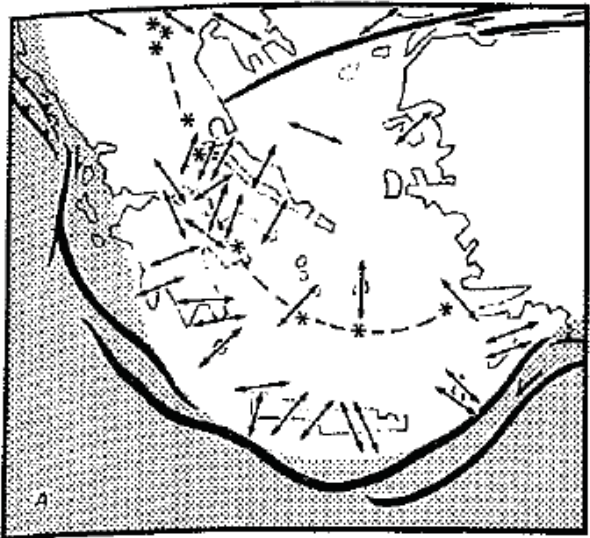


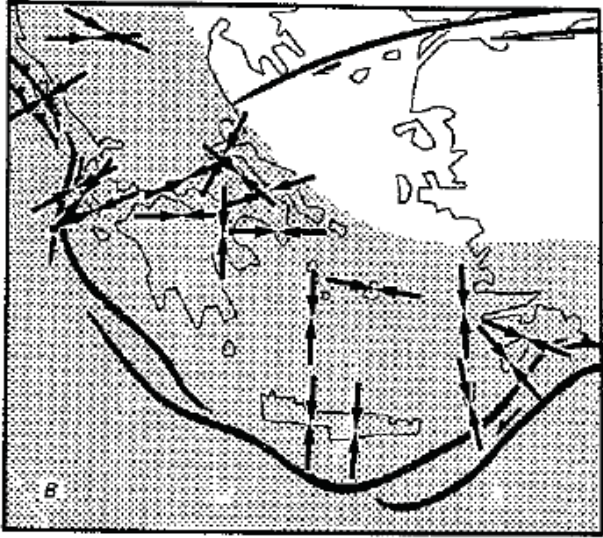
Hervé Philip:  
A summary of his contribution to Seismotectonics  
and Paleoseismology

1970's

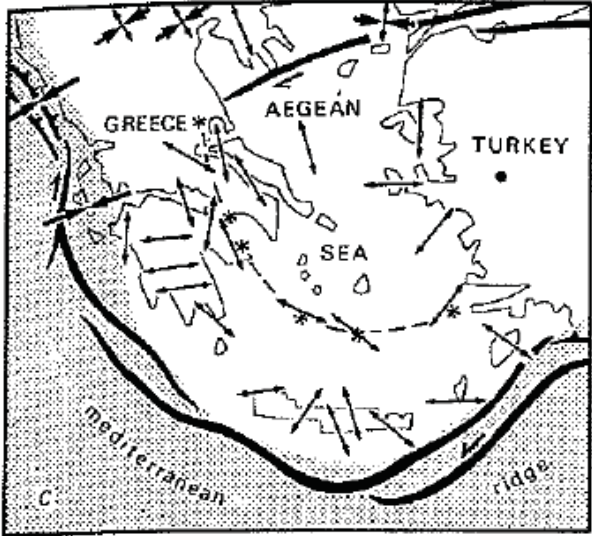
**Aegean Arc**  
**Evolution of the deformation during the Plio-Quaternary**



Pliocène



Lower Quaternary

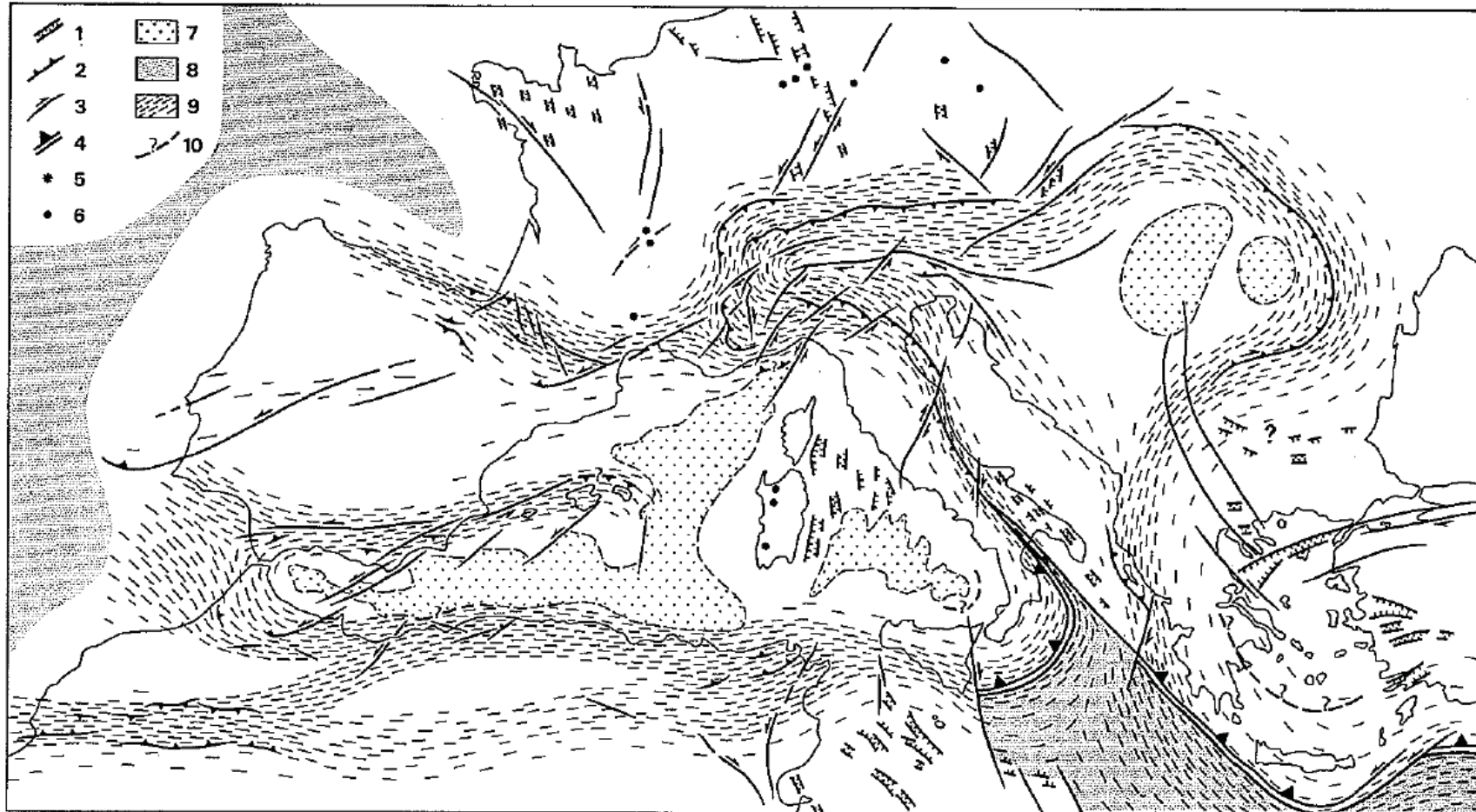


Upper Quaternary

Philip PhD 1974; Philip, BSGF 1976 + other sources (see Philip, 1987)

1980's

**Mediterranean region:  
Distribution of the deformation during Late Quaternary and Present Day**



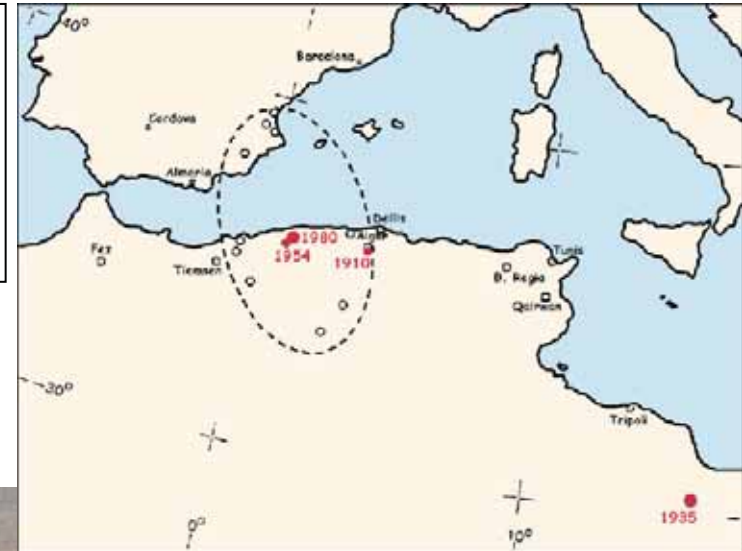
Philip, Thèse d'Etat 1983, Philip, Annales Geophysicae 1987 (also Rebai, Philip, Taboada, GJI 1992)

Supervising PhD theses neotectonics and geodynamics: P. Combes, J-F. Ritz, A. Taboada, S. Rebaï

Algeria, October 10, 1980  
El Asnam earthquake M7.3

A major event in the West Mediterranean since 1954  
The most important event recorded so far in North Africa

The starting point of a fruitful and original collaboration  
with IPG Strasbourg (A. Cisternas and collaborators)



**EL ASNAM, Algérie, 1980, M:7,3**



**EL ASNAM, Algérie, 1980, M:7,3**

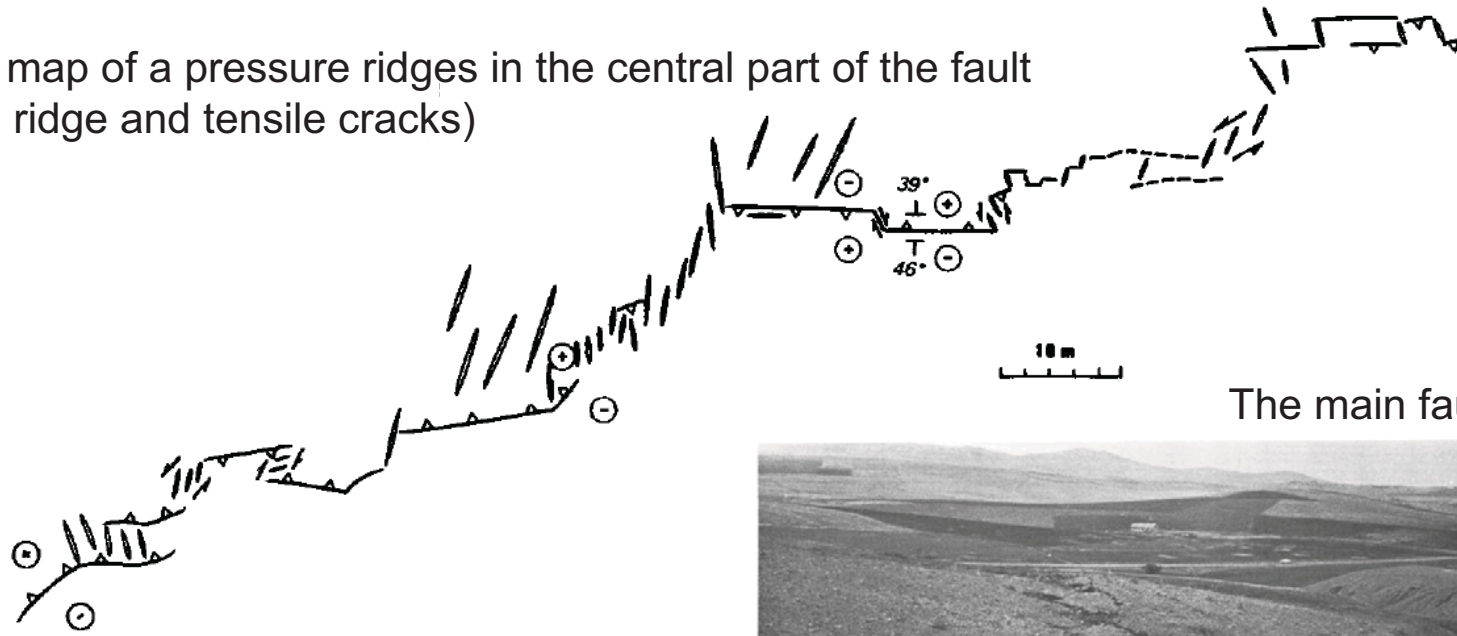




**EL ASNAM, Algérie, 1980, M:7,3**

## Example of the complexity of the ground ruptures pattern

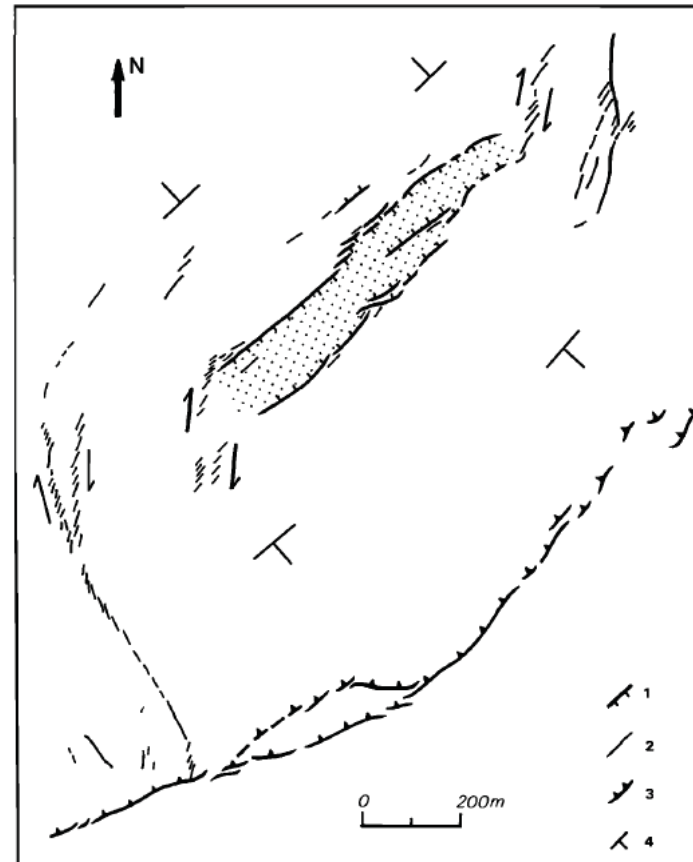
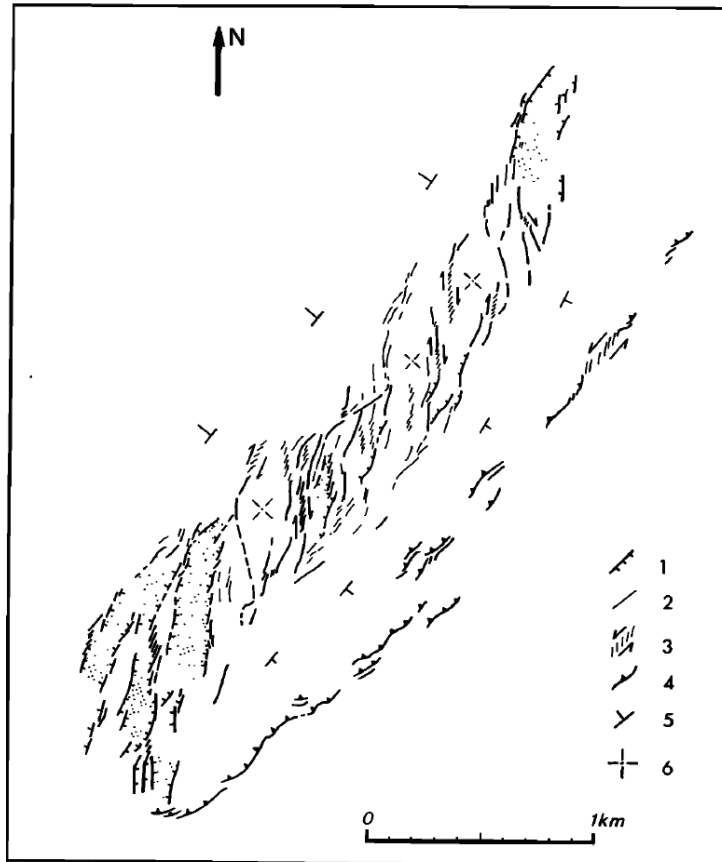
Detailed map of a pressure ridges in the central part of the fault  
(thrusting ridge and tensile cracks)



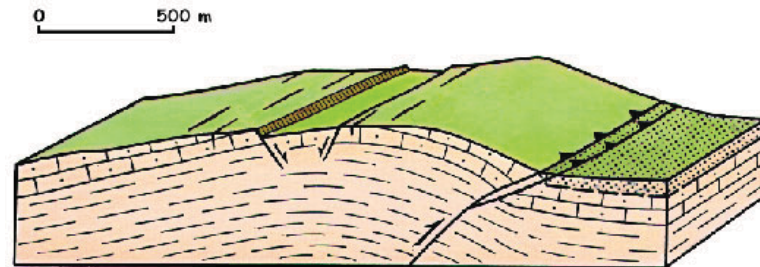
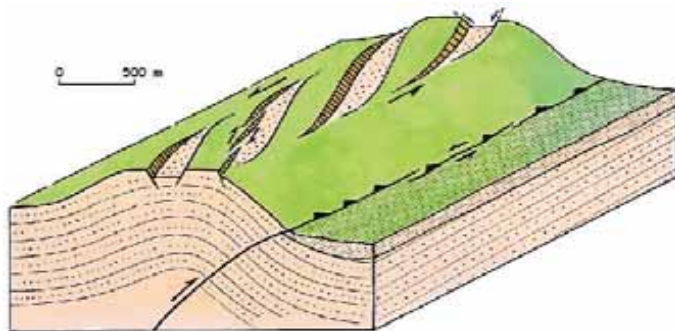
Aerial photo showing a zone of pressure ridges



# Examples of the complexity of the ground ruptures



Philip and Meghraoui, 1983



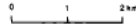
Normal faults (extrados), tensile cracks, pressures ridges, thrust and strike-slip faults



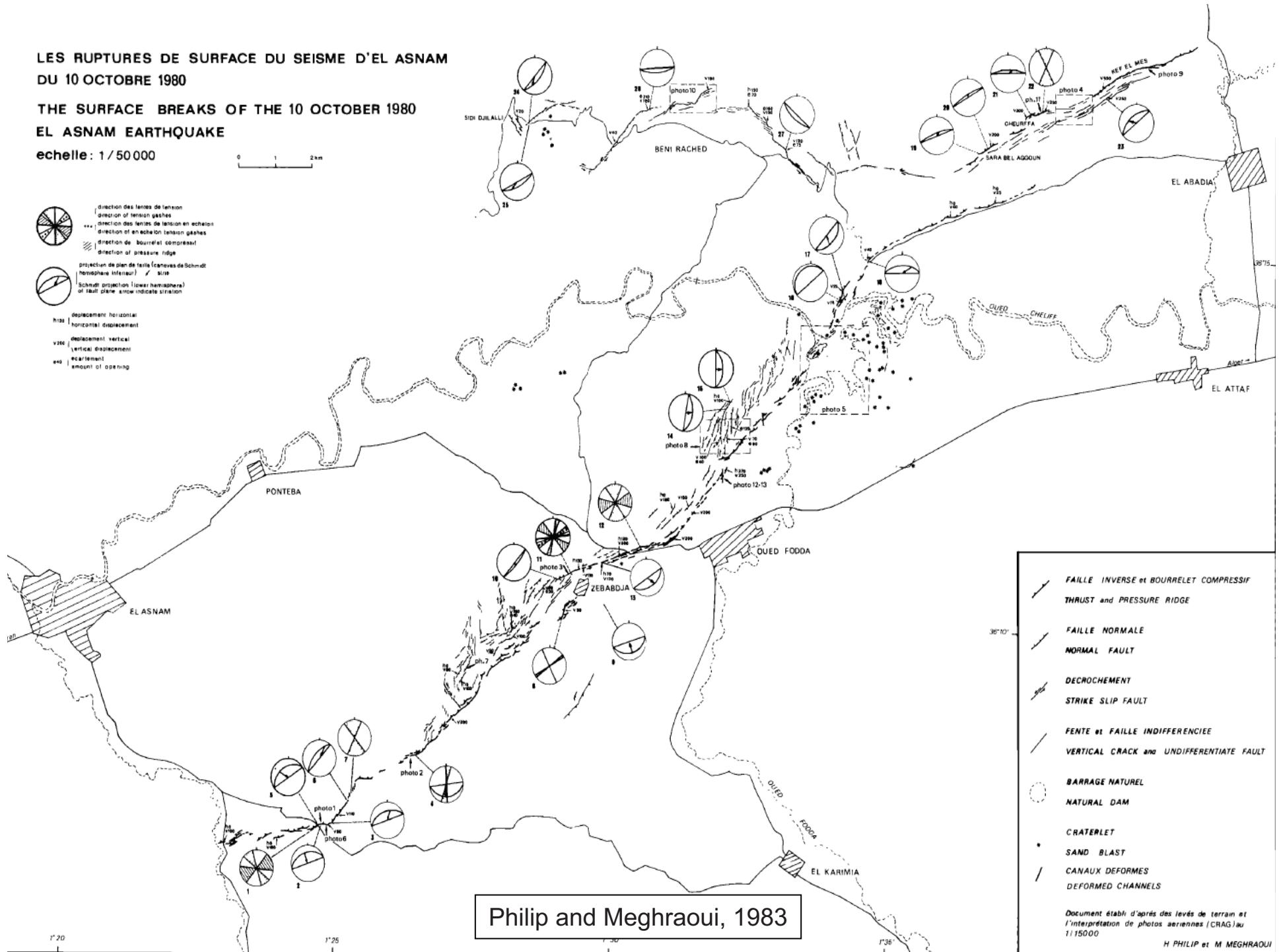
LES RUPTURES DE SURFACE DU SEISME D'EL ASNAM  
DU 10 OCTOBRE 1980

THE SURFACE BREAKS OF THE 10 OCTOBER 1980  
EL ASNAM EARTHQUAKE

echelle: 1/50 000



- direction des fentes de tension
- direction of tension gashes
- direction des fentes de tension en échelon
- direction of en echelon tension gashes
- direction de bourrelet compressif
- direction of pressure ridge
- projection de plan de faille (convoles de Schmidt)
- Schmidt projection (lower hemisphere) of fault plane, arrow indicates situation
- déplacement horizontal
- horizontal displacement
- déplacement vertical
- vertical displacement
- écartement
- amount of opening

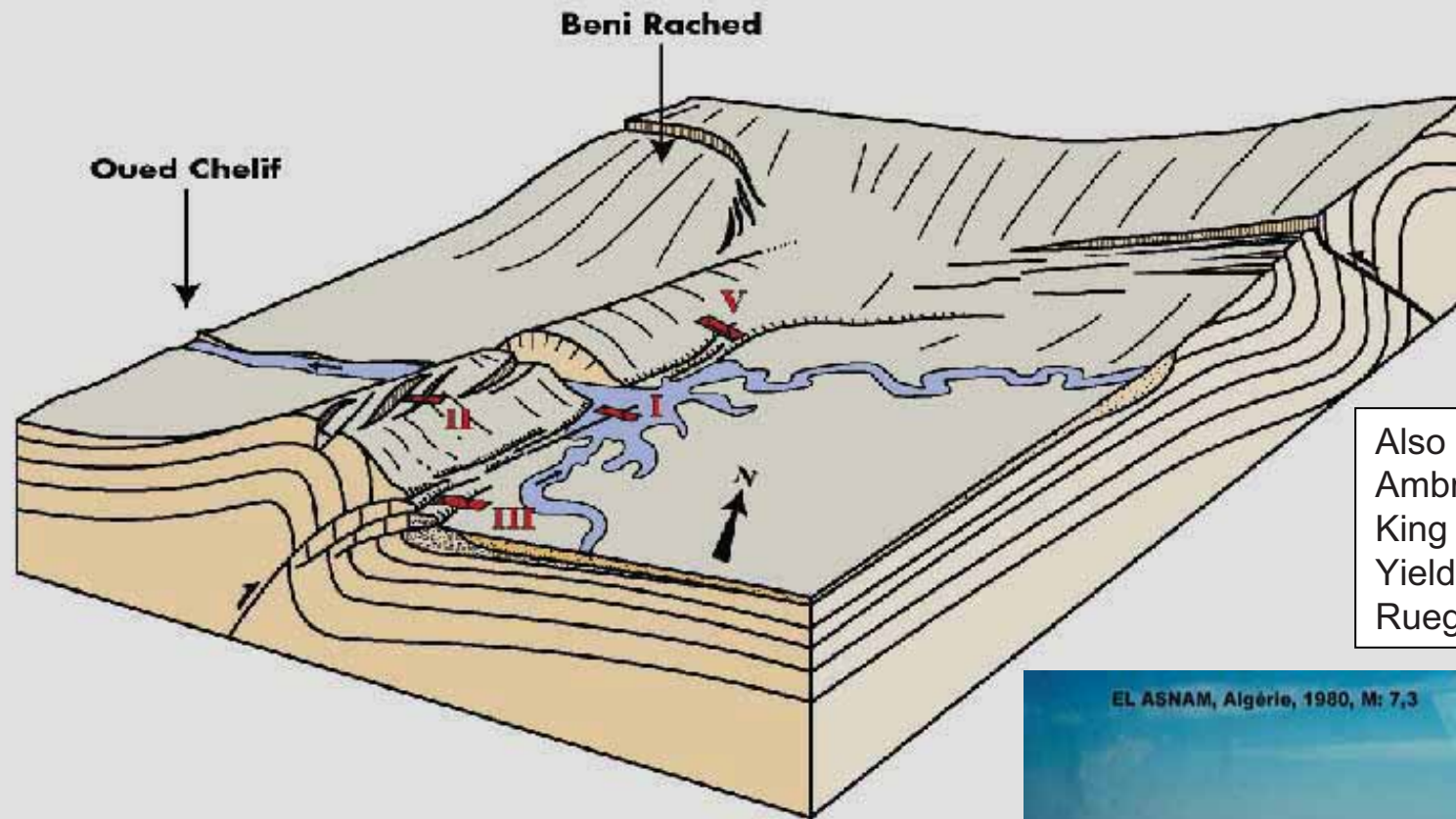


Philip and Meghraoui, 1983

- FAILLE INVERSE et BOURRELET COMPRESSIF
  - THRUST and PRESSURE RIDGE
  - FAILLE NORMALE
  - NORMAL FAULT
  - DECROCHEMENT
  - STRIKE SLIP FAULT
  - FENTE et FAILLE INDIFFERENCIEE
  - VERTICAL CRACK and UNDIFFERENTIATE FAULT
  - BARRAGE NATUREL
  - NATURAL DAM
  - CRATERLET
  - SAND BLAST
  - CANAUX DEFORMES
  - DEFORMED CHANNELS
- Document établi d'après des levés de terrain et l'interprétation de photos aériennes (CRAG) au 1/15000
- H PHILIP et M MEGHRAOUI

## El Asnam:

A comprehensive study of a large earthquake in its tectonic environment



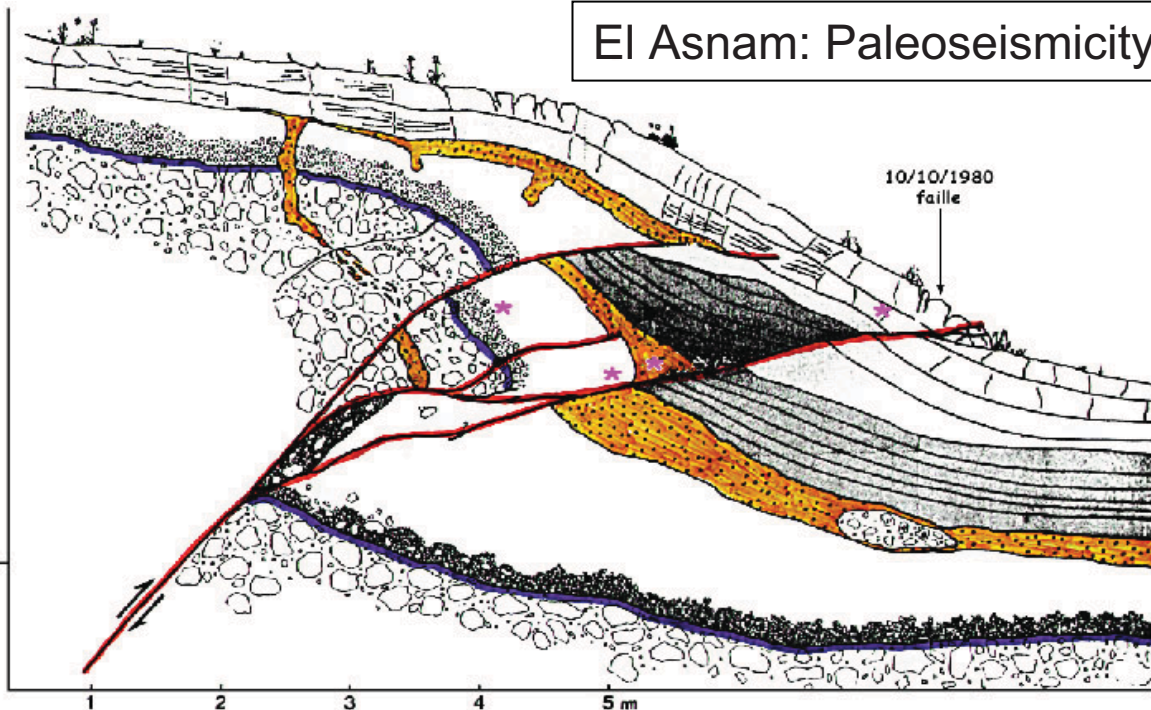
Also (e.g.)  
Ambraseys 1981  
King & Vita-Finzi 1981  
Yielding et al. 1981  
Ruegg et al. 1982

Complementary disciplines: structural geology, neotectonics, geodynamics and seismology

- Ouyed, Meghraoui, Cisternas, Deschamp, Dorel, Frechet, Gaulon, Hatzfeld, Philip, Nature 1981
- Philip and Meghraoui, Tectonics 1983
- Meghraoui, Cisternas and Philip, Tectonics 1986

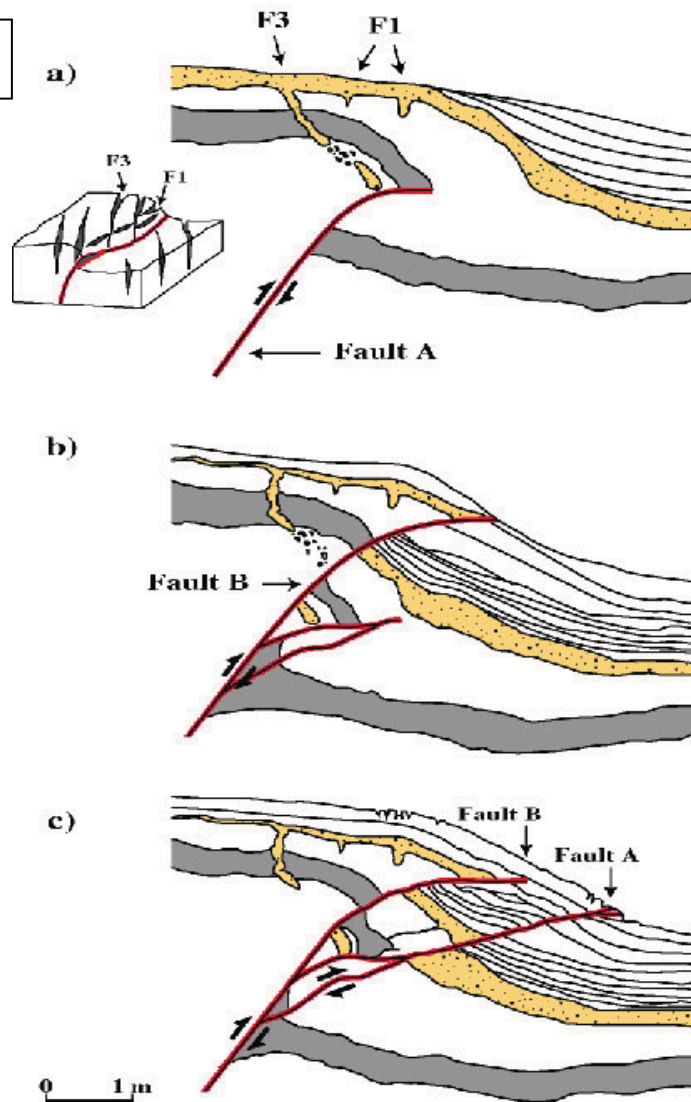
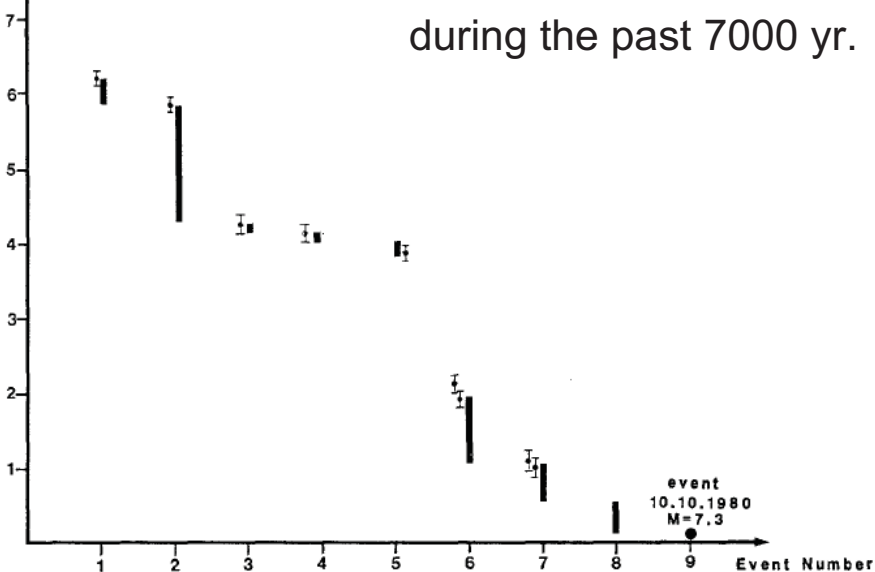


# El Asnam: Paleoseismicity



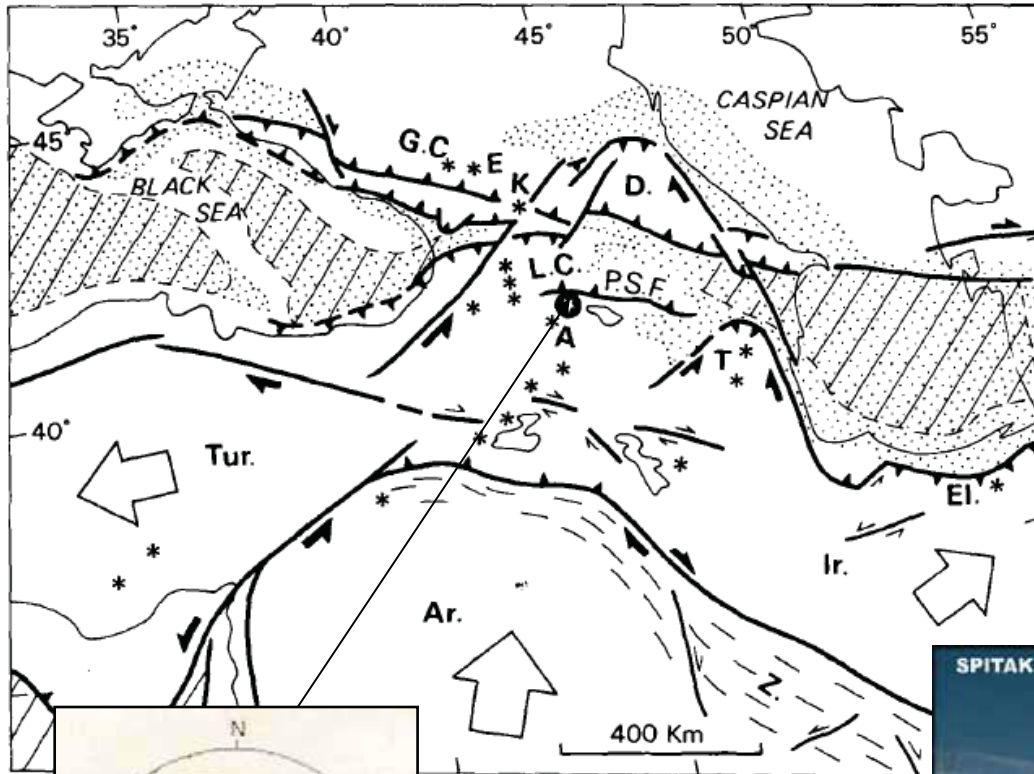
Date BP.  
(x10yrs)

Distribution of seismic events during the past 7000 yr.



Meghraoui, Philip,  
Albarède and Cisternas,  
BSSA 1988

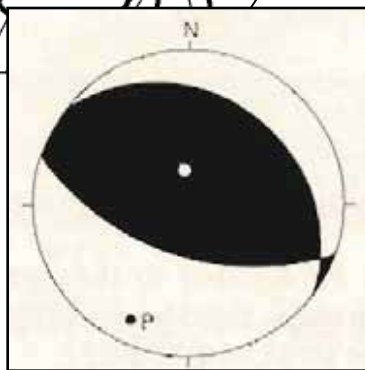
# The M6.9 Spitak earthquake, Armenia (December 7, 1988)



Philip, Cisternas, Gvishiani, Gorshkov  
Tectonophysics, 1989

- Cisternas, Philip, Bousquet, Cara,  
Deschamp, Dorbath, Haessler et al.  
Nature 1989

- Philip, Rogozhin, Cisternas,  
Bousquet, Borisov, Karakhanian  
GJI 1992.



The first well-documented earthquake  
with surface breaks in the Caucasus

# faille qui a détruit l'Arménie

■ Avant le 7 décembre, cette plaine enneigée proche de la ville de Spitak en Arménie, était comme la main. Le 7 décembre ce véritable haut par endroits d'un mètre soixante, s'est effondré d'un coup. Sous l'Arménie la terre venait de bouger, tuant plus de cinquante mille personnes et rasant des villes entières.

Ce document, que personne encore en Occident, a été rapporté par deux géologues de l'Université des Sciences et Techniques de Montpellier à Montpellier qui reviennent d'Arménie. Leur témoignage n'aurait rien de sensationnel. C'est une chose à tout ce qui a déjà été dit sur l'organisation — ou la désorganisation — de la catastrophe.

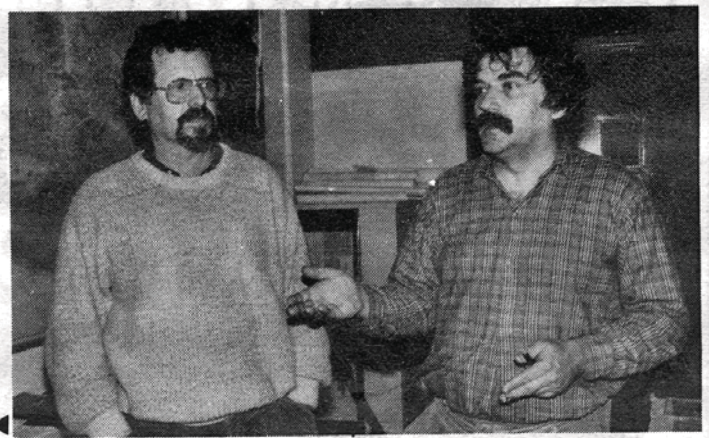
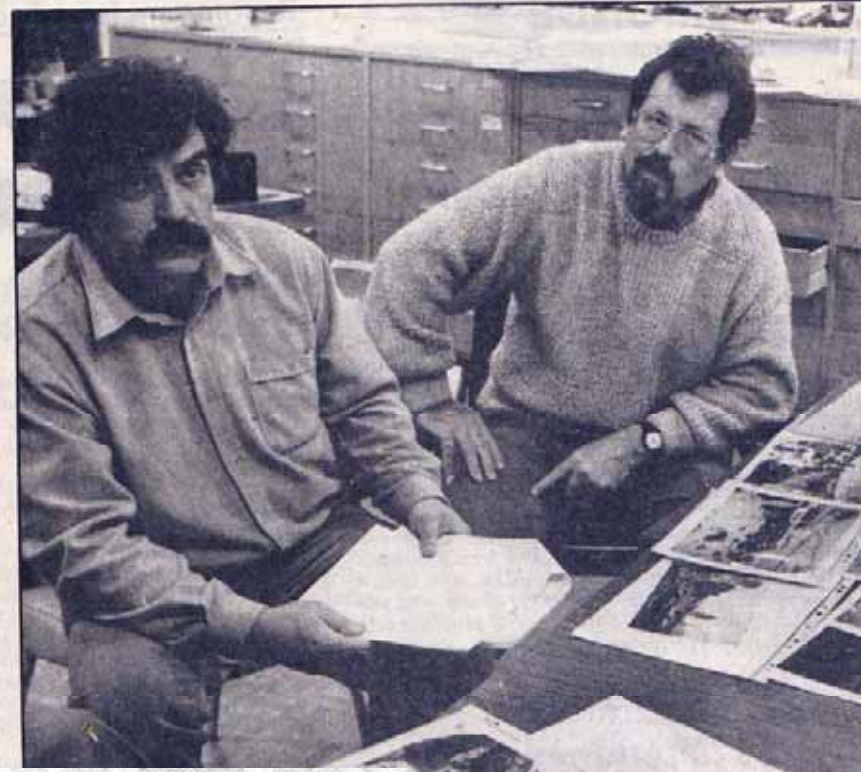
En revanche, les géologues de Montpellier ont constaté que la catastrophe quelques conclusions. Elles concernent pas seulement l'organisation — ou la désorganisation — de la catastrophe.

► Notre page spéciale

Aujourd'hui, sur le territoire toujours dramatique, les Arméniens essaient de survivre. Ils refusent pour la plupart de quitter leur pays. La Croix-Rouge fait un appel à la solidarité internationale. Les Etats-Unis ont promis de réhabiliter les débris et qui partent de l'équipe part de la région de l'Arménie. Par ailleurs, les Arméniens y ont de faibles ressources. La région de l'Arménie est pauvre. Les dégâts matériels sont énormes. On ne peut pas reconstruire en un temps court.



Photo Hervé Philip, Université des Sciences et Techniques de Montpellier



Jean-Claude Bousquet et Hervé Philip

cette date, ils présenteront le 19 janvier lors d'une conférence, les fruits de leurs observations. Elles ont été réalisées à la fin de l'année sur une terre désolée.

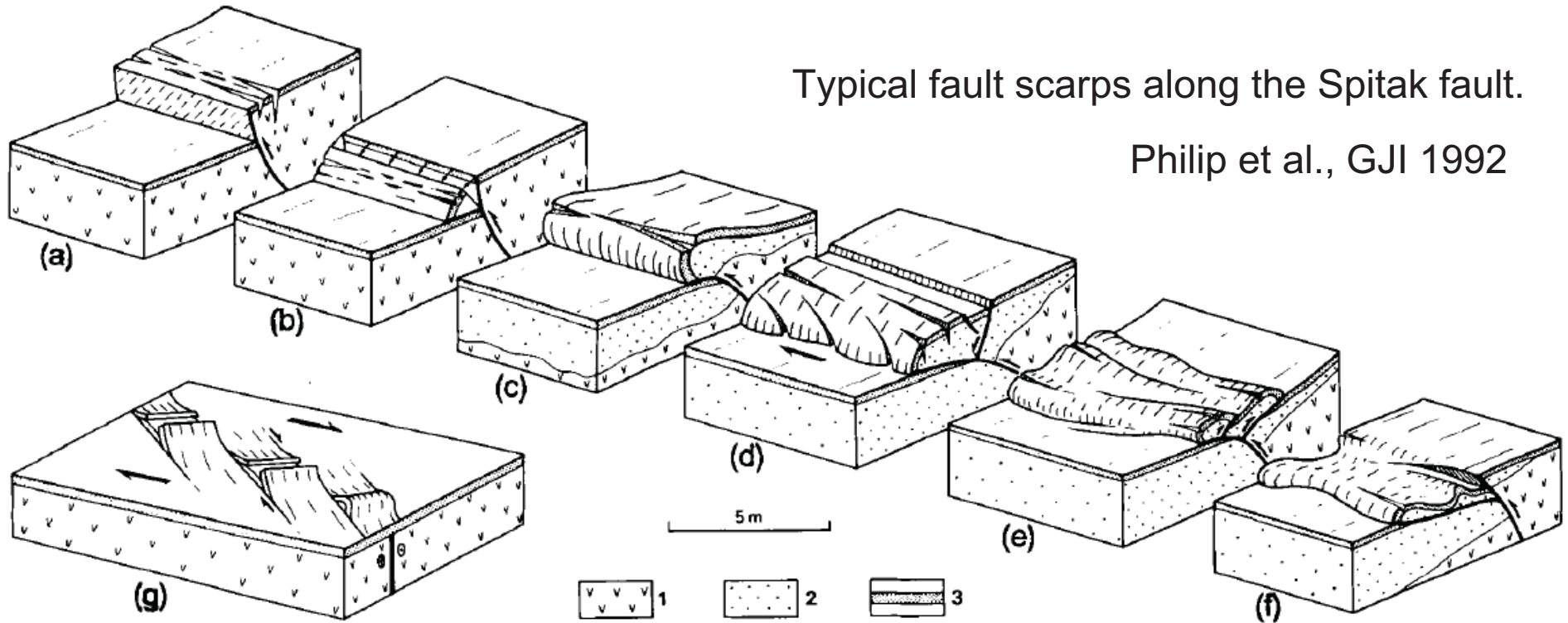
G.B.

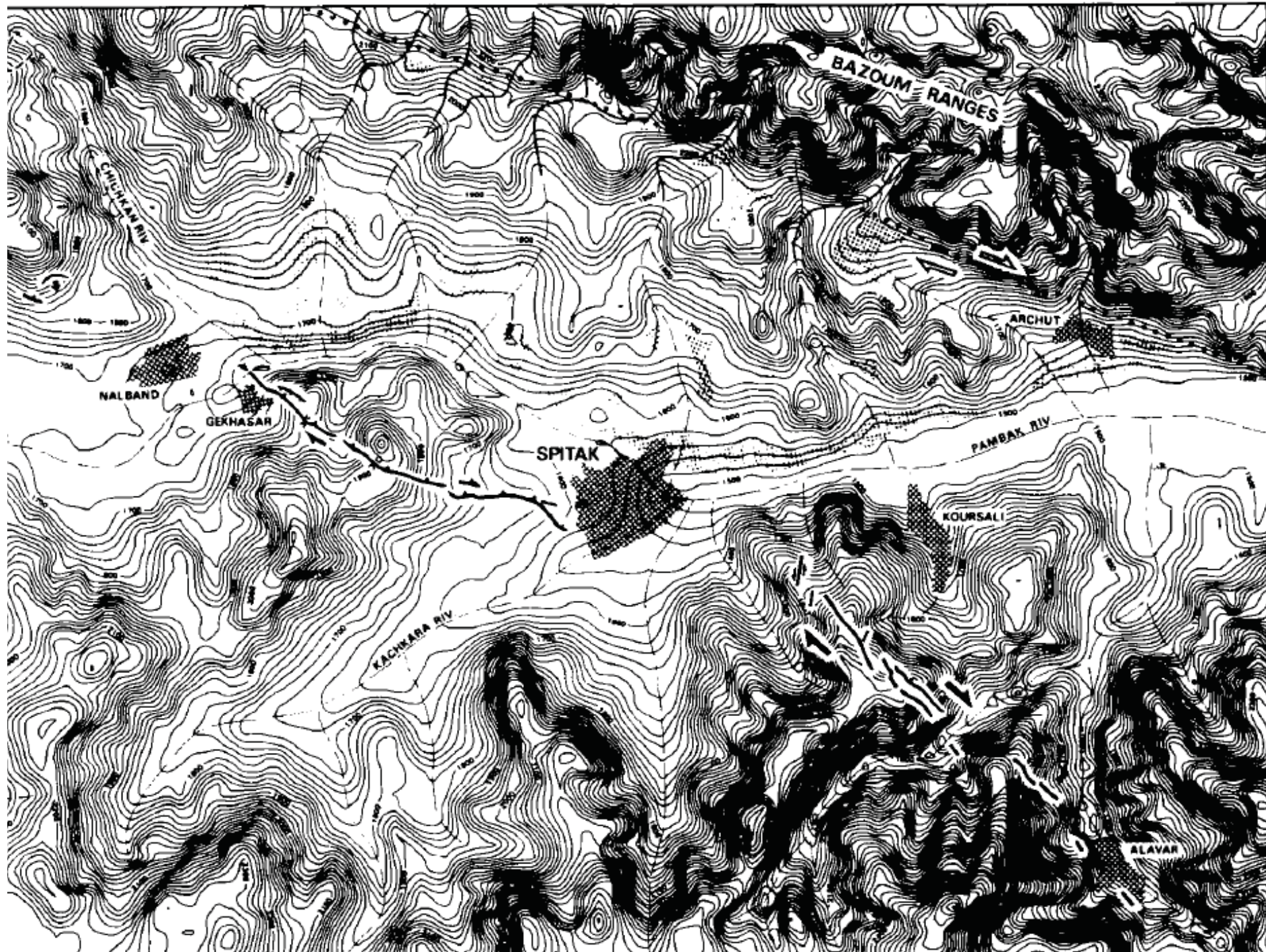
Conférence sur le tremblement de terre d'Arménie : le 19 janvier à 18 h à l'institut de Botanique, 163 rue Auguste Broussonnet. Vous pouvez toujours envoyer des dons en faveur de l'Arménie : à la Société bordelaise de crédit, 9 place de la Comédie à Montpellier. Chèque libellé à l'ordre de solidarité Languedoc-Arménie.

tous les siècles ou tous les mille ans... ». Il n'y a pas à cet endroit qui est sans doute le plus terrible de l'Histoire. En particulier, tous les monuments publics — et, bien sûr, les centrales nucléaires.

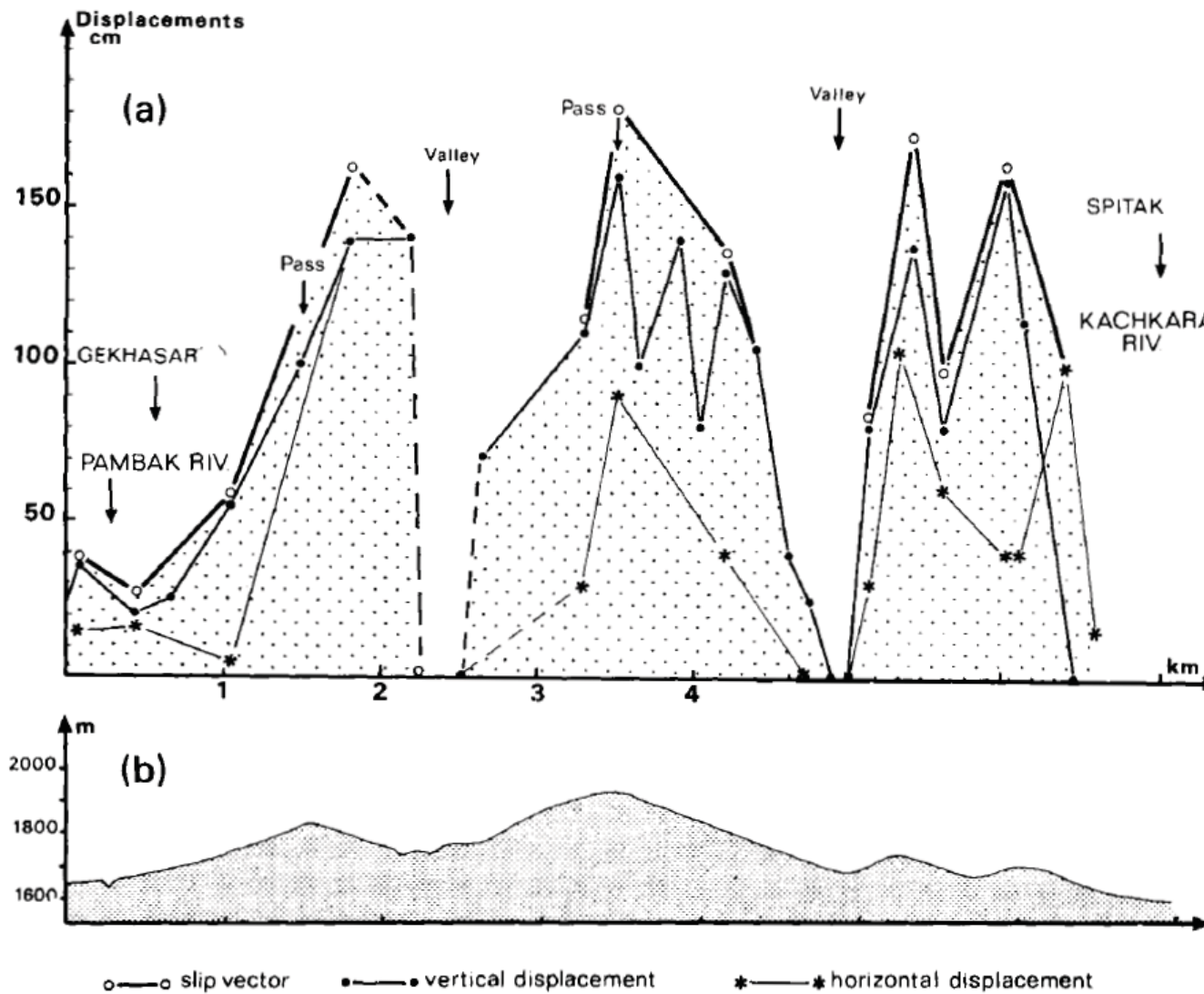
Typical fault scarps along the Spitak fault.

Philip et al., GJI 1992

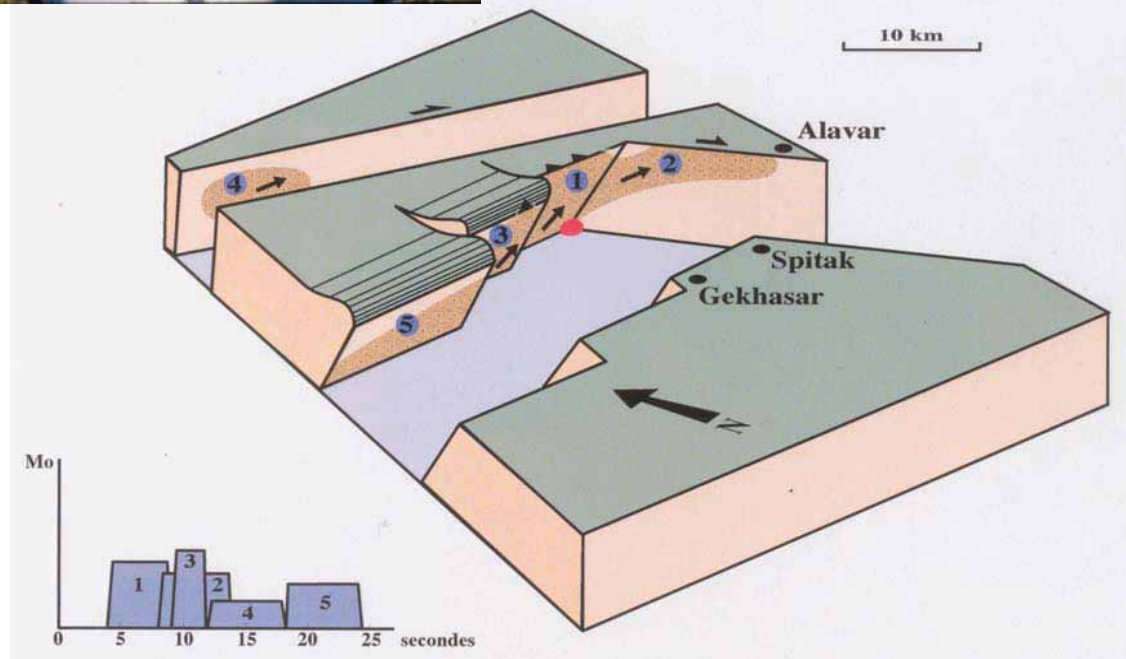




# Relationship between the amount of slip on the fault and the topography (small scale fault segmentation)

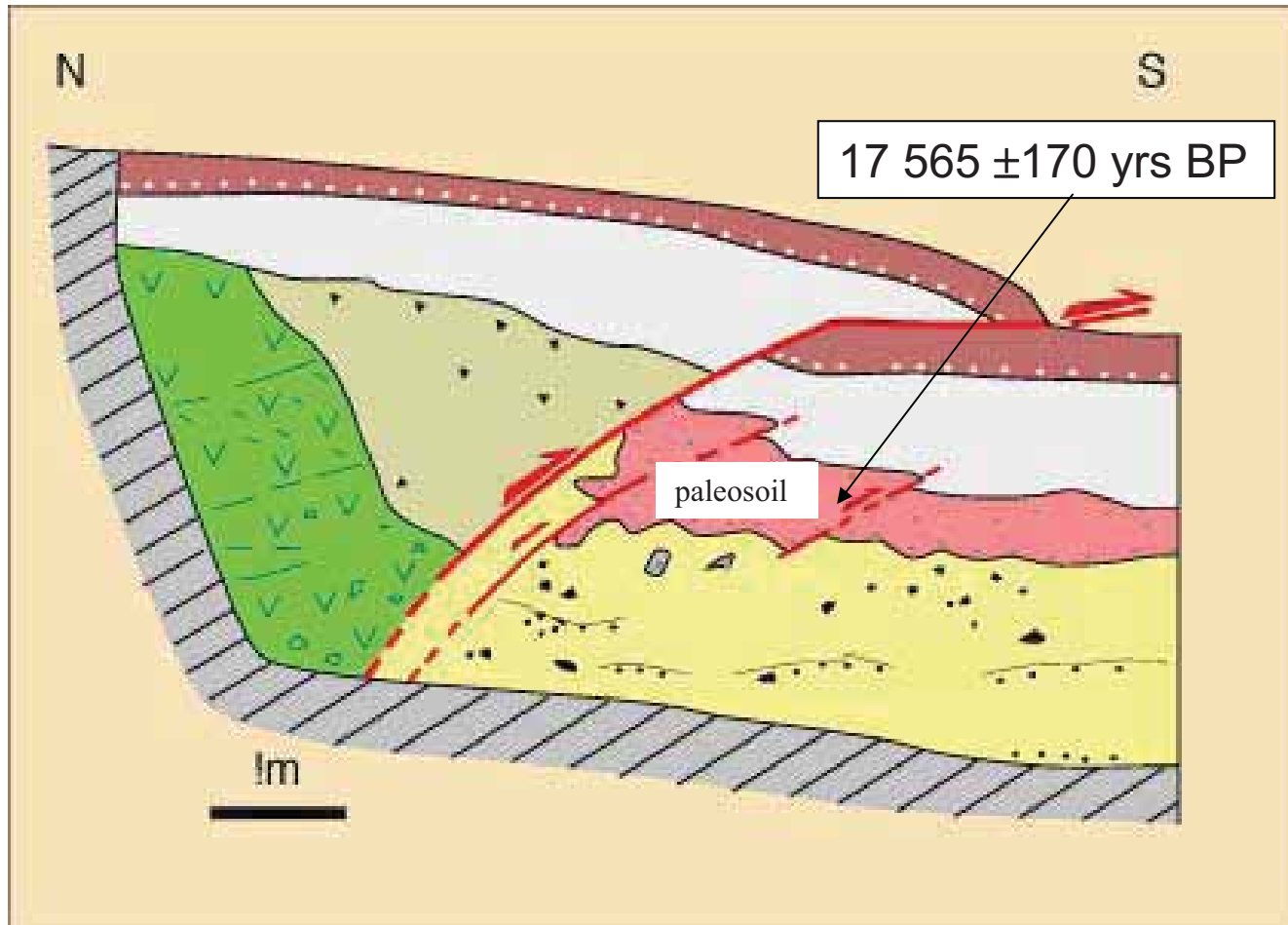




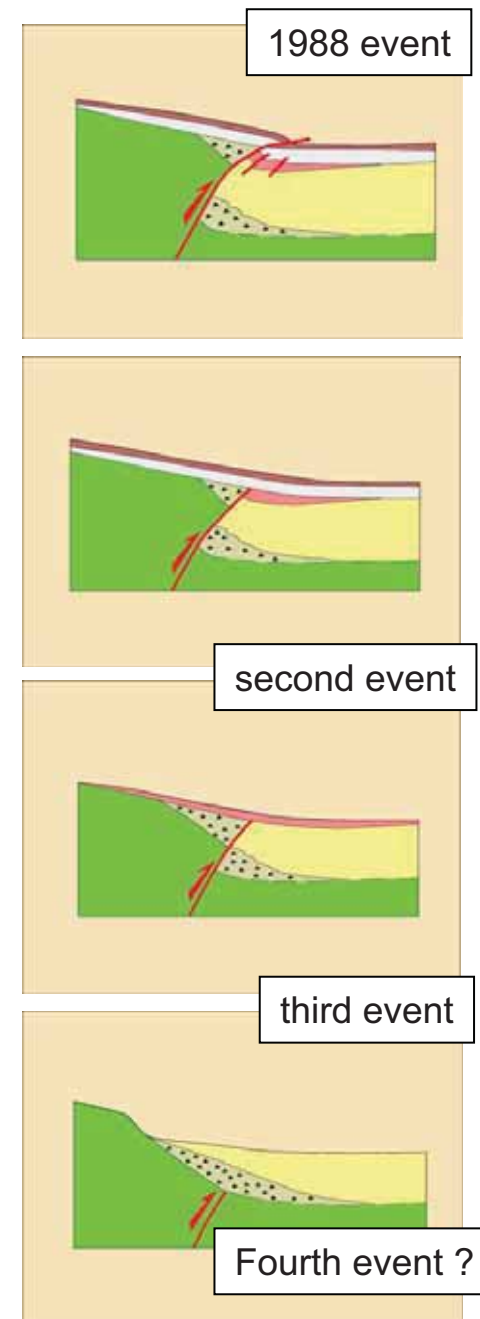


The complementarities of observations from tectonics (detailed map of co-seismic displacements at surface) and seismology (focal mechanisms, aftershocks and strong motions analysis) provided a detailed kinematic model of the fault zone having generated the earthquake.

# Spitak (Arménia) paleoseismology

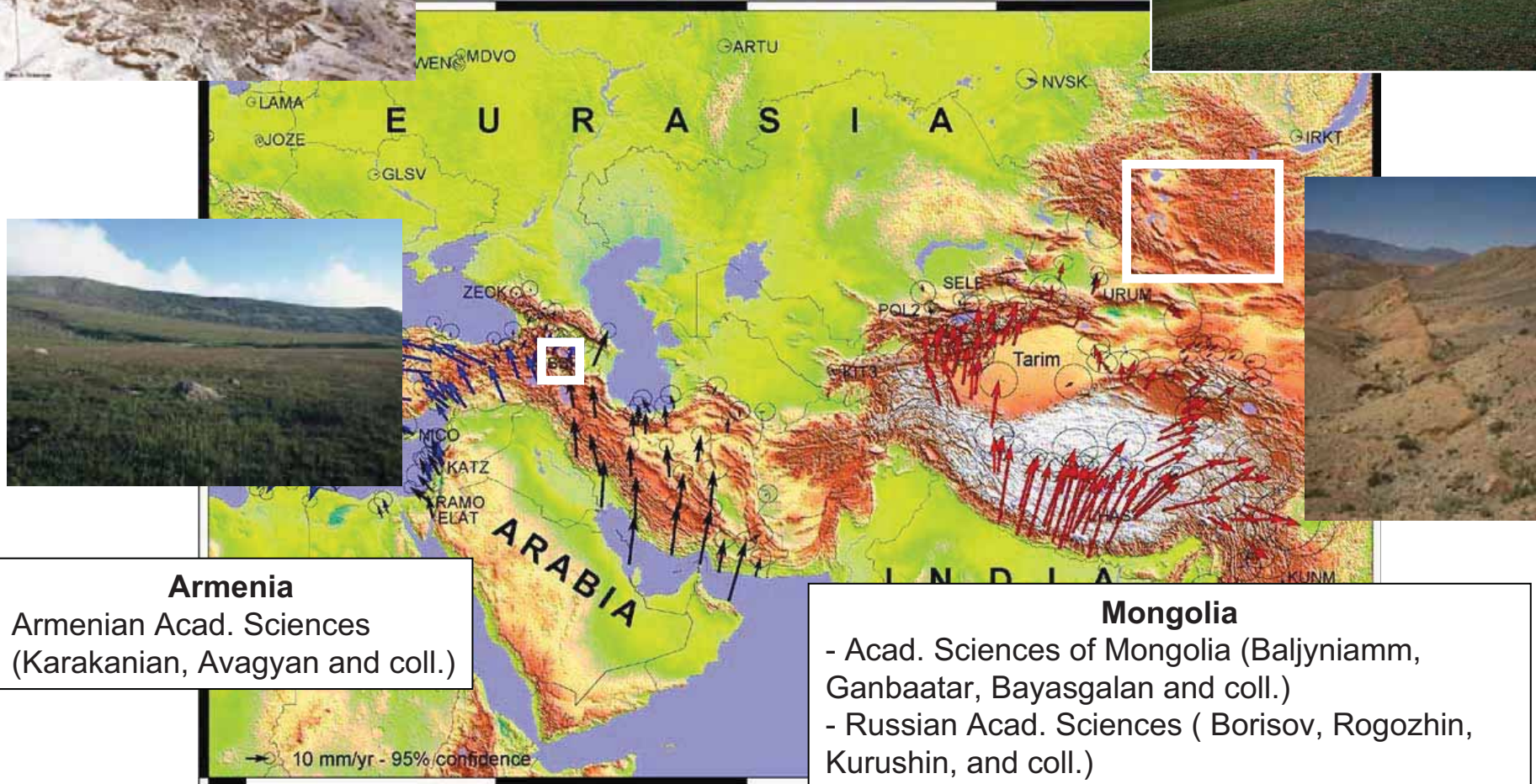


Reconstructing the scenario



The Spitak fault corresponds to a slow-moving intracontinental thrust fault with long recurrence intervals (one earlier event comparable to the Spitak earthquakes during the past 17000 years)

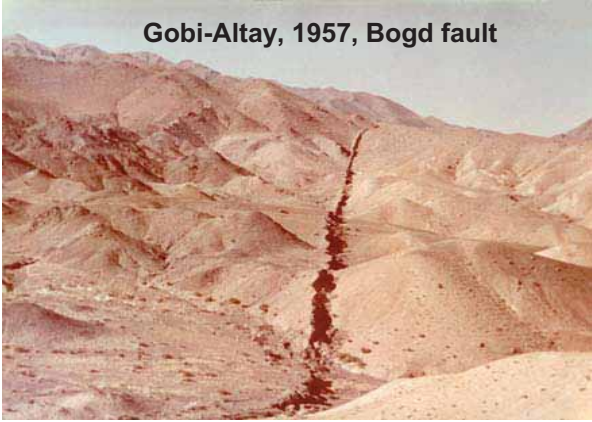
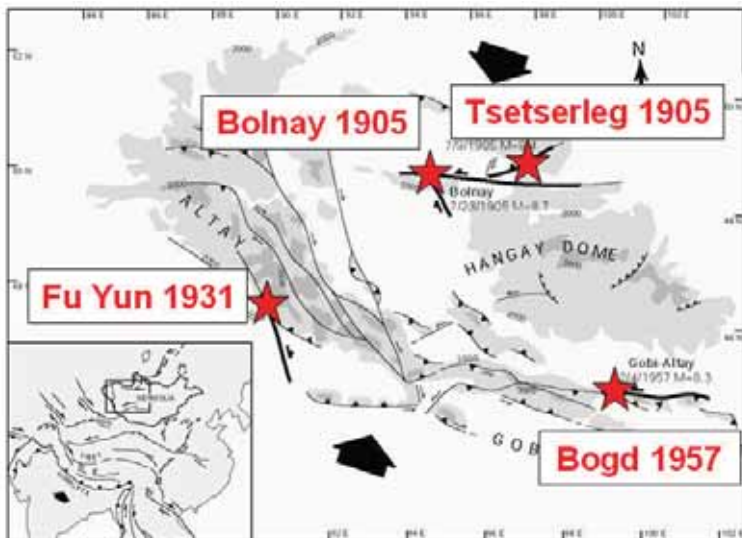
1990's:  
new collaborations



Goal: Characterizing the activity of large intracontinental strike-slip faults capable of generating strong earthquakes ( $M > 7$ ): slip rates and recurrence intervals

# Mongolia

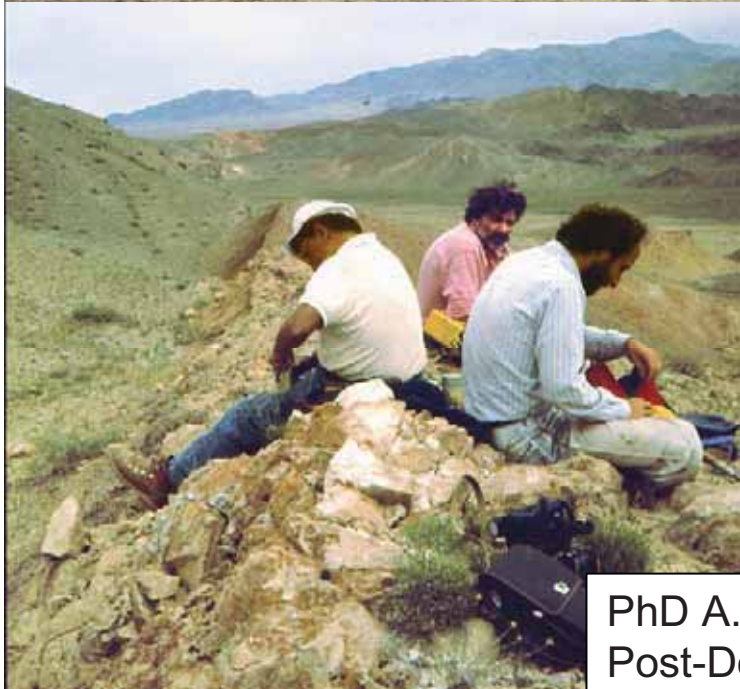
Analysing the ruptures of major historical earthquakes



Florensov & Solonenko, 1963

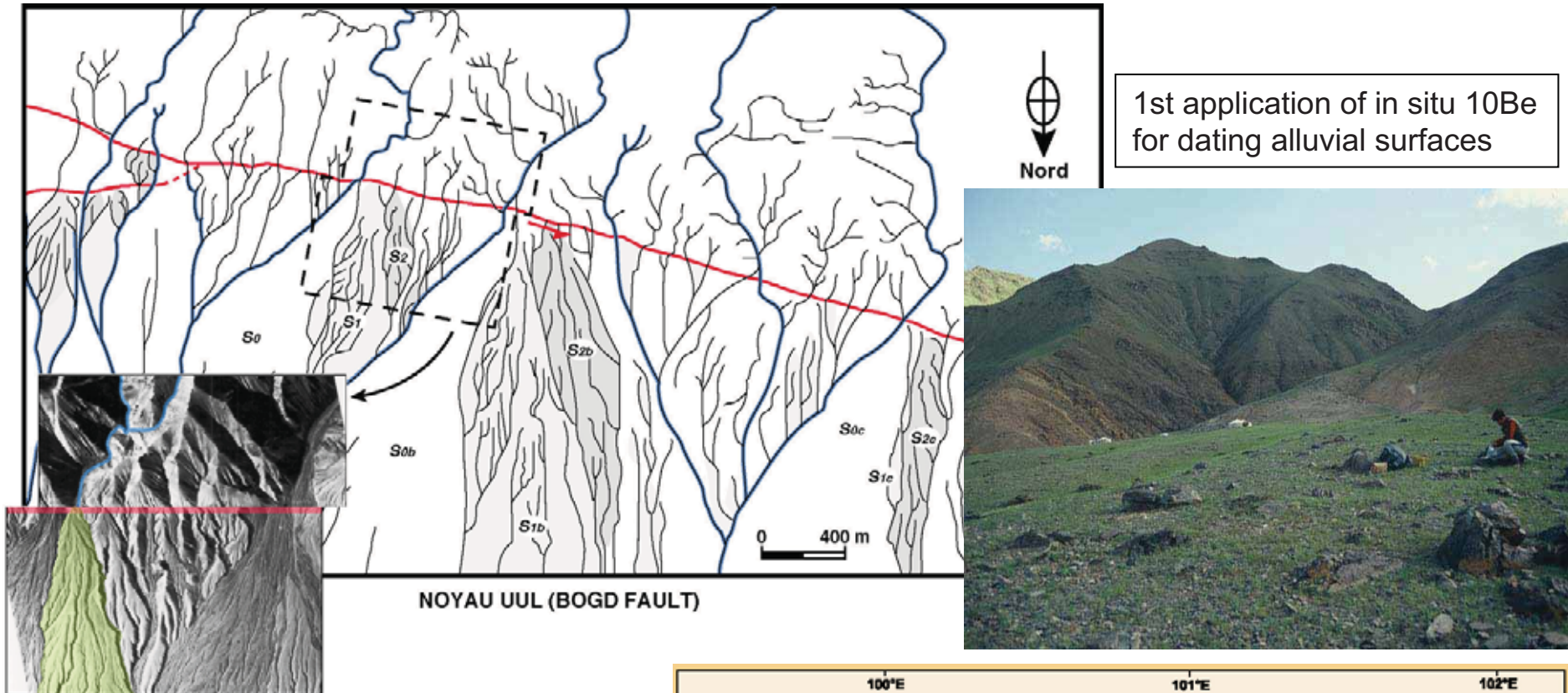


# Seismotectonics of western Mongolia and fault slip rate analyses

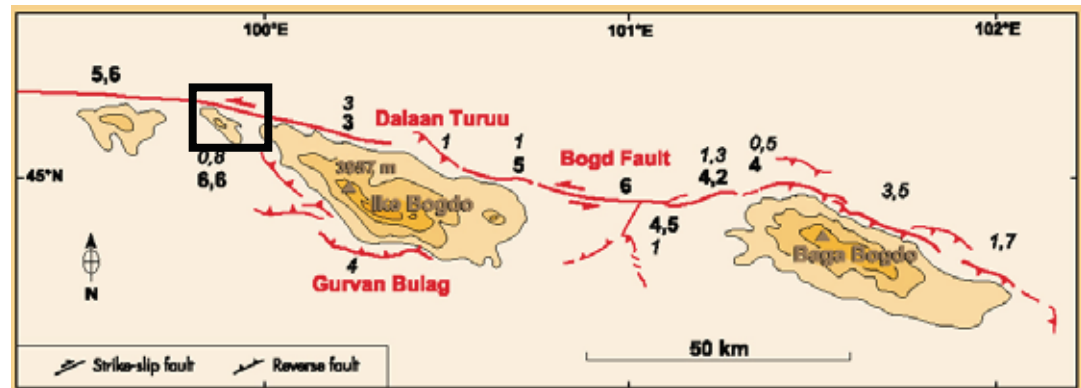


PhD A. Schlupp  
Post-Doc J-F. Ritz

# Slip rate along the Bogd fault, Gobi-Altay



Ritz, Brown, Bourlès, Philip, Schlupp, Raisbeck, Yiou, Enkhtuvshin, *Geology* 1995

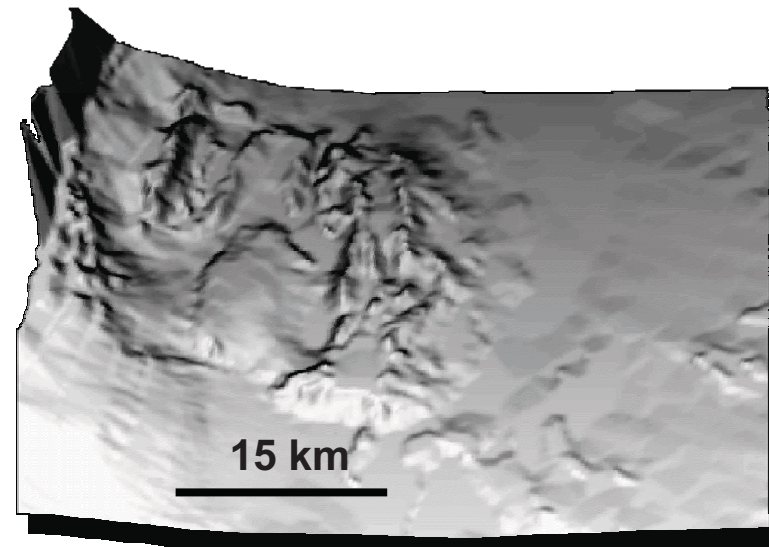
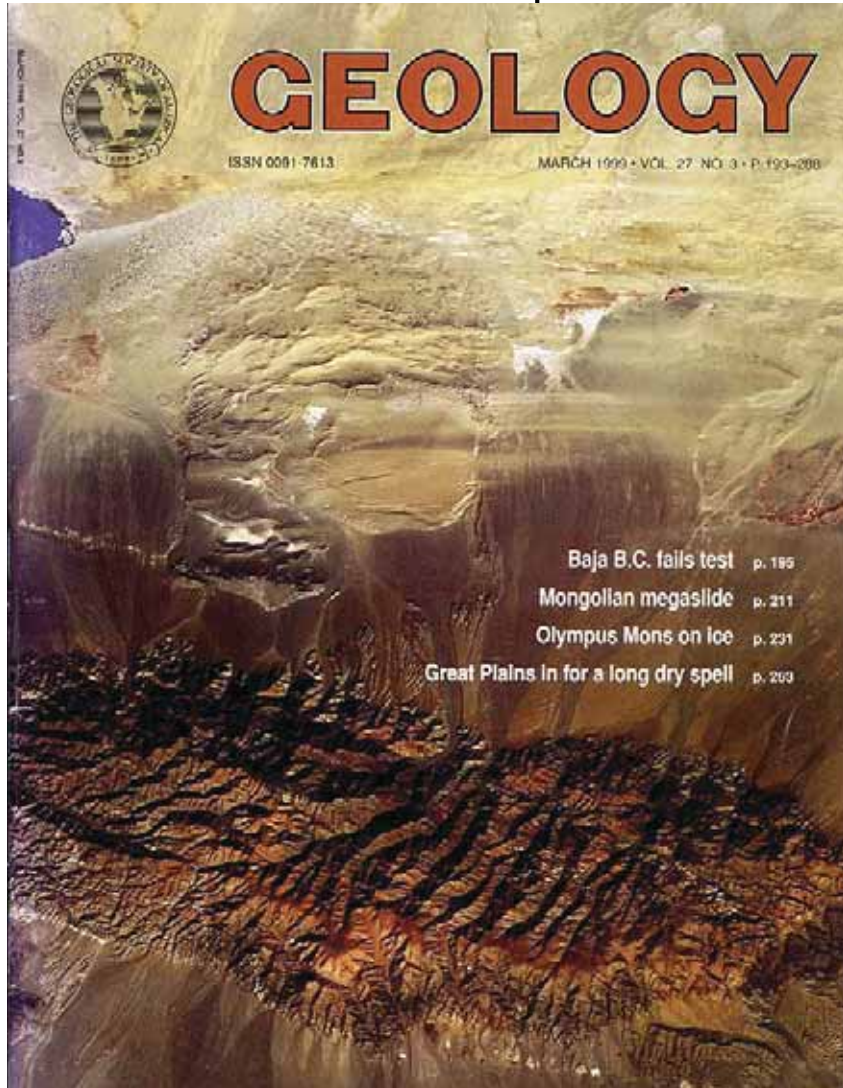
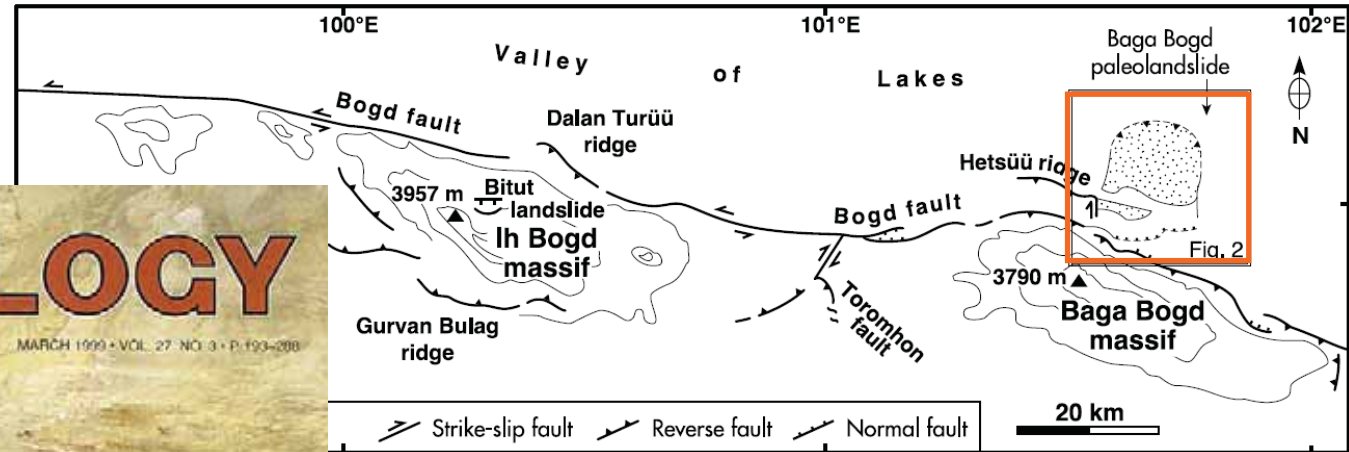


The Bogd fault: a major slow moving intracontinental strike-slip fault (~ 1 mm/yr) capable of producing M8 earthquakes separated by long intervals of quiescence (3000-5000 yrs)

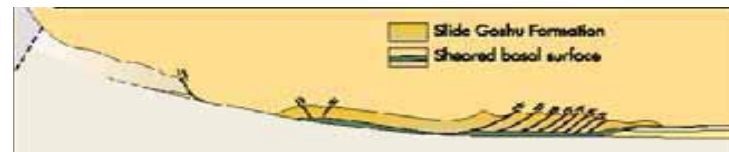
# The Baga Bogd landslide

the largest landslide on continents, probably triggered by an earthquake on the Bogd fault

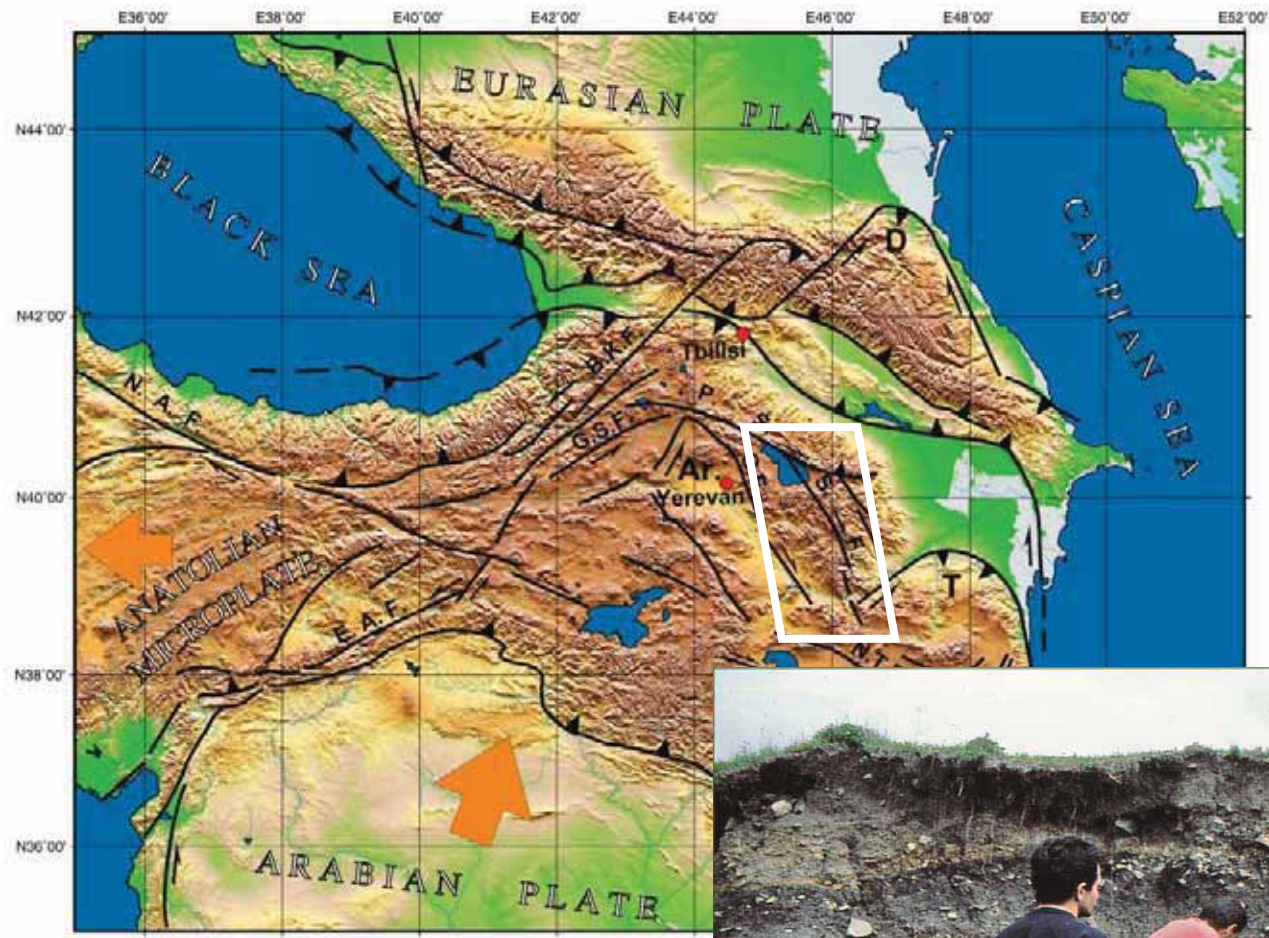
Philip and Ritz, *Geology* 1999



50 km<sup>3</sup> (100 billion tons of material)



# Armenia



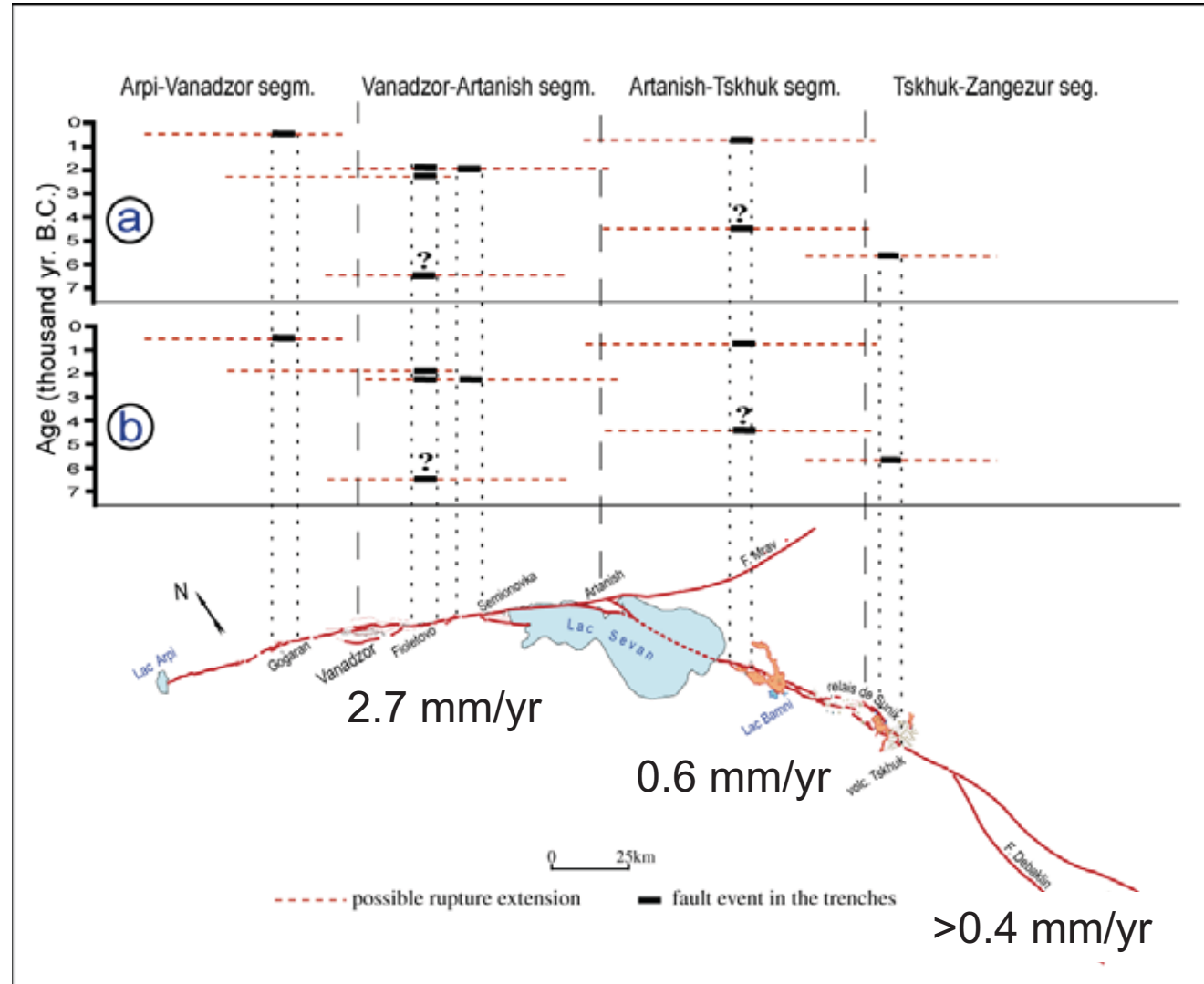
Estimating slip rates and recurrence intervals of earthquakes along the Pambak–Sevan–Sunik fault

PhD A. Avagyan  
Coll. H. Philip, A. Karakhanian  
J-F. Ritz, S. Rebaï.





# The Pambak-Sevan-Sunik Fault, Armenia



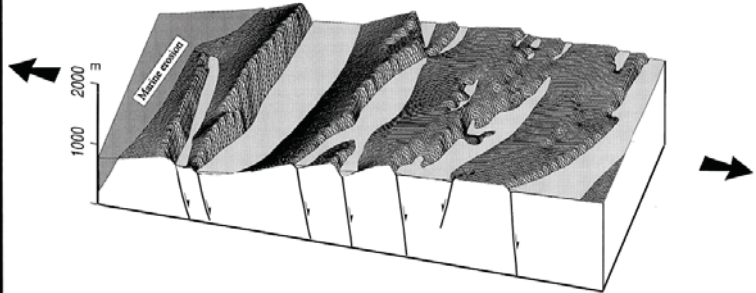
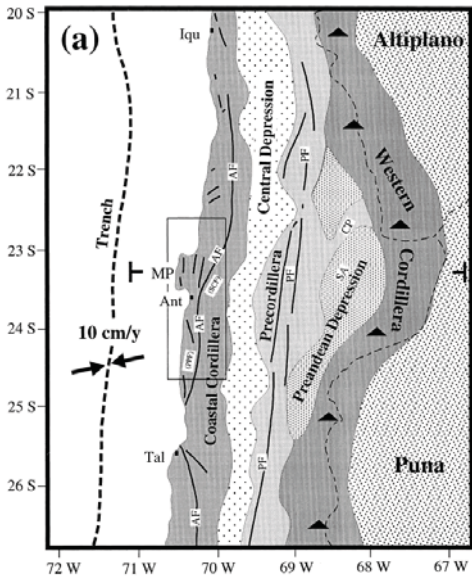
Distribution of the paleoseismicity and horizontal slip rates

Avagyan, PhD thesis 2001

Philip, Avagyan, Karakhanian, Ritz, Rebaï, Tectonophysics 2001

# Chile

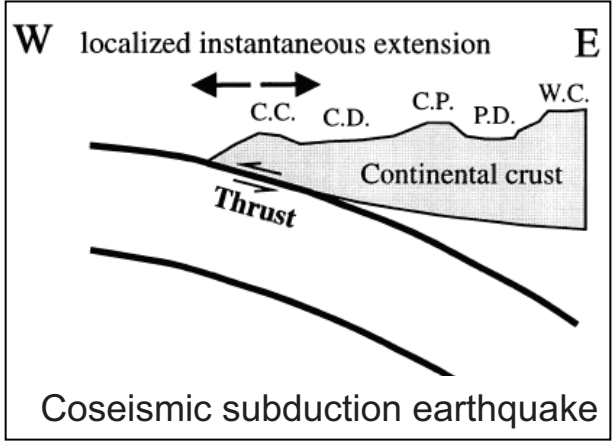
Recent crustal deformation in the Antofagasta region and the subduction process (Northern Chile)



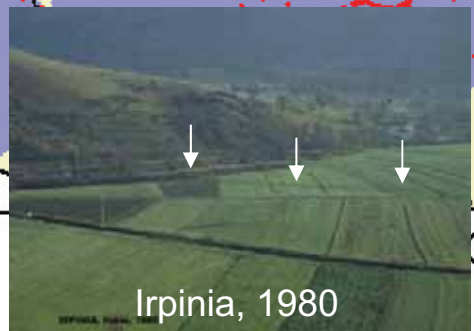
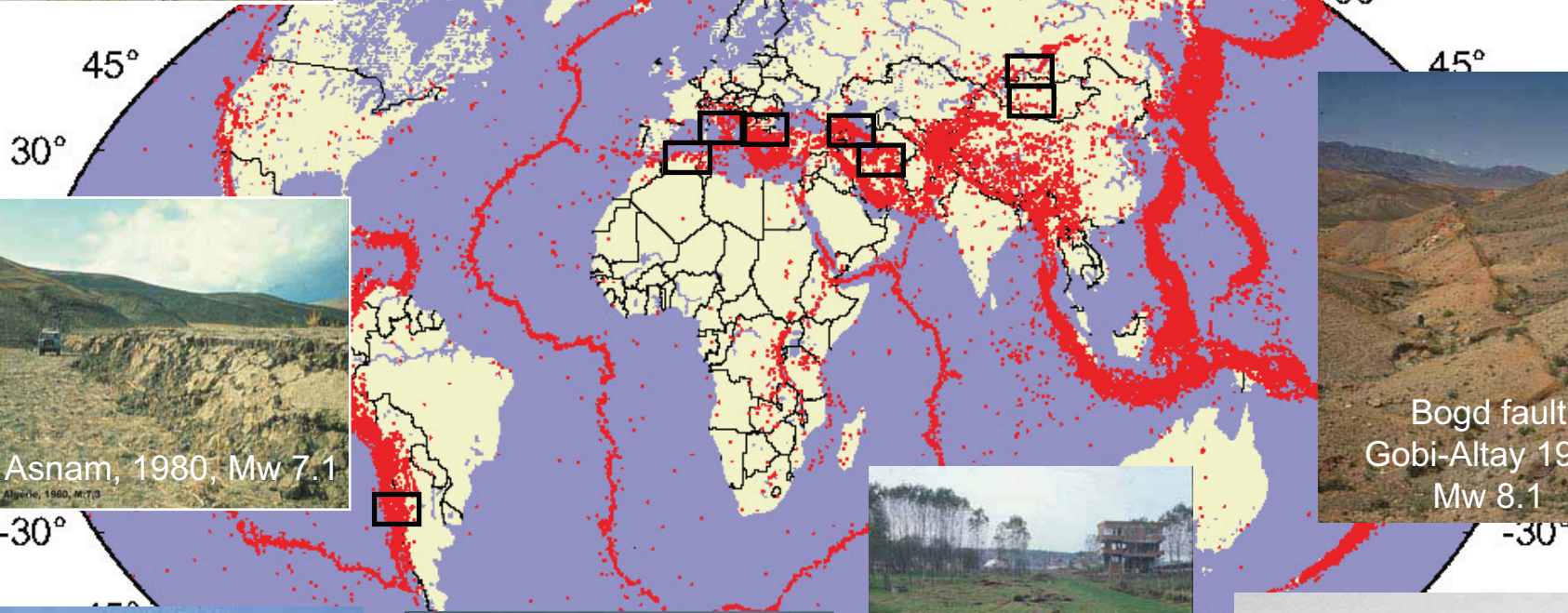
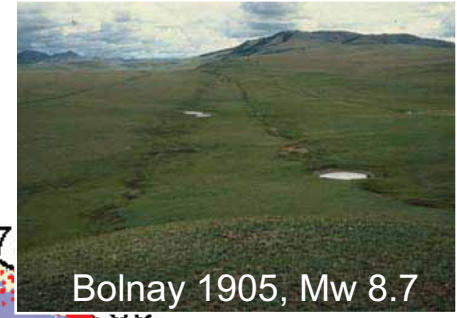
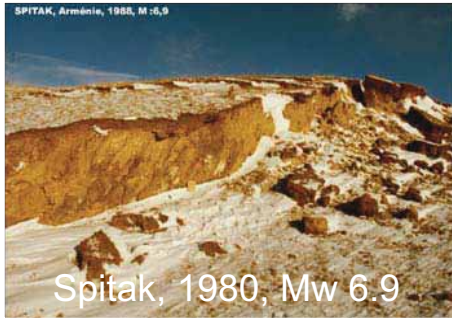
B. Delouis PhD thesis



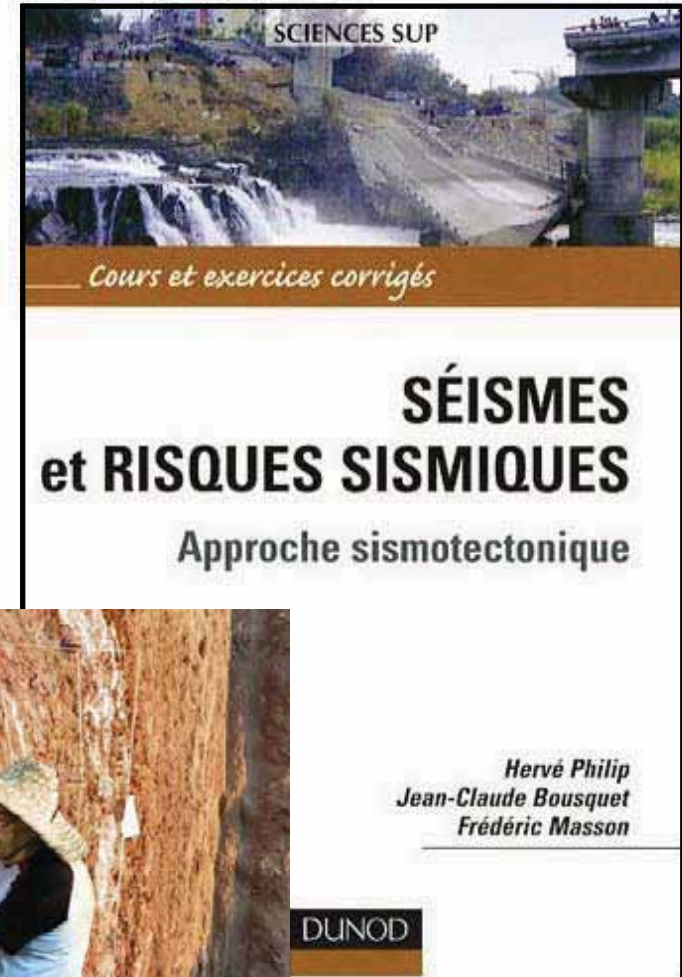
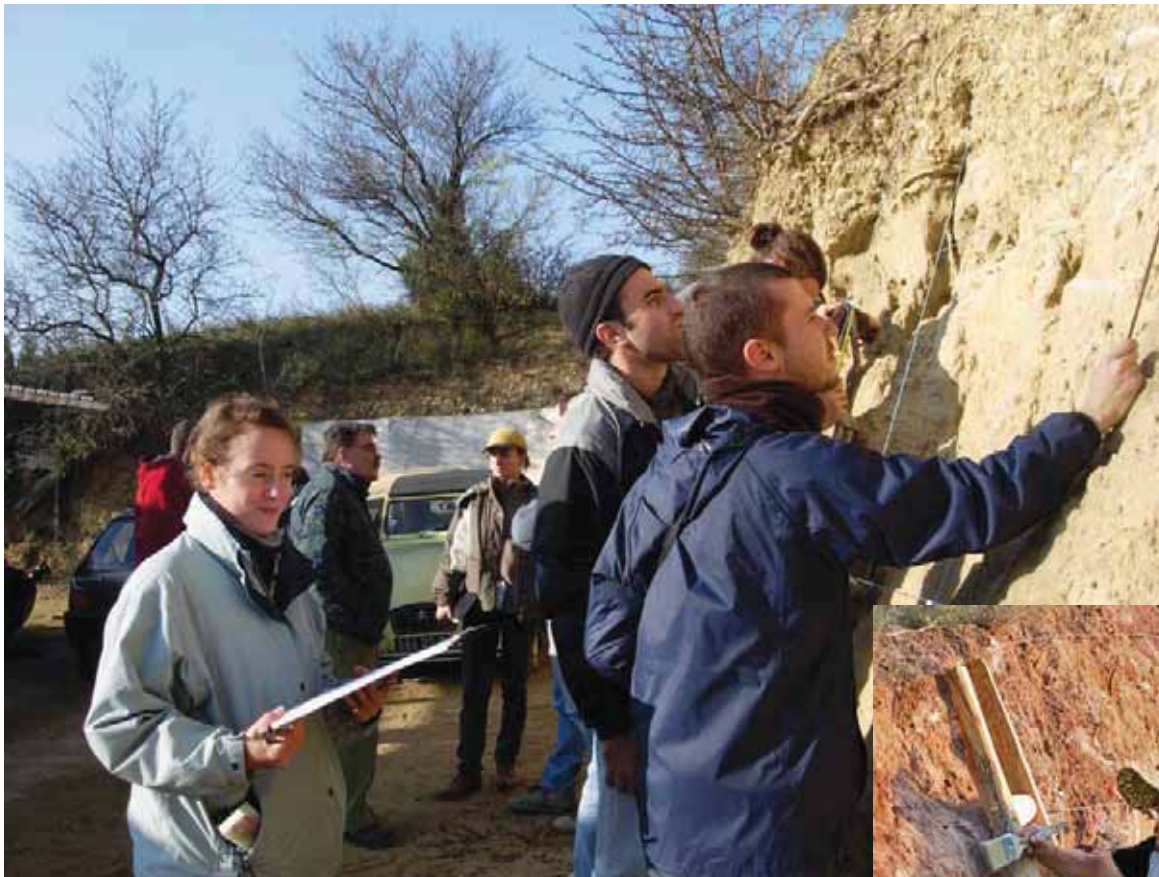
Delouis, Philip, Dorbath, Cisternas, GJI 1998



The Mw 8.0 Antofagasta earthquake (30/07/1995) showed that large subduction earthquakes produce E–W extension in the coastal region.



Hervé Philip and collaborators's studies brought important insights on numerous tectonically active regions where large earthquakes occurred (Algeria, Armenia, Chile, Georgia, Greece, Iran, Mongolia, Turkey..)



First comprehensive text book in French  
in the field of earthquake geology and  
seismic hazard

Philip, Bousquet, Masson 2007





