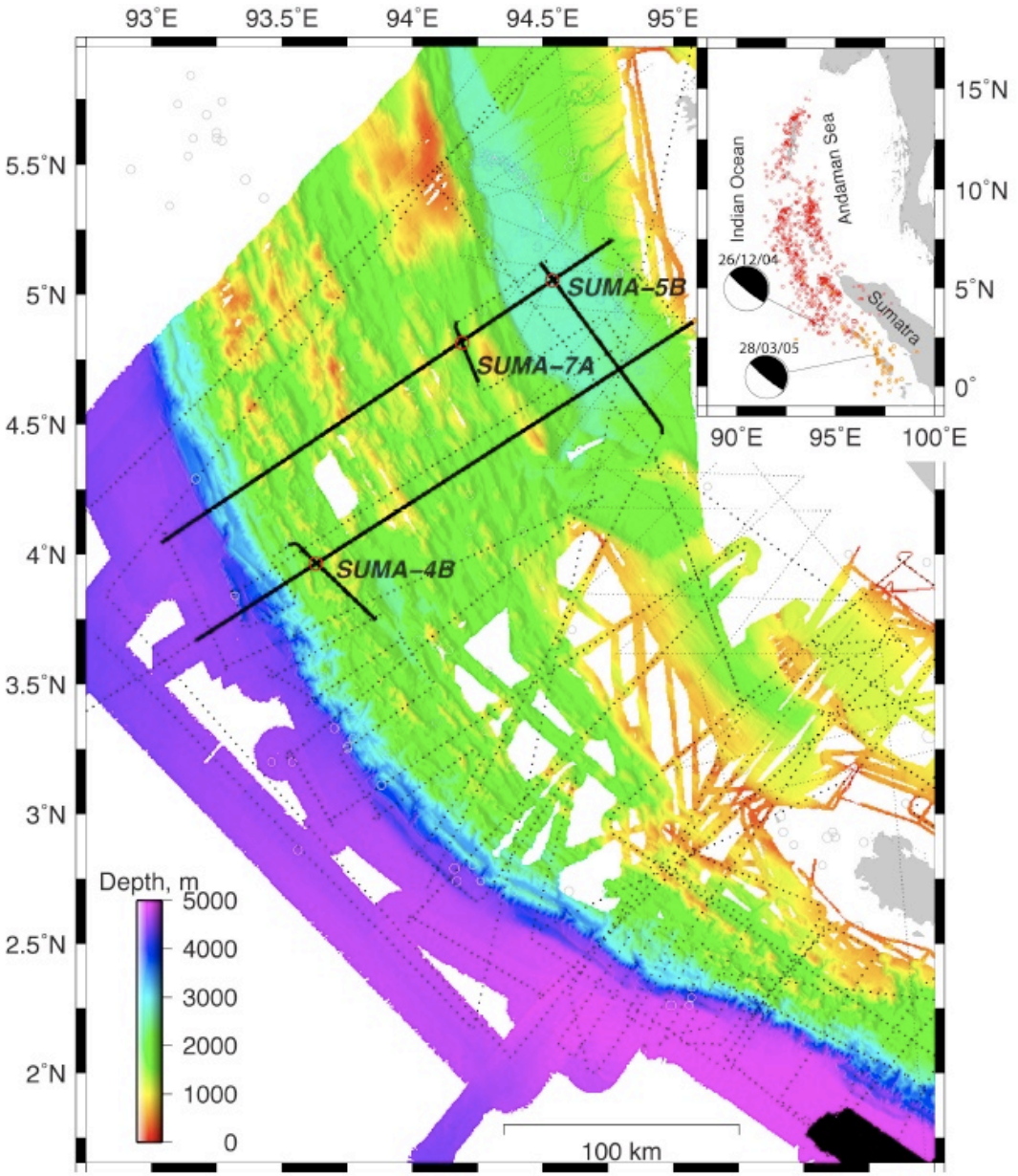
Source: UK Sumatra segmentation consortium http://www.noc.soton.ac.uk/gg/sumatra/navigation_sumatra/
See also summary of some of these activities in Henstock et al., 2010, Eos,91, 44, p. 405

Sumatra - IODP proposal

Proposal 704 Full, Goldfinger et al.

Focus on southern 2004 earthquake rupture zone:
A region of high coseismic slip beneath the accretionary prism
An unusual broad, thick, plateau-wedge structure

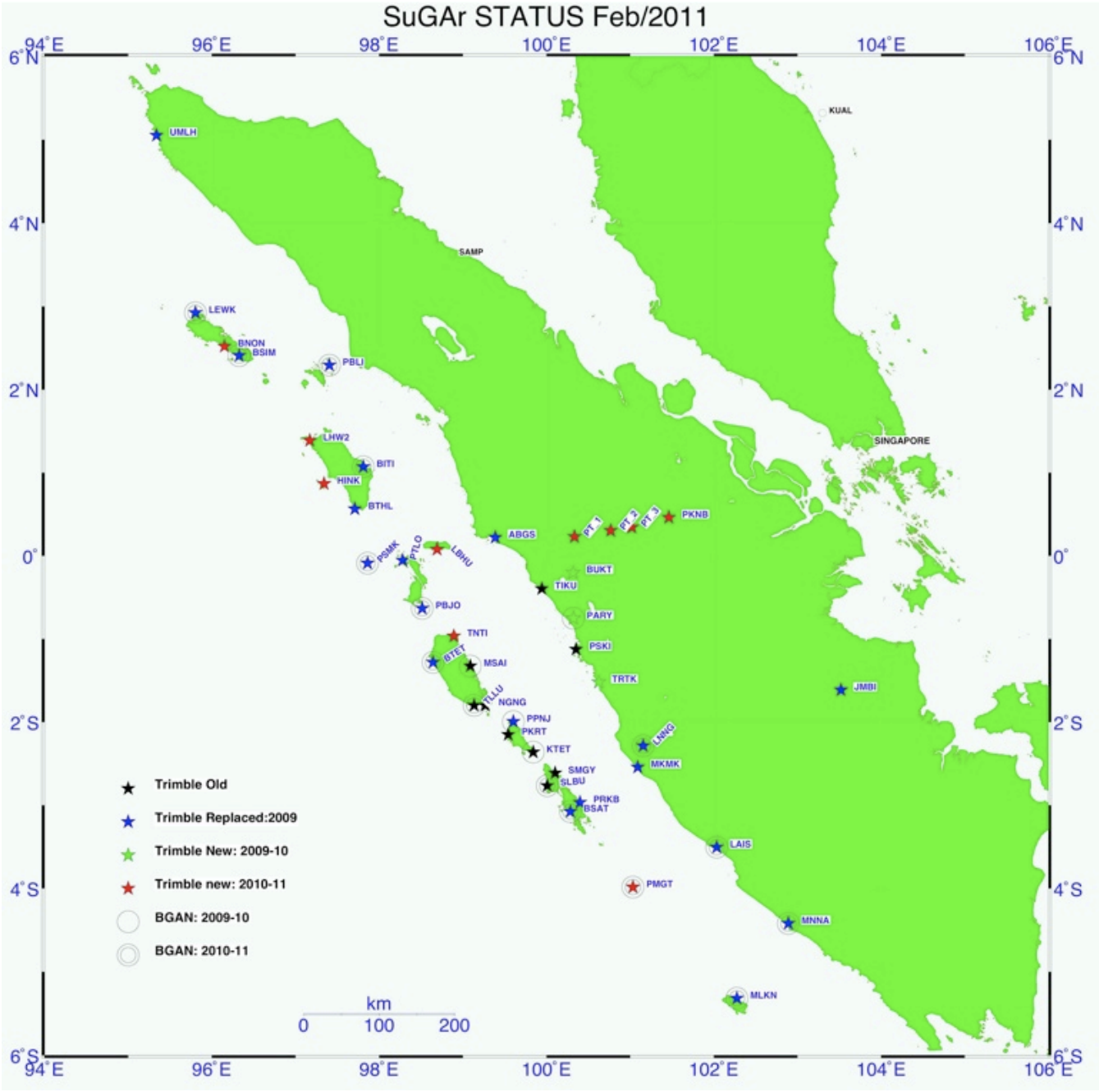
Aims:
Determine the development history of the forearc and causes of the unusual forearc structure - implications for wedge properties, backthrust activity and nature of 2004 cosesimic slip and tsunami generation



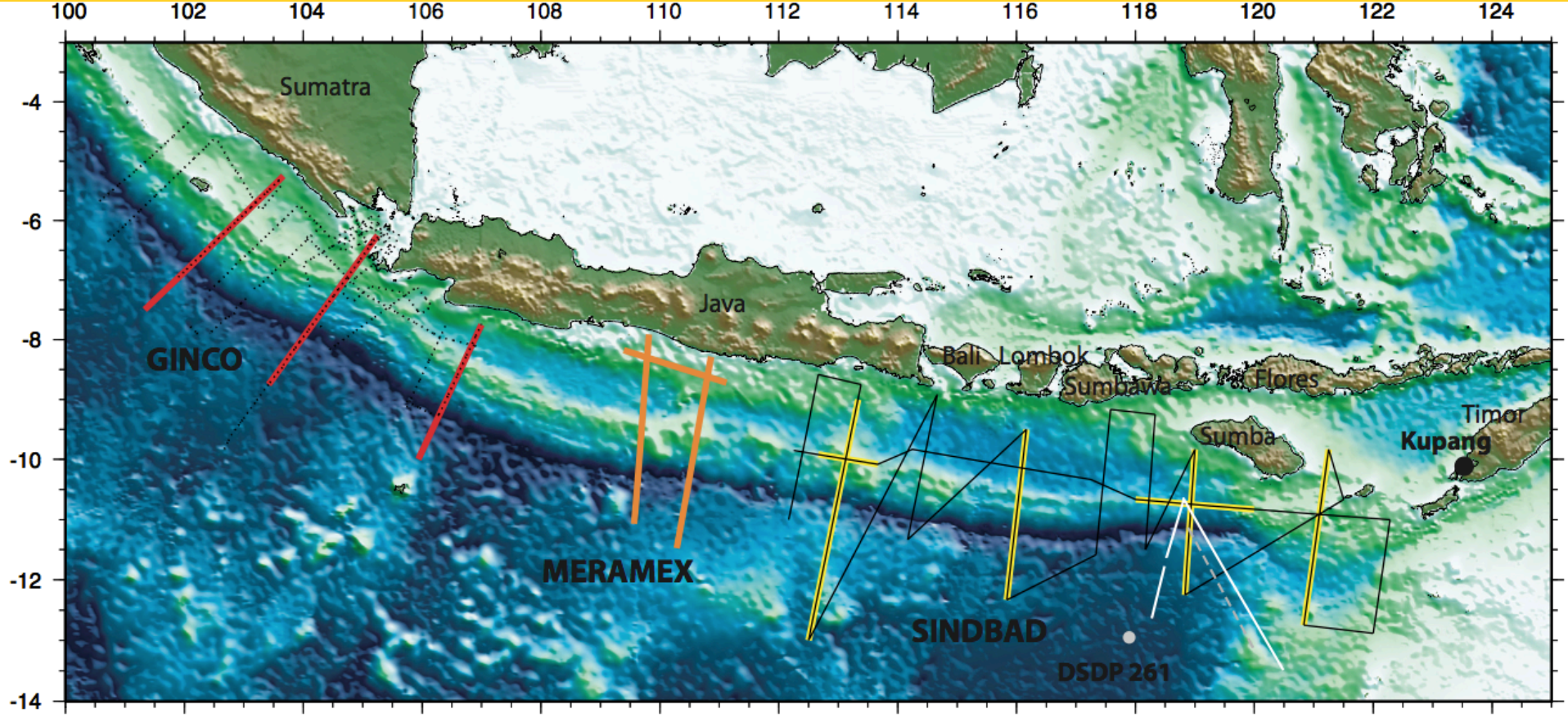
Sumatra - Geophysical infrastructure

Permanent GPS stations on Sumatra and forearc islands

SuGAR network: CalTech, LIPI (Indonesia), EOS (Singapore) collaboration



Sunda-Banda Studies



Three major marine experiments were conducted on the Java margin since 1997 using the German RV SONNE as platform. A total of 289 ocean bottom stations (OBS/OBH) were deployed along 15 transects; most of these are also covered by deep-penetrating MCS seismics and potential field measurements.

Affiliated Institutions:

BGR, Germany
IFM-GEOMAR, Germany
BPPT, Indonesia

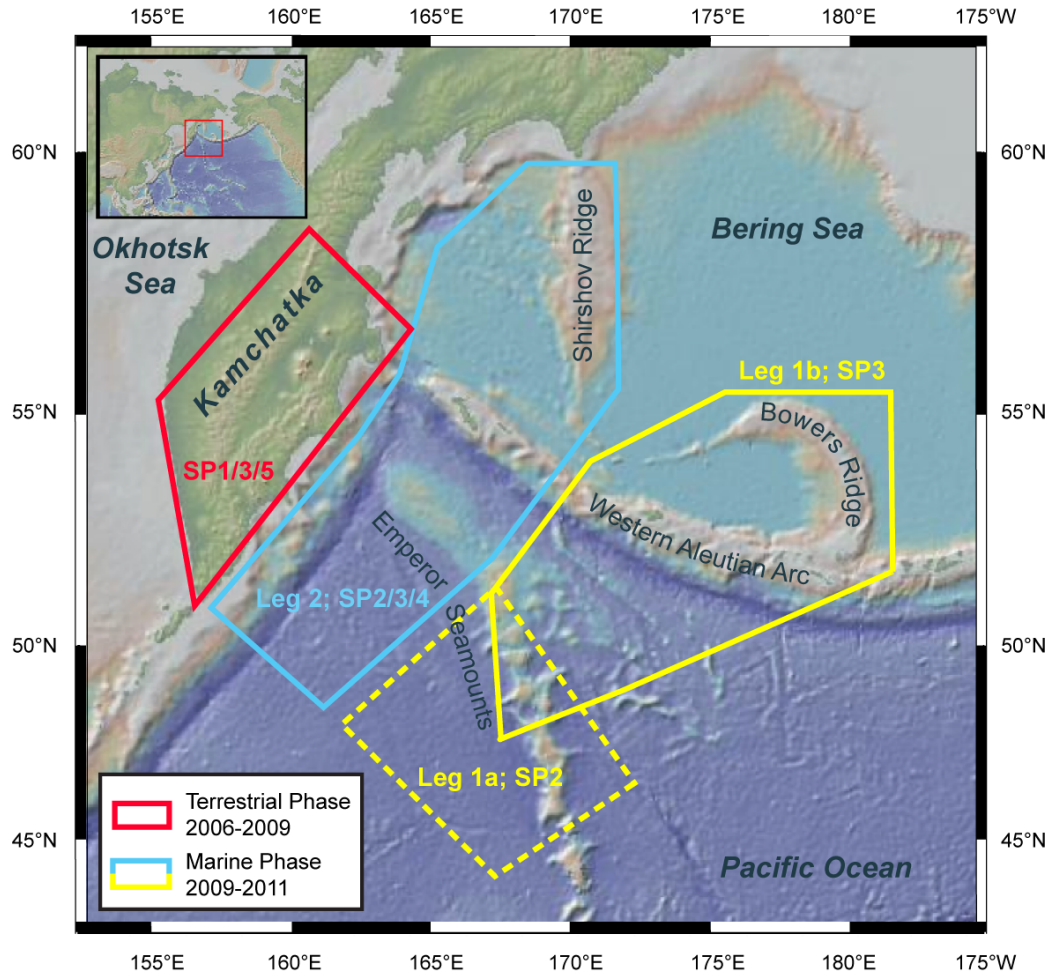
Kurile-Kamchatka and **Al**eutean **Mar**ginal sea-island systems: Geodynamic and climate interaction in space and time 2006-2011

KALMAR

bmb+f Bundesministerium für Bildung und Forschung

МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РОССИЙСКОЙ ФЕДЕРАЦИИ

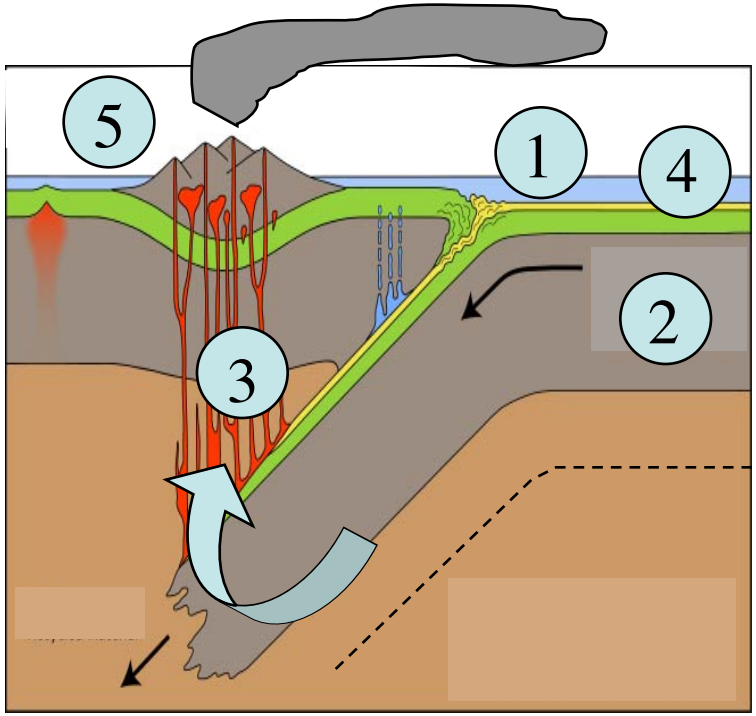
PHASE I



Geodynamic development of the Kurile-Kamchatka-Aleutean System and its active plate margins

Oceanographic and climatic development of the subarctic NW Pacific Ocean

1 Neotectonic
2 Geodynamic
3 Volcanic-magmatic
4 Ocean Climate
5 Terrestrial Climate



Kurile-Kamchatka and **Al**eutean **Mar**ginal sea-island systems: Geodynamic and climate interaction in space and time 2012-2016

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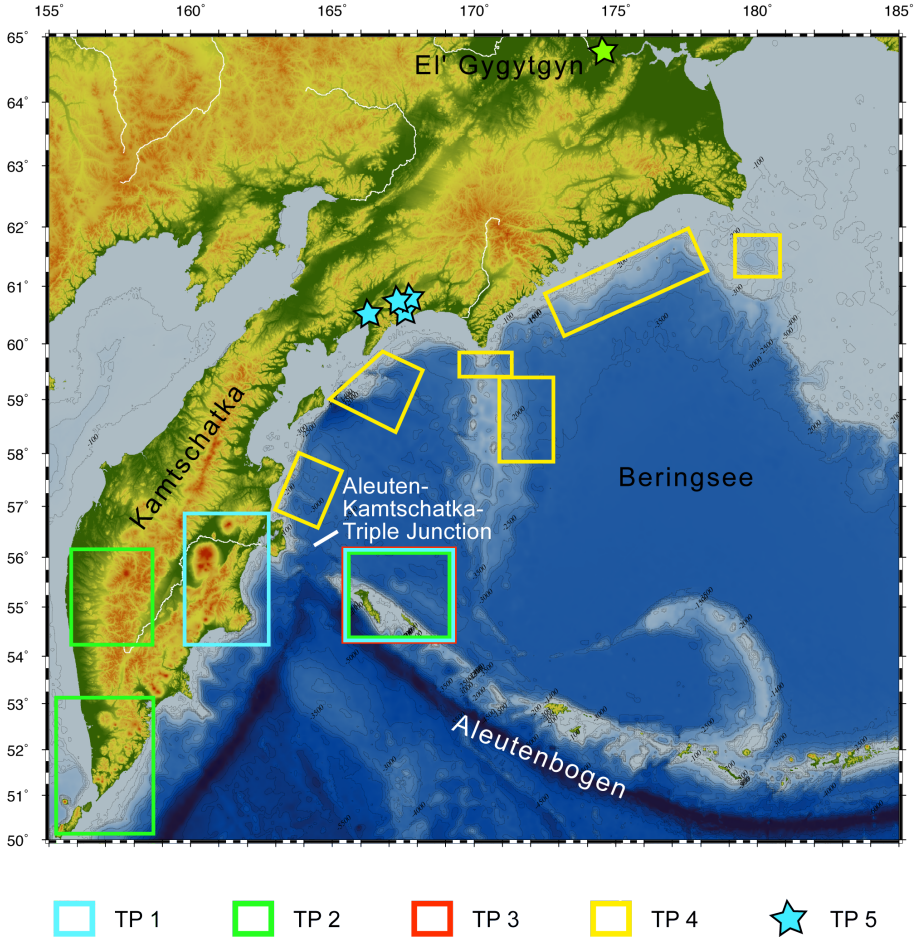
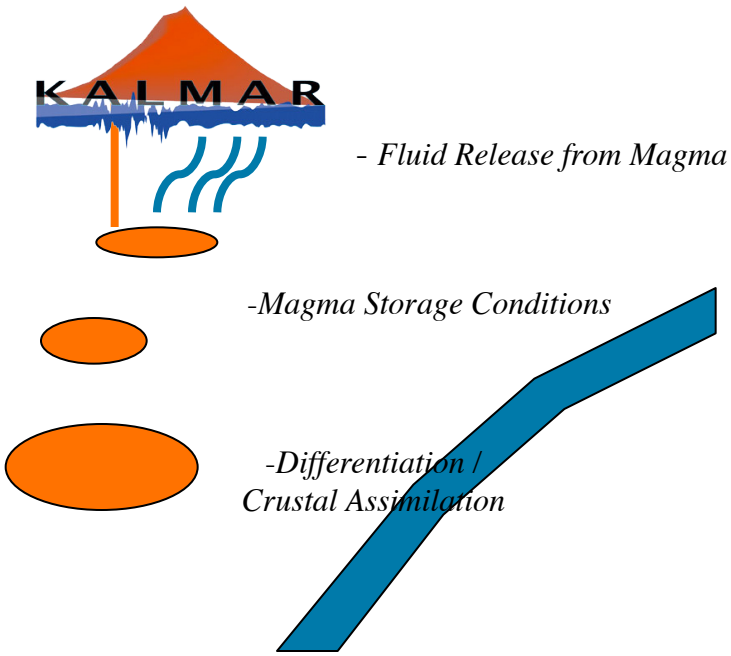
МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РОССИЙСКОЙ ФЕДЕРАЦИИ

PHASE II



Continue research in other areas
and additional topics:
* hydrothermal alteration
* experimental investigations of differentiation-processes and pre-eruptive conditions



Arc processes

- International collaboration through "State of the Arc" (information courtesy of Jon Davidson, Colin McPherson, Durham)

Other activities

- Southeast Asia Research Group (SEARG), Royal Holloway (Hall et al.) - predominantly industry funded, with several relevant research areas in active and ancient subduction zones. Currently preparing a new consortium funding bid.
- Range of studies including plate reconstruction, sediment provenance, thermochronology, igneous/volcanic history, arc magma composition, heat flow database compilation
- Margins include: Sunda, Marianas, Sangihe, Philippines, Negros, Manila, Halmehera

OngoingSpanish Initiatives of potential Interest to SCD – GeoPrisms

- Subduction Initiation along NW Africa-Europe Plate Boundary.
- The north Caribbean subduction and strike slip zone.

César R. Ranero

ICREA at CSIC, Barcelona Center for Subsurface Imaging

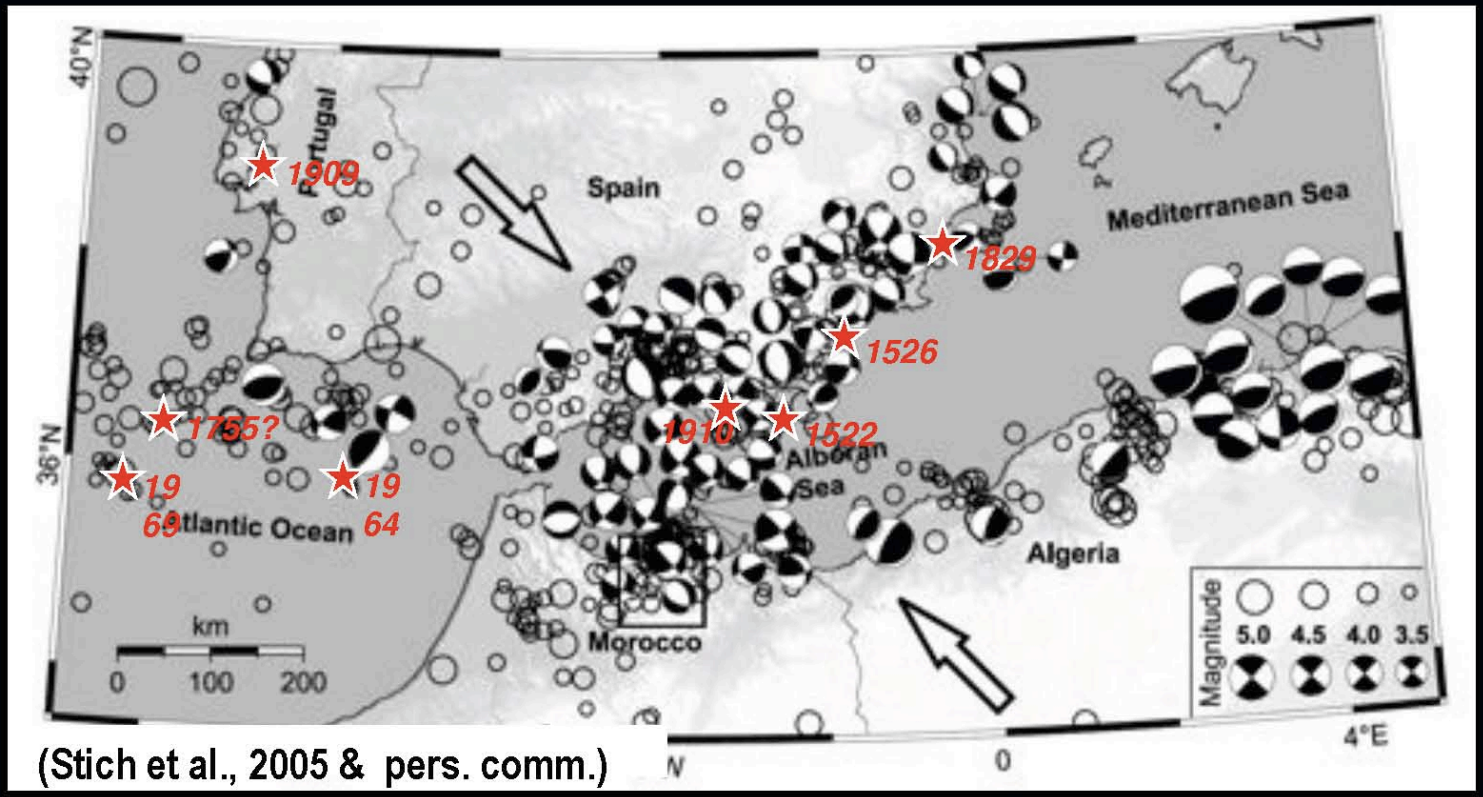
*iCrea
INSTITUCIÓ CATALANA DE RECERCA I ESTUDIS AVANÇATS

Barcelona CSI
Center for Subsurface Imaging

CSIC

Subduction Initiation along the African-European plate boundary ?

EUR-AFR diffuse plate boundary: Moderate seismicity, mainly reverse & SS focal mech.
Large instrumental and historical EQs have also occurred (AD1969, 1755, 1829)



(Stich et al., 2005 & pers. comm.)

Seismicity occurs up to 60 km depth offshore SW Iberia indicating lithospheric scale faulting in a Jurassic-age lithosphere.

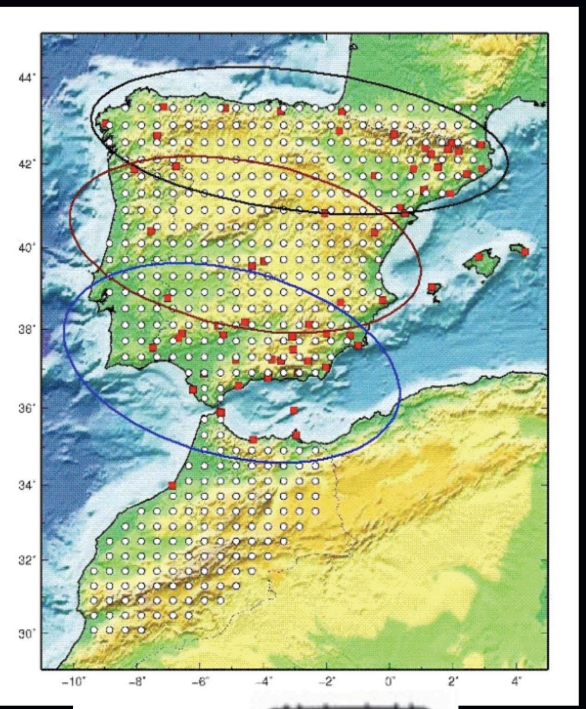
The *IberArray* Platform

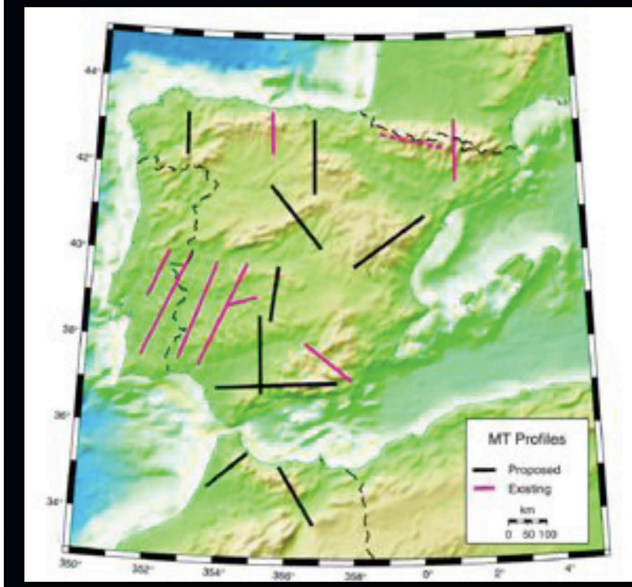
Topo-Iberia includes 3 networks:

Seismic: 70 broadband portable stations

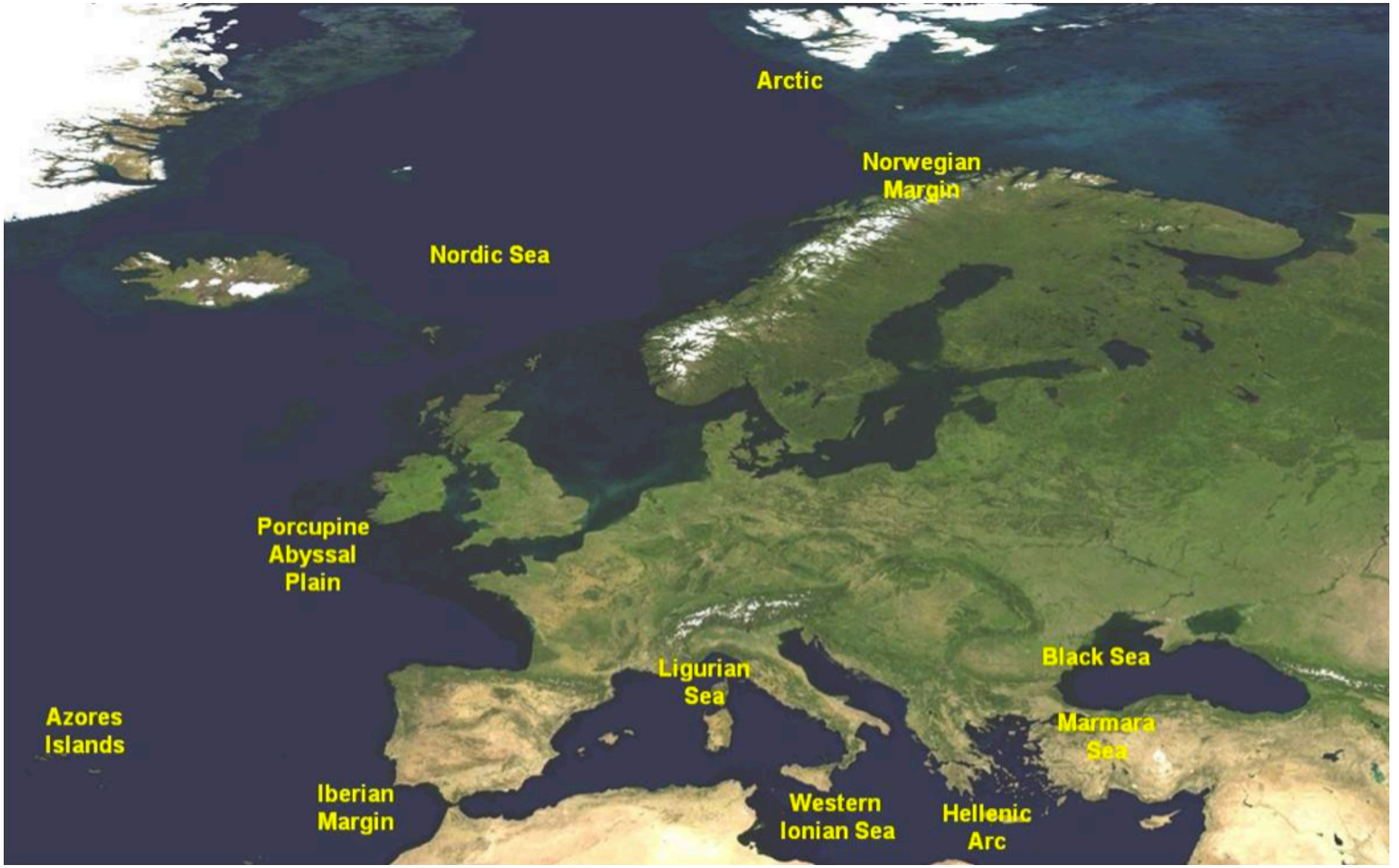
GPS

Magnetotelluric

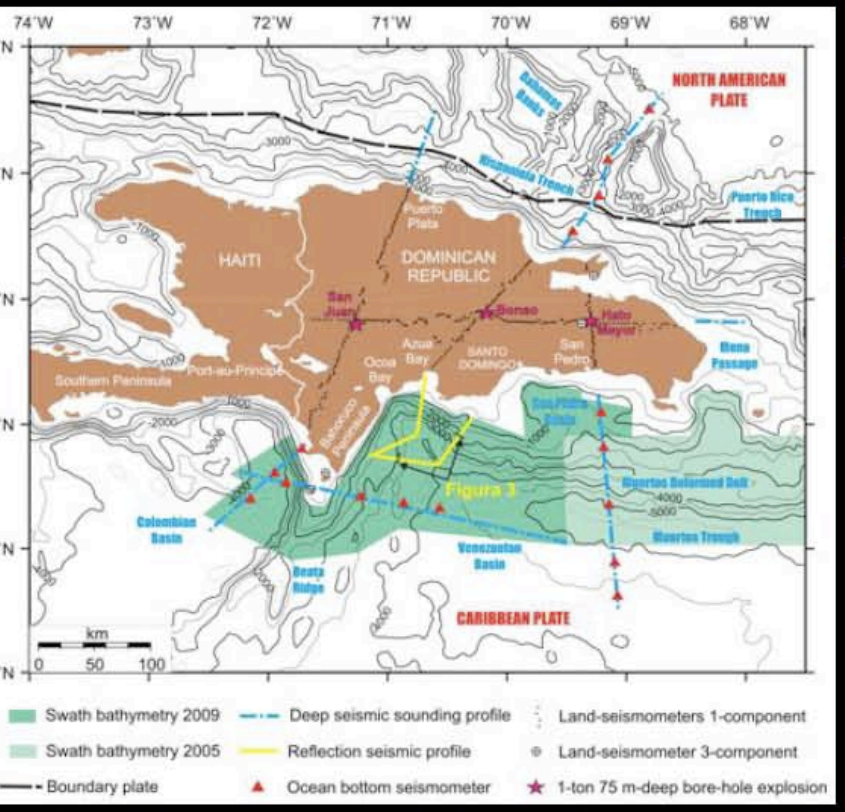


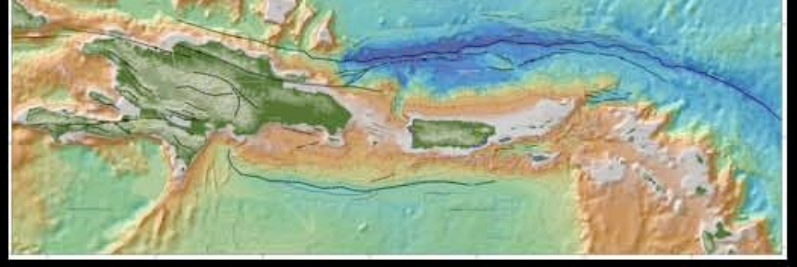


EMSO: European Multidisciplinary Seafloor Observatory



The North Caribbean

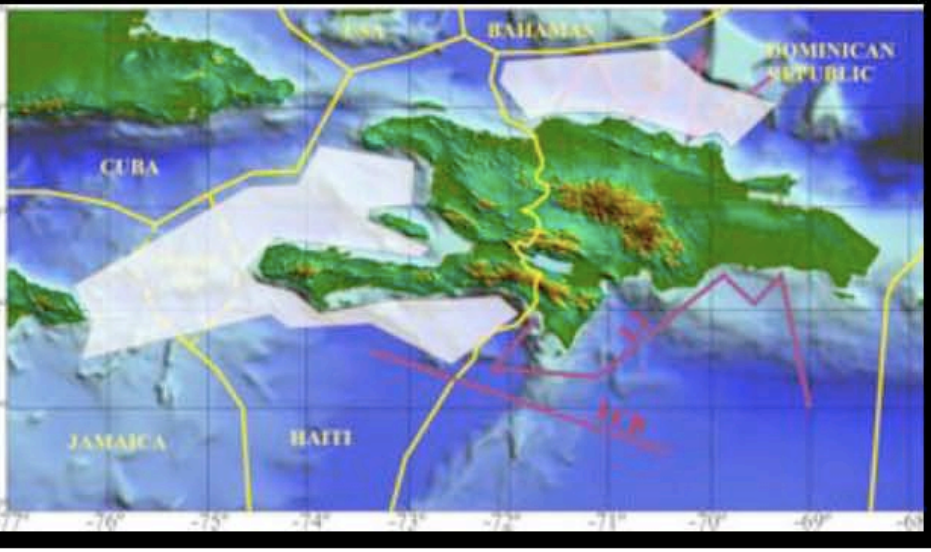




Coordinator: A. Carbo, Uni. Complutense Madrid

2009 cruise:

- Multibeam coverage green shaded.
- Lines in black: Land wide-angle seismic
- Lines in blue: Marine MCS and wide-angle seismic.



2012 cruise:

- Multibeam coverage grey shaded.
- Lines in Red: Marine MCS and wide-angle seismic.

Opportunities for collaboration with SCD

1. The Africa-Europe plate boundary is "mature" for focused studies, much time-consuming reconnaissance work has been done or is underway.

2. The region is in a convenient location from a logistic point of view.

3. **Subduction initiation** is a priority topic for SCD with few available places to study the active process.

4. Caribbean represents the counterpart as a poorly studied area where subduction grades into lithospheric strike slip faulting causing devastating earthquakes.

5. Spanish National Facilities are available and groups ready for collaborative work.

Italy's potential contributions to NSF-GeoPRISMS via partnership and collaboration

&

The forthcoming IODP Exp. 334: Costa Rica Seismogenesis Project "A"

New Italian lab facilities:
SHIVA (**S**low to **HI**gh **V**elocity **A**pparatus)

1. σ_n < 70 MPa
2. Slip rate = 10 μm/s - 9 m/s
3. Acceleration=80m/s
4. Sample diameter 40mm

- Environmental/ vacuum chamber equipped with a mass spectrometer.
- Control O_2 fugacity in the experiments.
- A pressure vessel to perform experiments in the

INGV: Giulio di Toro
(giulio.ditoro@unipd.it)

Forthcoming Italian lab facility: Triaxial deformation apparatus with pressure vessel

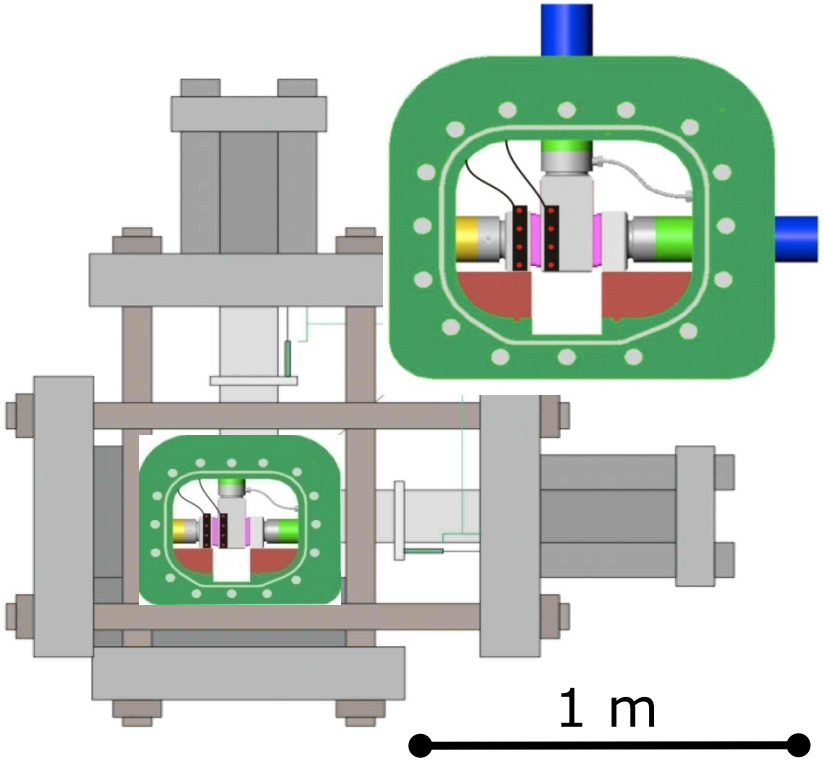


Image of a similar machine at PennState Lab, Chris Marone

1. Vertical and horizontal force up to 1 MN;
2. Sliding during experiment up to 5 cm;
3. velocity from 1 micron to 2 cm per second;
4. confinment pressure up to 75 MPa;

Innovations of the Italian machine:

- **60*60*60 cm pressure vessel;**
- **possibility to work on samples of 20*20*4 cm in size;**
- **possibility to apply fluid pressures;**
- **possibility to record different seismic transients.**

INGV: Cristiano Collettini
(colle@unipg.it)

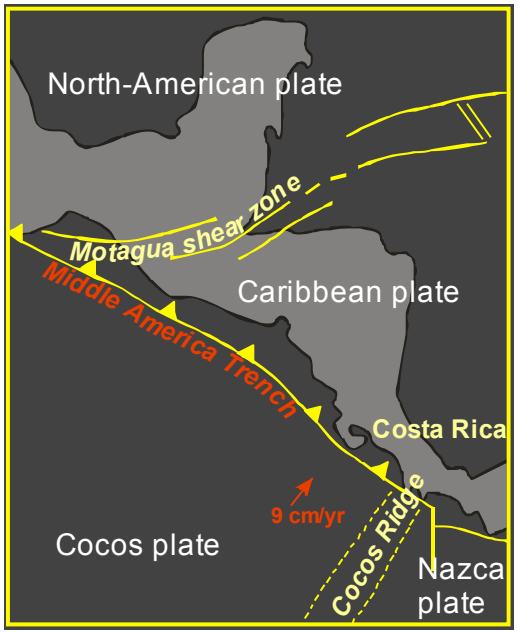
Exp. 334 CRISP A Operation

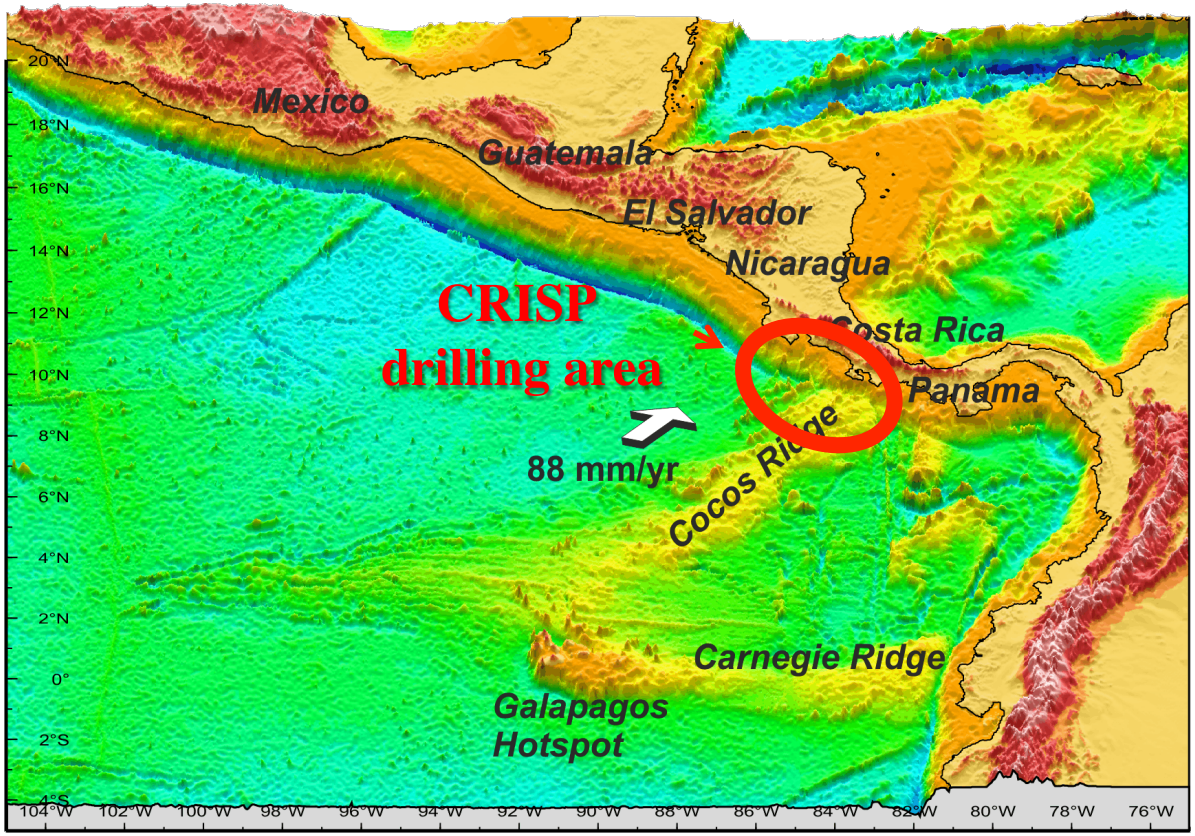
Dates: 15 March to 13 April 2011

Ports: Puntarenas to Puntarenas, Costa Rica

Co-chief Scientists: Paola Vannucchi & Kohtaro Ujiie

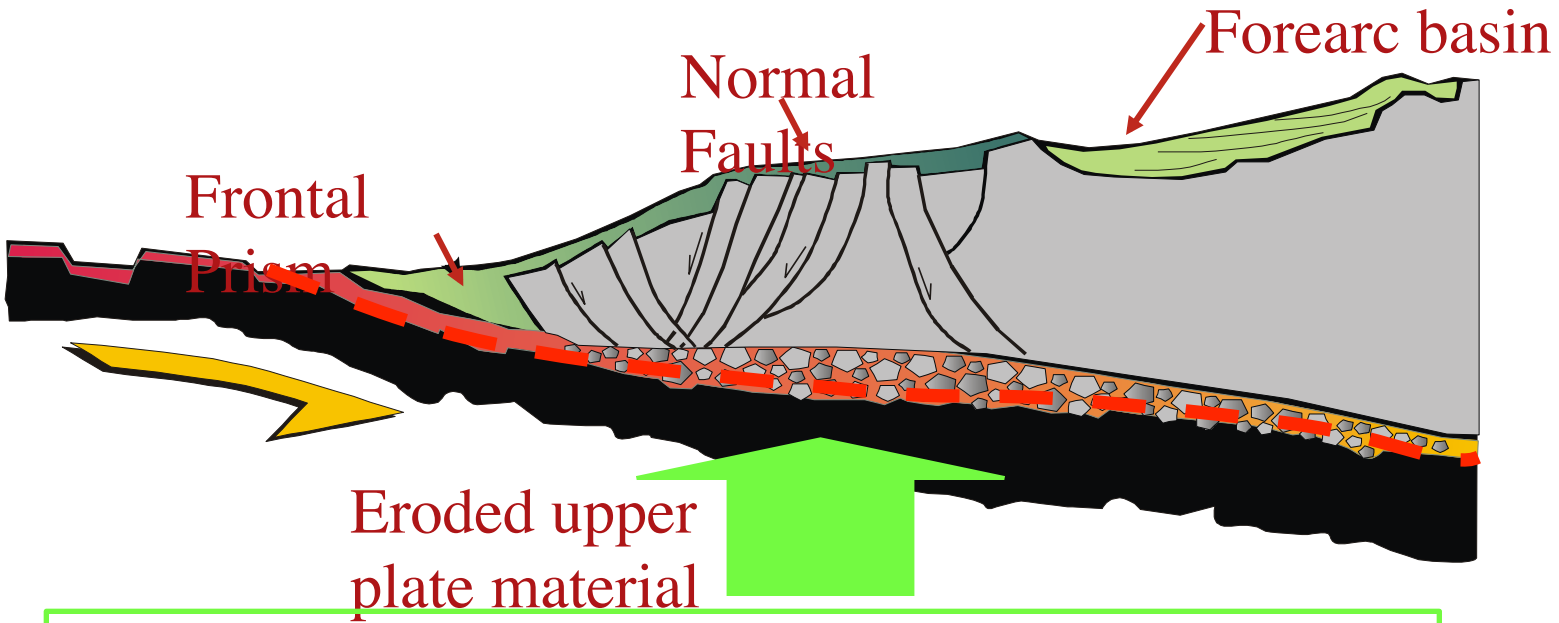
http://iodp.tamu.edu/scienceops/expeditions/costa_rica_seismogenesis.html





Focus on erosive plate boundary

CRISP is the first drilling program designed to study an erosive margin

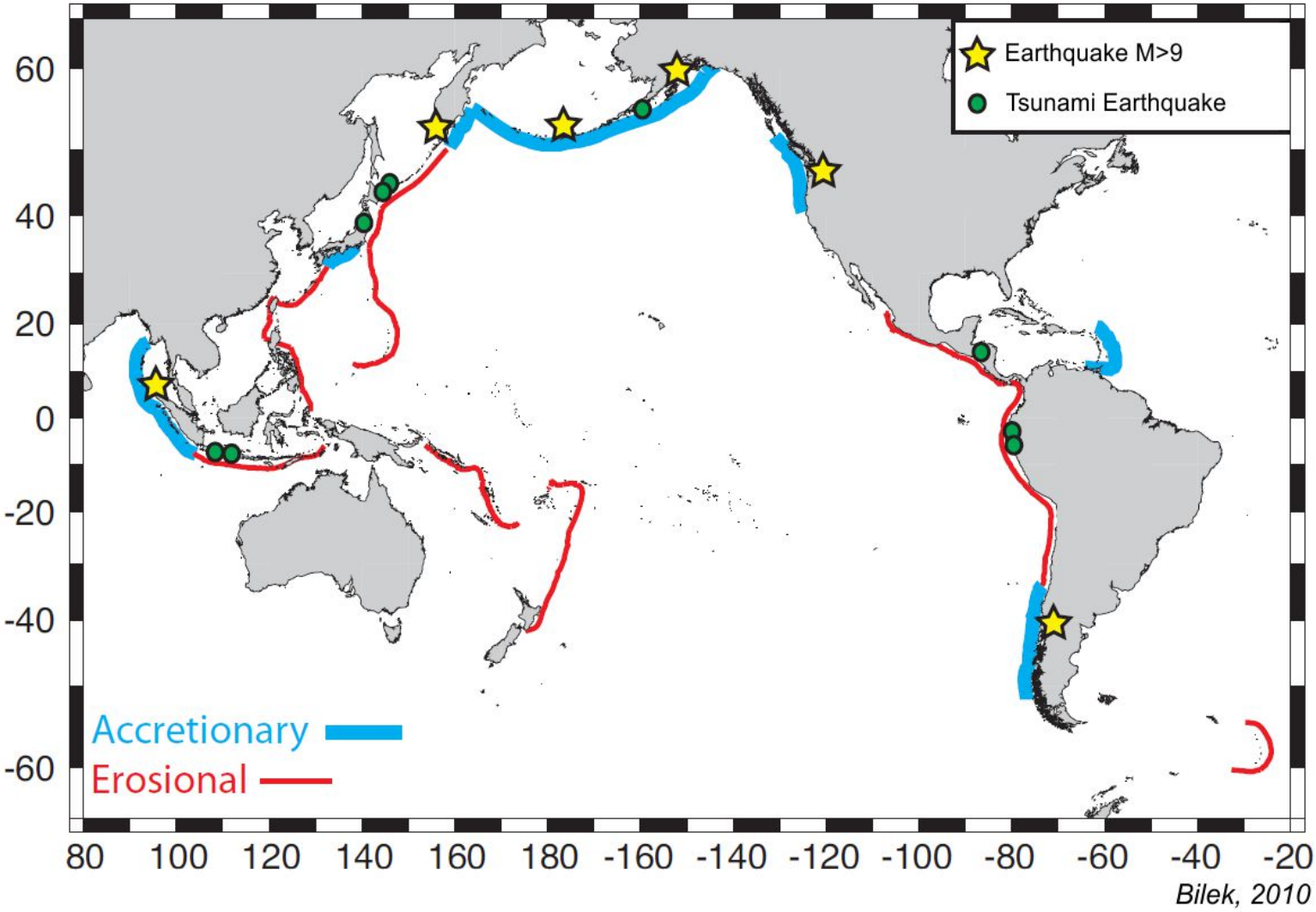


The erosive plate boundary migrates toward the upper plate ▸ the plate boundary input is material from the upper plate

Working model:

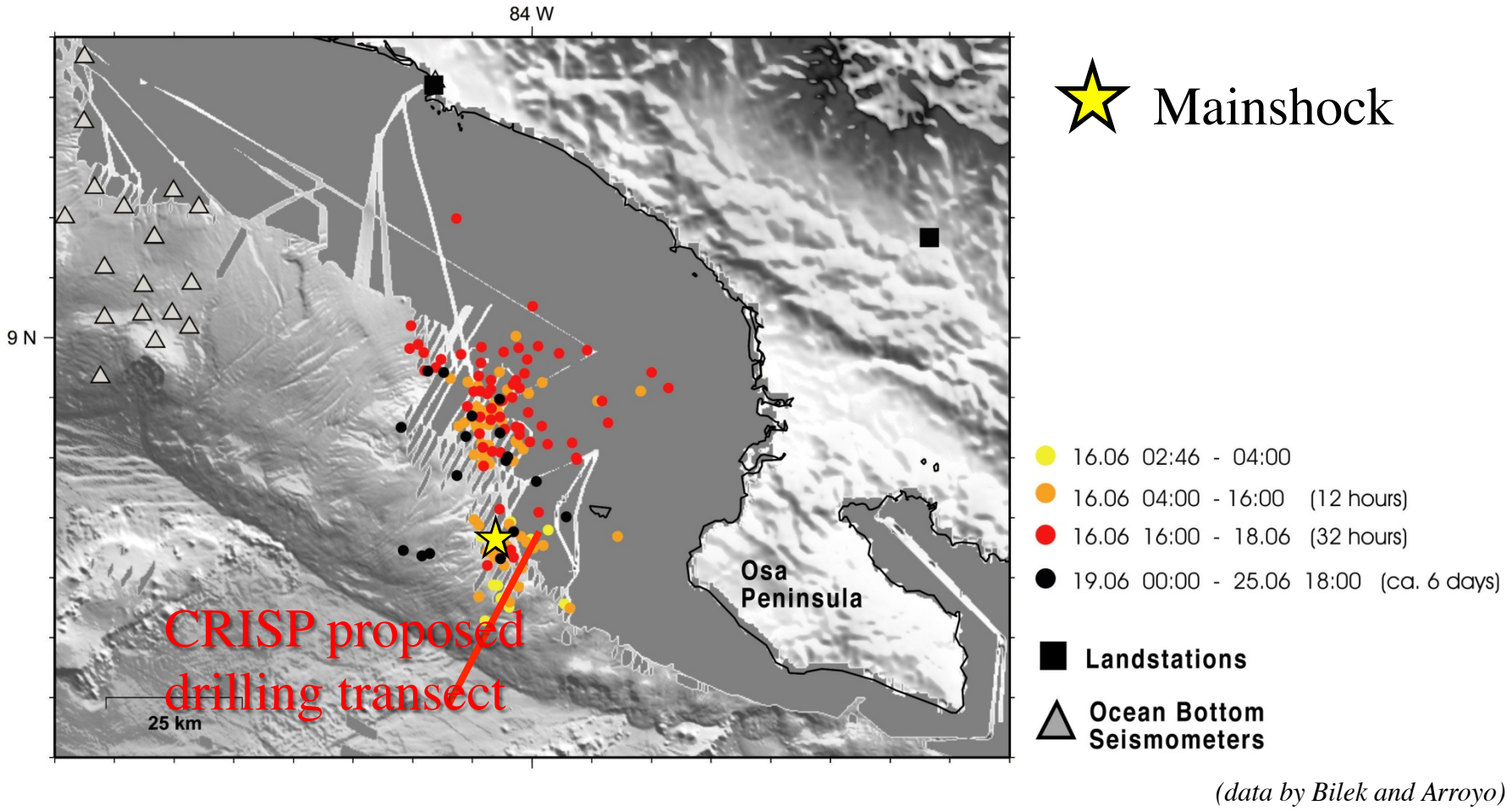
- The plate boundary is not a simple fault, but rather a shear zone = deformation is largely concentrated in a subduction channel
- Fluid driven processes weaken the upper plate and promote upward migration of the active décollement

Subduction, EQ and Tsunami



- Largest recorded events at accretionary margins
- Tsunami EQs (producing large tsunamis relative to their seismic moment and unusually long time of rupture) are primarily located in erosive margins

June 2002 Mw 6.4 aftershock sequence



(data by Bilek and Arroyo)

- CRISP is designed to penetrate an EROSIVE plate boundary in an area of active seismic slip

C.Ri.S.P.

(Costa Rica Seismogenesis Project)

IODP Exp. 334
CRISP A
Middle and Upper Slope
non riser

3D seismic reflection survey will be performed in Spring 2011

To be scheduled:
CRISP B
Aseismic vs. Seismic Plate Boundary
riser

Ref. and Lower slope
Contingency plan for IODP Exp. 335