



CRL School 2018

Corinth Rift Observatory



Patras-Nafpaktos, Greece
21-25 September 2018

Welcome!!!

Dear Participants, welcome to the 2018 edition of the CRL-School!

As you know, the general objective of the School is to unite Master and PhD students from various Greek and foreign universities collaborating in the Corinth Rift Observatory (<http://crlab.eu>), together with high school European teachers to introduce them to different geophysical and geological methods and observations and first-hand scientific knowledge. At the School, methods such as seismology, GPS, SAR interferometry, the methods underlying the ESA-SENTINEL mission, the Geohazards Exploitation Platform (GEP) and paleomagnetism, will be examined from a theoretical point of view as well as from the point of view of their applications and results in the specific area of the Corinth Rift. This rift is one of the most seismically active regions of Europe. It is used here as a natural laboratory where seismic, geodetic and geological data and products are collected and analyzed to enhance the understanding of the area from plate tectonic to local scales. The knowledge acquired there is applicable to other seismically active regions worldwide and, thus, has a general signification.

We foresee that the participants will gain understanding of all these methods and their results and be engaged in discussions about the interpretation of the results and how they can be used in teaching and learning in general Earth Sciences, Chemistry, Physics, Biology and Geology.

As last year, this school will comprise a mixture of topical presentations, excursions in the field and hands-on activities. It will take place partly in Nafpaktos and partly in Patras.

In Nafpaktos, the presentations will be done in the Municipality Building, which has been generously proposed to us by the Mayor and the Council of the city of Nafpaktos. In Patras we will be hosted in several departments of the University.

Highlights will be, among others, the all-day long excursion on the “Milady Mylord”, the oceanographic vessel of the University of Patras, the educational activities for High School, the dissemination to the general public, the presentation of the seismobox, the hand-on ESA software, the field training sessions and the presentation of cores from the sea bottom. There will also be a presentation of the structural monitoring and geometric control of the Rio-Antirrio Bridge.

The session showing posters by the students and teachers will also be another of the highlights of CRL-School 2018!

The Scientific Committee has been one of the actors in preparing this School, but other persons and/or Institutions have contributed to it. We would like to continue to offer

students and teachers the opportunity to the CRL School in future years. Of course, this depends upon us being able to show our sponsors that the School has been useful to students and teachers in their studies and in their daily teaching, or as inspiration for teaching geoscience in new ways in their schools.

After the School we will ask you:

- To complete the evaluation forms (for students and for teachers) as soon as possible and email it back to us,
- To make a presentation of your experiences at the CRL School to a group of your colleagues after your return from Nafpaktos and
- Teachers we invite you to send us reports and photographs about how you have used the CRL School information in your classrooms. We also encourage you to write reports on the School in publications specifically intended for geosciences, science and geography teachers.

For now, please enjoy your CRL-School 2018 in Nafpaktos-Patras! If you do not fully enjoy your time with us, please tell us, this will help us to do better next time. If, as we hope, you do enjoy attending this School, please tell your colleagues at school, fellow students and friends about it and encourage them to come to future editions of the School!

The Scientific Committee
CRL-School

Acknowledgments

The CRL School 2018 has been organized by the Scientific Committee, but also benefitted from the generous help of:

The Centre National de la Recherche Scientifique (CNRS) and the European Geosciences Union (EGU) for financial support,

The University of Patras for logistical support,

Prof. George Papatheodorou for organising the cruise on board the science vessel,

The municipality of Nafpaktos for logistical support for the lectures given in Nafpaktos,

Annita Panteleli for her invaluable help in the organization of the School,

And we thank all the speakers who have contributed to the School and their institutions.

Scientific Committee

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Corinth Rift Laboratory School – 2018

(Patras-Nafpaktos September 21-25, 2018)

Program

Friday September 21, 2018

At the department of Physics, University of Patras

Chairperson: Anna Serpetsidaki

13:30 - 13:45 WELCOME!

Vassilis Anastassopoulos, University of Patras, Greece

13:45 - 14:30 Monitoring the Seismicity

Anne Deschamps, Université Côte d'Azur, GeoAzur & EduMed, Nice, France

14:30 - 15:15 Monitoring the deformation with GPS

Pierre Briole, CNRS / Ecole Normale Supérieure / PSL Research University, Paris, France

15:15 - 15:45 – Break

Chairperson: Georgia Koukiou

15:45 - 16:30 Monitoring the deformations with InSAR

Panagiotis Elias, National Observatory of Athens, Greece

16:30 - 18:00 Hands-on InSAR (ESA software and on-line tools)

Terradue - TBD

Panagiotis Elias, National Observatory of Athens, Greece

Isaak Parcharidis, Harokopio University of Athens, Greece

18:00 Departure to Nafpaktos (Akti Hotel)

Saturday September 22, 2018
Nafpaktia municipality room at the old harbor
This event is open to the public of the City of Nafpaktos

8:30 Departure from Akti Hotel

Chairperson: Christian Beck

09:00 - 09:30 Tectonics, structural setting and tectono-sedimentary processes in the Corinth Rift

Haralambos Kranis, National and Kapodistrian University, Athens, Greece

09:30 - 10:00 Observing and modelling evidences of extensive tectonics in rock fracturation

Jean-Arthur Olive, CNRS / Ecole Normale Supérieure / PSL Research University, Paris, France

10:00 - 11:30 Paleomagnetic studies of rotational deformations in western Greece: at large and small geographic scale.

Catherine Kissel, Laboratoire des Sciences du Climat et de l'Environnement, CEA-CNRS, Gif-sur-Yvette, France

Massimo Mattei, Università Roma Tre, Italy

Carlo Laj, Ecole Normale Supérieure, Paris, France

11:30 - 12:00 - Break

Chairperson: Efthimios Sokos

12:00 - 12:45 Corinth Rift Seismicity and Applications

George Kaviris, National and Kapodistrian University, Athens, Greece

12:45 -13:30 Deterministic seismic risk assessment with the use of stochastic simulation of strong ground motion taking into account site-effects and empirical vulnerability. Case study the city of Aigion.

Ioannis Kassaras, National and Kapodistrian University of Athens, Greece

13:30 - 15:00 – Lunch break

15:00 - 16:30 Hands-on GPS and seismic instruments (two different stands in the meeting room)

16:30 - 17:00 - Break

Chairperson: Pierre Briole

17:00 - 19:30 White scientific session to be organized on Friday 22 with any of the attendees presenting a 3mn question followed by questions and discussions

Sunday September 23, 2018

8:30 **Departure from Akti Hotel**

Two groups

Chairperson: Panagiotis Elias

1st group **Field trip to Psaromita** and visit of several seismic and GPS stations in the field. Performing GPS Measurements, with Panagiotis Elias, National Observatory of Athens, Greece
A short overview of a few rich outcrops near Nafpaktos with Christian Beck, Université de Savoie, France

Chairperson: Catherine Kissel

2nd group **Paleomagnetic sampling at sites near Aegion**
Massimo Mattei, Catherine Kissel, Francesca Cifelli and Carlo Laj

14:00 **Back at Nafpaktos (Akti Hotel)**

Afternoon: Nafpaktia municipality room at the old harbour

Chairperson: Ioannis Kassaras

15:00 - 16:30 **Presentation of the “Seismobox” to the CRL School participants and to the general public.**
Francesca Cifelli, Università Roma Tre, Roma Italy

Chairperson: Francesca Cifelli

16:30 -18:00 **Presentation of the students’ posters** (at the same time coffee break)

Chairperson: Athanassios Ganas

18:00 - 19:30 **Open session:** questions by the students, the school teachers and the public to the scientific team

Monday September 24, 2018

8:30 **Departure from Akti Hotel**

Two groups

Chairpersons: Maria Geraga

1st group (all day) **Cruise on board the science vessel of the University of Patras**
[weather permitting the vessel will come to Nafpaktos to pick the School there, otherwise the participants will have to go by car to the harbour of Patras]

Back at Nafpaktos (Akti Hotel) at 16:30

Chairperson: Massimo Mattei

2nd group (morning) **Presentation of the Seismobox at the Lyceum in Nafpaktos in front of the high-school students and their teachers**
Francesca Cifelli, Università di Roma Tre, Roma Italy

2nd group (afternoon) **Brainstorming on the didactic component to be implemented at CRL for the local and European schools**

End of the afternoon: Nafpaktia municipality, Nafpaktia room at the old harbour

Chairperson: Anne Deschamps

17:30 – 19:30 Debriefing of the matters learned during the cruise. This session will be under the entire responsibility (including the animation) of the students and school teachers who will have to set up a 2-hours session with a rich scientific and technical content and a clear didactic structure.

20:30 **Dinner**

Tuesday September 25, 2018

08:15 **Departure from Akti Hotel**

At the laboratory of seismology of the university of Patras

Chairperson: George Kaviris

09:00 - 09:30 **Presentation of the Seismology Laboratory, University of Patras**
Anna Serpentsidaki, University of Patras, Greece

09:30 – 10:00 **Structural Instrumented Monitoring and Geometric control of the**
Rio-Antirrio bridge
Akis Panagis, GEFYRA, Greece

10:00 – 10:30 **Initial results of IODP 381 drilling in the Gulf of Corinth**
Spyros Sergiou, University of Patras, Greece

11:00 - 11:30 ***Move from Seismology to Geology***

At the department of Geology of the university of Patras

Chairperson: Haralambos Kranis

11:30 - 12:30 **Presentation of marine core in the Geology Laboratory of UPAT**
Maria Geraga, Spyros Sergiou, University of Patras, Greece

12:30 - 13:00 **Introduction to the afternoon field trip at the Helike Fault**
Athanasios Ganas, National Observatory of Athens, Greece

13:00 - 13:45 **Quick lunch at the cafeteria near the dpt of Physics**

13:45 - 14:30 ***Drive to the Helike Fault***

14:30 - 16:30 **An overview of the Helike Fault scarp**
Athanasios Ganas, National Observatory of Athens, Greece

16:30 - 17:00 General remarks by everyone, an open air session in the Diakofto
village

End of the CRL 2018 School

Departures from Aigion to Athens or back to Nafpaktos

Students

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Speakers



Anastassopoulos Vassilis, Professor

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Homepage&subCatExist=true&u=5

EDUCATION

Born in Patras, Greece, in 1958. He received the B.Sc. degree in Physics in 1980 (8.41) and his Ph.D. in Electronics in 1986, both from the University of Patras, Greece. His Ph.D. Thesis was on Digital Signal Processing and Delta Modulation Systems.

CAREER

From 1980 until 1985 he was employed as a Research Assistant in the Electronics Laboratory, University of Patras. Since 1987 he has been a faculty member in Electronics Laboratory, University of Patras, where in 2005 he was elected as a full professor. He worked for two years in Canadian Universities (Toronto 1989-1990, and Quebec City 1994-1995) dealing with Non-linear Filters, Pattern Recognition, Classification Techniques and Signal Detection in Noise.

RESEARCH INTERESTS

His research interests are within the scope of Digital Signal and Image Processing, Radar Signal Detection, Pattern Recognition and Remote Sensing. He has given emphasis on processing Multi-spectral, SAR and Infrared Imagery, in Handwritten Analysis and Biometrics, in Information Fusion including Image Fusion, Decision Fusion and Sensor Fusion Architectures. He has also carried out work on Super-Resolution and Inverse Problems. Lately, he was involved in image processing techniques for Astro-particle Physics. His publication record contains over 110 journal and conference papers with over 1800 citations (<http://scholar.google.gr/citations?user=BYcshrUAAAAJ&hl=en&oi=ao>).

PUBLICATIONS AND SERVICES

1. A book on Sigma-Delta Modulators published by Imperial College Press (Singapore, 2003).
2. V. Tsagaris and V. Anastassopoulos: 'Multispectral image fusion for improved RGB representation based on perceptual attributes', *International Journal on Remote Sensing*, Vol. 26, No. 15, 10 August 2005, pp. 3241-3254.
3. V. Anastassopoulos, 'Fusion and Super-Resolution in Multispectral Data using Neural Networks for Improved RGB Representation', *The Imaging Science Journal*, Vol. 53, No. 2, June 2005.

Welcome to the CRL School 2018

Vassilis Anastassopoulos

Department of Physics, University of Patras, Greece

This CRL School 2018 is the third edition of the CRL School. This School was created in 2016 as an educational component of the Corinth Rift Observatory (<http://crlab.eu>). This first edition in 2016 allowed us to test and validate the concept of the School, which duration was 5 days already. During the second edition of 2017 five school teachers (from Italy, Portugal, France and Greece) were invited and a strong link established with the GIFT programme of the EGU, the CRL School offering a sort of GIFT in the field with hands-on many sensors and techniques in a real situation. The main objective of the CRL School is however to gather master and early PhD students from the various universities collaborating in the Corinth Rift Observatory. This Observatory, the most advanced Near Fault Observatory in Europe, is a superb and very important place to observe, measure and model the evolution of hazardous seismic faults and therefore gain theoretical and practical knowledge about the genesis of earthquakes. The city of Patras and its surroundings is exposed to large earthquakes and related hazards (e.g. tsunami and landslides) and the CRL School is an important event for both the scientific community and the inhabitants of the area.



Anne Deschamps

Directeur de recherche émérite

Université Côte d'Azur

Géoazur, EduMed

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Education:

Studies in France.

University studies at ENS

Agregation of Physics Sciences, Thesis in Seismology at the University of Paris.

Career

After three years as Assistant Professor at ENS, I joined the CNRS (Centre National pour la Recherche Scientifique) as research scientist in seismology. From 1979 to 1992, I was affected at IPGP (Institut de Physique du Globe de Paris). In 1992, I moved to Géoazur (CNRS/University of Nice Sophia Antipolis) where I was in charge of the regional seismic network in Provence Alpes Côte D'Azur region and developed the broad band seismological observation on land and more recently on sea floor in the frame of ESONET and EMSO programs.

Research Interests: Working on seismic sources studies, I have participated to the characterisation of the Mediterranean large seismic events (in Algeria, Italy and Greece). I contributed to seismological studies in different countries (Colombia, Mongolia, Tanzania, Haiti, Ecuador...) to understand of relation between faults, large earthquakes and seismic crisis. Since late 1980's I am strongly involved in different projects in Greece on large earthquake, seismicity, seismogenesis and tectonics and since 2000 I contribute to the development of the Corinth Rift Laboratory recently integrated in EPOS as an European Near Fault Observatory.

More recently, I turned also my interest towards effects of strong ground motions produced by earthquakes: characterisation, site effects, site/structure interaction.

Since 15 years I am following "Sismo à l'Ecole", an initiative to bring seismology at schools and more recently EduMed (<http://edumed.unice.fr/fr>), a program to provide to teachers and undergraduate students with easy access to controlled data sets on meteorology, hydrology, oceanography and seismology across Mediterranean area for teaching applications.

I have published over 180 articles in international scientific journals.

I supervised 10 PhD students in seismology and different Masters of Science, mostly at the Université Côte d'Azur

Seismic network of Corinth Rift Laboratory and micro-seismicity in the last 20 years

Anne Deschamps,
Géoazur, Université Côte d'azur, CNRS

The Western part of Corinth Gulf which can be considered as the Western end of the North Anatolian fault, presents a high level of micro-seismicity which varies in time. The CRL seismological network starts in 2000/2001, with installation of a local network around Aigio to follow the seismicity on Aigio fault. Due to the important seismicity and a better understanding of the fault system, the network increase progressively towards West, including a participation of different institutions. The present state of the network was reached in 2013 and allows to addressing some scientific questions on the deformation of the crust in the area and the potential for large earthquakes:

- Distribution of main faults, migration of the deformation towards off shore faults.
- Near fault damaging in the upper crust.
- Clustering of micro earthquakes: what are the dimensions of the related fault segments? How they are connected with the faults on which have been observed the last main events?
- How explain de deformation budget? What is the part controlled by the seismicity?
- Role of fluids in the micro-seismicity, are these upper crust faults connected and large earthquakes.
- Can we observed creeping on low dipping normal fault...

To address these questions, CRL has developed a multidisciplinary set of observations. GNSS and deformation instruments have been very soon added, but also works on fault mapping, satellite images processing ...

I will present the present state of the network, with some examples of the instrumentation and a discussion on the interest and the limitations of some specific points.

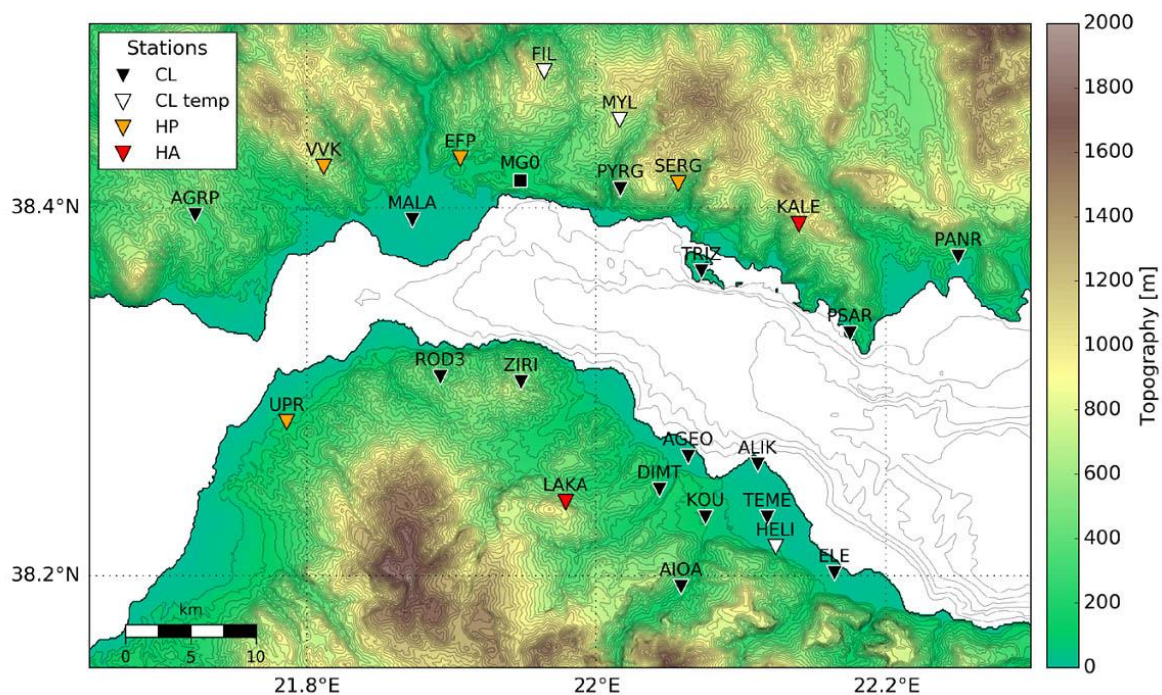


Figure 1: The main CRL seismic network (present state). Some stations on the border are also includes in CRL.

In the second part, I will present the knowledge on the background micro-seismicity from 2001 to 2015 and discuss the importance to develop methods to increase the resolution of the individual location of epicentres.

I will present in some details the relocation procedure (theory and data processing) with some examples on available data.

Obtained images for 15 years of seismicity (maps and cross sections) will be analysed in relation with known faults (faults mapped at the surface, and fault plane of 1995 event at depth).

Then, I will present the knowledge on the background micro-seismicity from 2001 to 2015 and discuss the importance to develop methods to increase the resolution of the individual location of epicentres. The relocation procedure [theory and data processing the obtained images (maps and cross sections)] will be analysed in relation with known faults (faults mapped at the surface, and fault plane of 1995 event at depth).

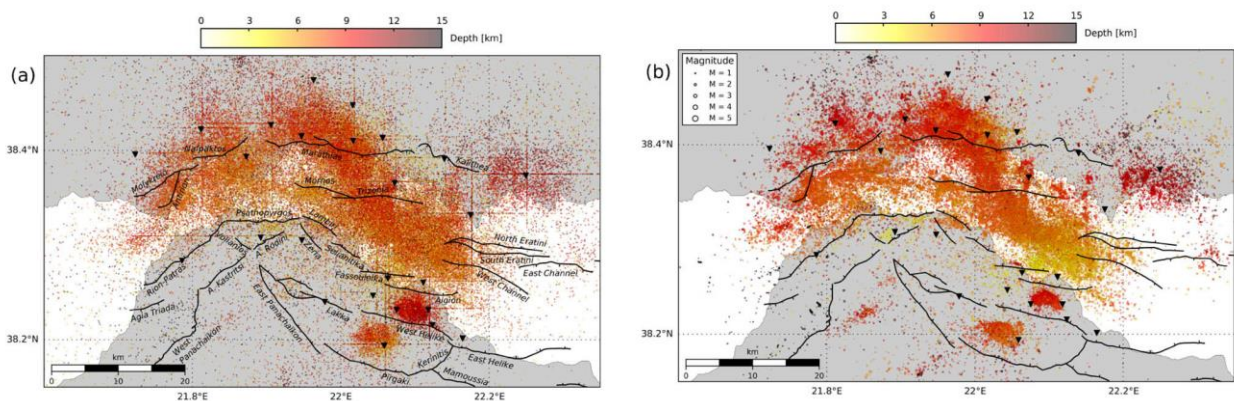


Figure 2: 15 years of micro-seismicity a) P and S automatic picking (205 000 events), b) after relocation procedure (95 000 events).

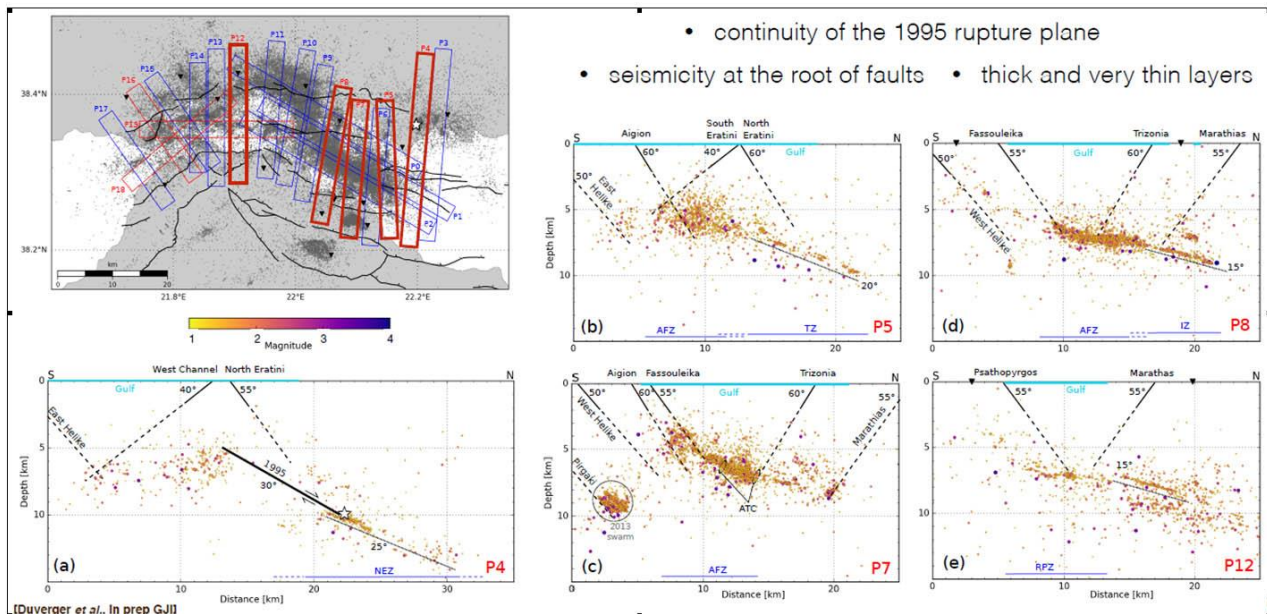


Figure 3: Selected cross sections on the micro-seismicity to discuss the relation with faults observed on the surface.

The last part of my presentation will be dedicated to the study of some swarms which have been studied in detail and I will show how fluids can be invoked to explain the time/spatial history of an

almost permanent swarm in the middle of the Gulf, when such behaviour is not seen in the 2013 swarm South of Aigion.

Main bibliography:

- Duverger, C., Godano, M., Bernard, P., Lyon-Caen, H., & Lambotte, S., 2015. The 2003/2004 seismic swarm in the western Corinth Rift: Evidence for a multiscale pore pressure diffusion process along a permeable fault system, *Geophysical Research Letters*, 42(18), 7374–7382.
- Duverger C., S. Lambotte, P. Bernard, H. Lyon-Caen, A. Deschamps, A. Nercessian, 2018. Dynamics of microseismicity and its relationship with the active structures in the western Corinth rift (Greece), accepted to *Geophysical Journal International*, 2018
- Godano, M., Deschamps, A., Lambotte, S., Lyon-Caen, H., Bernard, P., & Pacchiani, F., 2014. Focal mechanisms of earthquake multiplets in the western part of the Corinth Rift (Greece): influence of the velocity model and constraints on the geometry of the active faults, *Geophysical Journal International*, 197(3), 1660–1680.
- Kapetanidis, V., Deschamps, A., Papadimitriou, P., Matrullo, E., Karakostas, A., Bozionelos, G., Kaviris, G., Serpetsidaki, A., Lyon-Caen, H., Voulgaris, N., et al., 2015. The 2013 earthquake swarm in Helike, Greece: seismic activity at the root of old normal faults, *Geophysical Journal International*, 202(3), 2044–2073.
- Lambotte, S., Lyon-Caen, H., Bernard, P., Deschamps, A., Patau, G., Nercessian, A., Pacchiani, F., Bourouis, S., Drilleau, M., & Adamova, P., 2014. Reassessment of the rifting process in the western Corinth Rift from relocated seismicity, *Geophysical Journal International*, 197(3), 1822–1844.



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EDUCATION

Ecole Normale Supérieure de Cachan

- Applied Physics
- PhD, University Paris VI, Paris 1990
- Agrégation 1983

CAREER

2007-today	Research Director CNRS Ecole Normale Supérieure/Paris Sciences et Lettres Research University - Département des Géosciences - Laboratoire de Géologie 09/2008-2009: Directeur des études, 2010-2013: Head of the Department
2004-2007	Research Director CNRS Institut de Physique du Globe de Paris 2005-2006 Director of the laboratory of Geodesy
1990-2004	Chargé de Recherche CNRS Institut de Physique du Globe de Paris - Département de Sismologie
1989-1990	Researcher Institut Géographique National – Laboratoire d’Opto-Electronique et de Micro-informatique

RESEARCH INTERESTS

Study of the deformation of volcanoes (Etna, Campi Flegrei, Vulcano (Italy), Piton de la Fournaise (France), Nisyros (Greece), Sakurajima (Japan)) and seismic zones (Asal Rift (Djibouti), Gulf of Corinth (Greece), Northern Chile, Umbria (Italy), Algeria, Bulgaria) using various methods, including GPS, radar interferometry, high resolution imaging and local methods (tiltmeter, micro-gravity, ...). Modelling of ground deformations and interpretation combining tectonic, geodetic, and seismological data. Development of new technologies (Projects of satellites, ground based radars, robots).

PUBLICATIONS AND SERVICES

73 articles in journals with peer review, 2951 citations
194 communications in international meetings
3 articles in outreach journals, participation to 4 educational &/or educative movies, several interviews in French radios, several lectures in schools

Coordinator of the “Insegnaci Etna” project <http://ietna.eu>

Monitoring the deformation with GPS

Pierre Briole

CNRS / Ecole Normale Supérieure / PSL Research University

Since 1990 the deformation of the western rift of Corinth is monitored using the Global Positioning System (GPS) technique. In the first decade the observations were made during campaigns and since 2001 a permanent network has been gradually installed in the area. This network is nowadays composed of ~30 stations. The campaign network was also gradually developed and it gathers now more than 200 points. The western rift of Corinth is the fastest extending area in Europe and one of the fastest in the world. In my presentation, I will show the main results obtained in the last three decades and I will explain the basics of the GPS observation technique. This lecture will also prepare the hand-on GPS instruments presented on Saturday and the GPS observations in the field presented on Sunday.



Panagiotis Elias

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EDUCATION

- 2013** PhD in the framework of co-tutelle agreement between the École Normale Supérieure (Département des Géosciences, France) and the University of Patras (Department of Physics, Greece), with title “Ground deformation observed in the western Corinth rift (Greece) by means of SAR interferometry”.
- 2007** MSc in Signal Processing for Telecommunications and Multimedia of the department of Informatics and Telecommunications of the University of Athens, Greece.
- 2003** Degree of Electronics Engineering of the Technological Educational Institute of Piraeus.

CAREER

2005-today Scientific staff of IAASARS/NOA.

1998-2005 Research assistant of Institute for Space Applications and Remote Sensing (later IAASARS) of NOA.

RESEARCH INTERESTS

I have participated in more than 40 research projects in the field of satellite geodesy and image/signal processing exploiting the synergy of active and passive earth observations satellites as well as GNSS and other in-situ measurements such as inclinometers, levelling and seismological data. My research interest is focused in the detection and measurement of ground deformation and infrastructure instability due to geophysical processes of man made activities. Moreover I am contributing to the development of methodologies and to the modelling of the deformation sources considering the particular underlying geodynamic and geophysical background.. I am author of 17 peer refereed publications in international journals, 5 peer refereed proceedings of SPIE and 58 presentations in international conferences.

PUBLICATIONS AND SERVICES

Elias P. and Briole P., 2018. Ground deformations in the Corinth rift, Greece, investigated through the means of SAR multi-temporal interferometry. *Geochemistry, Geophysics, Geosystems*, in press.

Ganas A., Elias P., Bozionelos G., Papathanassiou G., Avallone A., Papastergios A., Valkaniotis S., Parcharidis I and Briole P, 2016. Coseismic deformation, geo-environmental effects and seismic fault of the 17 November 2015 M=6.5, Lefkada Island, Greece earthquake. *Tectonophysics*, Vol. 687, 26 September 2016, pp 210–222.

Co-responsible for the operation of 22 GNSS stations of the CRO network

AWARDS AND HONORS

- Member of the *ESA Living Planet Symposium Scientific Committee* for the years 2010 and 2013
- Member of the executive secretary of the Remote Sensing and Space Applications Committee of the Geological Society of Greece

Monitoring the deformations with InSAR

Panagiotis Elias

National Observatory, Athens, Greece

How can we measure a seismic fault buried many kilometers under the ground from 600km away? How can we map a displacement of a few mm or cm from such distances? The technological advancements of the recent decades in the remote sensing permitted the sensing and measuring of the deformation of the earth crust due to earthquakes, aseismic tectonic processes, volcanoes and landslides but also to manmade activities. How can we link the deformation of the surface to the fault in depth through modelling? The basics of the satellite Synthetic Aperture Radar (SAR) characteristics and properties of its provided data as well as the basics for differential and multi-temporal interferometry methodologies will be presented. Links with the presentation of GNSS will be shown. We will focus on the case of the Corinth Rift Observatory area and present our findings so far.

The Corinth Rift is one of the narrowest and fastest extending continental regions worldwide and has one of the highest seismicity rates in the Euro-Mediterranean region. At its western termination, several active faults are located beneath the city of Patras and the surrounding area, a region of major socio-economic importance to Greece.

Apart from moderate earthquakes striking often, additional non sudden geological phenomena, such as slow and continuous ground displacements, are occurring. Both are being provoked by the movement of the tectonic plates. In many cases slow displacements are part of the seismic cycle occurring before an earthquake.

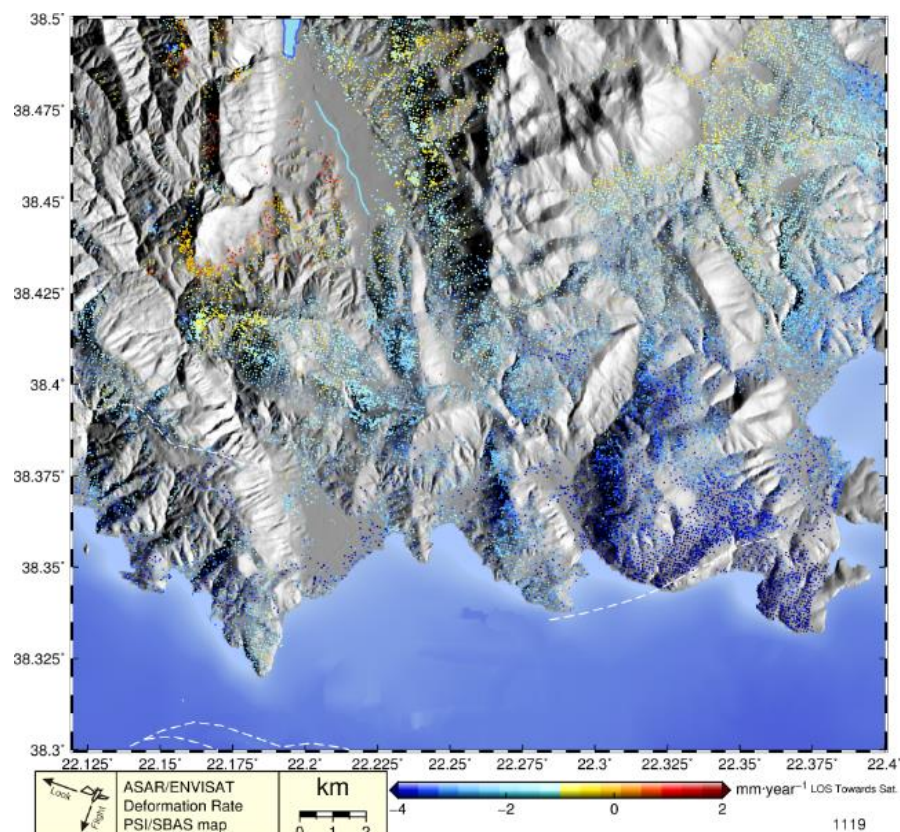


Figure 4: Velocity map produced from ASAR/ENVISAT Multitemporal interferograms of Psaromita and Galaxidi area in the North Gulf of Corinth. The coast of Central Greece is moving away from the coast of North Peloponnesus with a maximum velocity of about 1.5 cm per year.

Displacement rates for the period of 2002-2010 obtained from ascending and descending ASAR/ENVISAT multi-temporal interferometry are combined with Global Positioning System measurements from permanent and campaign stations to produce a map of vertical and east-west ground velocities.

In the city of Patras and through the gulf of Patras, the northern continuation of the 2008 Movri earthquake fault is connected to the oblique, creeping aseismically, transform zone of Rio. Further east, our observations suggest that the Aigion fault is creeping at shallow depths. To the west the Aitoliko-Stamna-Katouna fault zone is creeping in strike direction. The contribution of the SAR interferometry to the study of the recent earthquakes of Aigion (1995), Movri (2008), Efpalio (2010), Lefkada (2003 and 2015) and Cephalonia (2014) will be demonstrated.

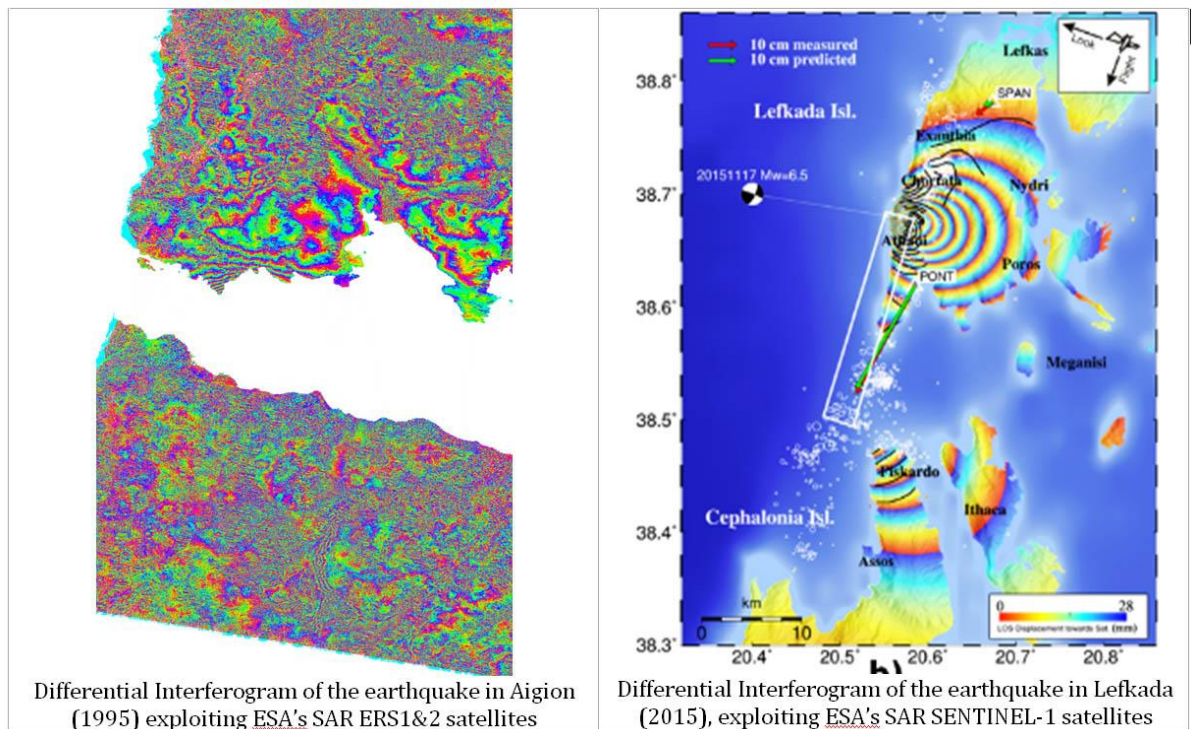


Figure 5: Example of interferograms

Additionally, in Mornos Delta, Patras and all the Deltas, subsidences of no tectonic origin were detected. All these slow phenomena constitute natural hazard affecting the socio-economical activity of the region and in some cases threatening the public safety.

Hands-on InSAR (ESA software and on-line tools)

Panagiotis Elias

National Observatory, Athens, Greece

We will present basic information on the SNAP software of ESA and the GEP-TEP on-line InSAR tool. The work will be done in a computer room with 2 or 3 students per computer.



Haralambos Kranis

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Secretary General, Geological Society of Greece

Education:

Degree in Geology (NKUA), Post-graduate Diploma, in Seismology, (International Institute for Seismology and Earthquake Engineering), Ph.D. in Geological Sciences, (NKUA)

Career

My scientific career mainly involves working for the Department of Geology and Geoenvironment, at the Sector of Dynamic, Tectonic and Applied Geology, while I have also served as Tectonics and Structural Geology expert for the General Secretariat for Civil Protection, collaborated with the Earthquake Research and Planning Organization (EPPO), and the Hellenic Centre for Marine Research (HCMR); and as a consultant for major infrastructure projects, such as gas and oil pipelines, and management of natural hazards.

Research Interests:

My main research interests include, but are not limited to, Tectonics and Structural Geology (especially brittle deformation), Neotectonics, Active Tectonics and Earthquake Geology, Tectonic Geomorphology and Palaeoseismology. In the last decade, I am involved in research on the tectonic control on sedimentation and basin formation in actively evolving continental rifts and their inactive analogues. Extending my scope in field geology and geological mapping, I have adopted methods and techniques that involve spatial analysis of geological structures through Structure from Motion (SfM), 3D outcrop modelling of outcrops, digital field mapping and modelling of tectonically-controlled landscapes.

Publications and Services

I have published over 40 articles in peer-reviewed scientific journals, several field guides and special reports, as well as geological and neotectonic maps at various scales.

Awards and Honors:

Scholarship from the Government of Japan (Japan International Cooperation Agency)
Goldschmidt Lecturer, Geological Survey of Norway

Tectonics, structural setting and tectono-sedimentary processes in the Corinth rift

Haralambos Kranis

Department Geology and Geoenvironment, National and Kapodistrian University of Athens,
Greece; hkranis@geol.uoa.gr

The Gulf of Corinth (GoC) Rift, is one of the most active continental rifts worldwide, which develops within the broader plate convergence context of the Hellenic Arc. Extension and strain localization within the overriding Aegean Plate has led to the formation of this rapidly extending domain. The available data so far point to its inception at ca (?)5 Ma most probably linked to two interrelated processes, namely (i) the onset of the pronounced curvature of the Hellenic Arc; (ii) the propagation of the North Anatolian Fault into the Aegean domain.

The GoC rift has developed in two phases, namely the Rift 1 phase, from 5.0-3.6 to 2.2-1.8 Ma and Rift 2, from 2.2-1.8 Ma to present. Rift 1 is recorded in a >3 km thick syn-rift succession, (Lake Corinth) which shows upward deepening from fluvial to lake-margin conditions and finally to sub-lacustrine, deposited in a 30 km-wide zone of distributed normal faulting. Rift 2 marks a 39 km northward shift in the locus of rifting, accompanied by footwall and regional uplift, which destroyed Lake Corinth in the central and eastern parts of the rift, while giant Gilbert deltas in the west built into a deepening lake depocenter in the hanging-wall of the newly developing border fault system. Self-organization and strain localization along co-linear border faults are considered to be responsible for the growth, linkage and death of normal faults during these two rifting phases. The major Patras dextral strike-slip fault controls the interaction between the GoC and the Patras rifts; this led to the opening of the Rio Straits at c. 400-600 ka.

The overall landscape and stratigraphic evolution of the rift was strongly influenced by factors related to structure of the Hellenide fold and thrust basement, which controlled regional palaeotopographic variations and local antecedent drainage, the latter especially visible at the southern shoulder of the rift. Along-strike, regional topography north and south of the rift is relatively high in the west, compared to the east; this exerted a first-order control on the depositional environments during rifting. The majority of sediment to the CoC rift has been supplied by north-flowing antecedent catchments on the southern flank. However, the contribution of S-flowing catchments appears to be increasing over time.

On a crustal scale, the extensional thinning of the Hellenide nappe stack, which is observed in the Peloponnesus, is overprinted by the high-angle normal faulting that controls the GoC rift inception and evolution. The interplay between these two processes is another major factor and geochronological and structural data are sought to further constrain rift evolution.



Jean Arthur Olive

Research Scientist

CNRS / Ecole Normale Supérieure

PSL Research University

24 Rue Lhomond, 75231 Paris CEDEX 5

EDUCATION

B.S. Earth Science, Ecole Normale Supérieure (2007).

M.S. Geophysics, Ecole Normale Supérieure / Institut de Physique du Globe de Paris (2009).

PhD. Marine Geophysics, Massachusetts Institute of Technology / Woods Hole Oceanographic Institution Joint Program in Oceanography (2015).

CAREER

Research Assistant: Massachusetts Institute of Technology / Woods Hole Oceanographic Institution (2009–2014).

Postdoctoral Scientist: Lamont-Doherty Earth Observatory / Columbia University (2015–2017).

Research Scientist: CNRS / Ecole Normale Supérieure (Since 2018).

RESEARCH INTERESTS

Geodynamics of the lithosphere. Thermo-mechanical modeling of plate boundary evolution. Feedbacks between deformation and fluid Earth processes. Mechanics of extensional faults.

Ongoing projects:

- Feedbacks between extensional tectonics and surface processes.
- Detachment fault evolution at slow and ultraslow-spreading mid-ocean ridges.
- Mechanisms of distributed brittle deformation in the upper crust.

PUBLICATIONS AND SERVICES

~20 publications in international journals.

Software development and distribution: SiStER (Simple Stokes solver with Exotic Rheologies), a 2-D code for long-term tectonic modeling; eiSPLIT, a package for shear-wave splitting analysis.

Advisor: 3 undergraduate students, 1 master's student (co-advised).

Co-chair: InterRidge Working Group on Hydrothermal Research (IMOVE).

AWARDS AND HONORS

Lamont-Doherty Earth Observatory Postdoctoral Scholarship (2015).

CSDMS Student Modeler Award (2014).

AGU Outstanding Student Presentation Award (2011, 2014).

How to build a half-graben

Jean-Arthur Olive
Ecole Normale Supérieure / CNRS

The Eastern Gulf of Corinth is a prime example of half-graben: a structure in which extensional strain is primarily taken up by a master normal fault, inducing flexure of the adjacent blocks. Footwall up-warping and hanging wall down-warping typically result in the formation of a small mountain range and sedimentary basin, respectively (**Fig. 6**). Half-grabens are a common motif in extensional tectonics from mid-ocean ridges to both narrow (East Africa, Lake Baikal...) and wide (Basin & Range) rift settings, yet the reasons for such ubiquity are not fully understood.

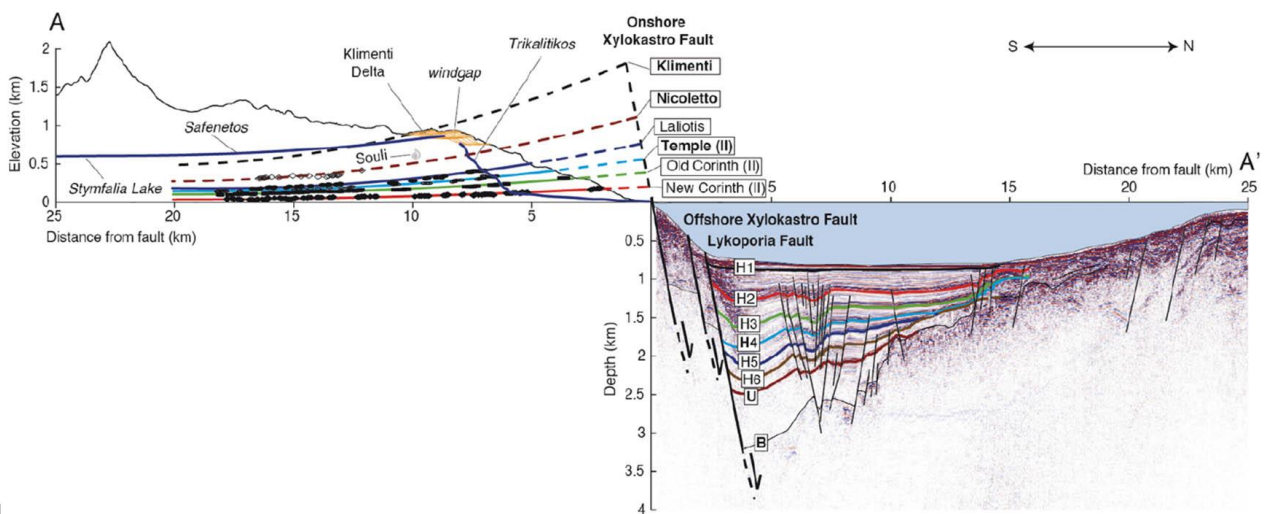


Figure 6: The Eastern Corinth half-graben [modified from *de Gelder et al.*, 2018, *EarthArXiv preprint*: doi.org/10.31223/osf.io/4sh8e], where strain is accommodated by steep north-dipping normal faults (e.g., the Xylokaastro fault), and in a more diffuse fashion through distributed faults in the down-warped hanging wall (seismic profile by *Taylor et al.* [2011]). Footwall flexure is recorded by the continuous uplift and deformation of marine terraces (paleo-horizontals, dashed curves) of known age.

This presentation will focus on the mechanics of half-graben formation and evolution, beginning with the crustal deformation mechanisms that enable short-wavelength (< 20 km) flexure of the upper lithosphere in response to fault slip. The observed deflection of paleo-horizontals in the footwall (**Fig. 6**) is generally consistent with a low effective elastic thickness for the upper crust, suggesting that widespread brittle yielding takes place in the vicinity of the master fault. Using a combination of field observations and geodynamic modelling, I will argue that this manifests as distributed faulting in the sedimentary basin, but also as fracture growth across a range of scales in the footwall.

This first point will then bring up a key paradox in our understanding of half-graben mechanics: *Given that slip on a master normal fault induces yielding of the adjacent blocks, it is unclear why new crustal-scale master faults do not rapidly initiate and turn half grabens into full-grabens or horsts.* I will address this question by presenting theoretical models that predict the lifespan of a

half-graben as a function of internal parameters (e.g., thermal regime, crustal rheology), as well as external forcings (e.g., surficial mass redistribution due to erosion and sedimentation, **Fig. 7**). I will show that the stability of half-grabens depends on a subtle balance between strain-localizing phenomena (fault weakening, active surface processes...) and delocalizing effects (a strong upper crust, a viscous lower crust...). I will conclude by discussing how the long-term processes documented in half-graben structures might manifest on seismic cycle time scales.

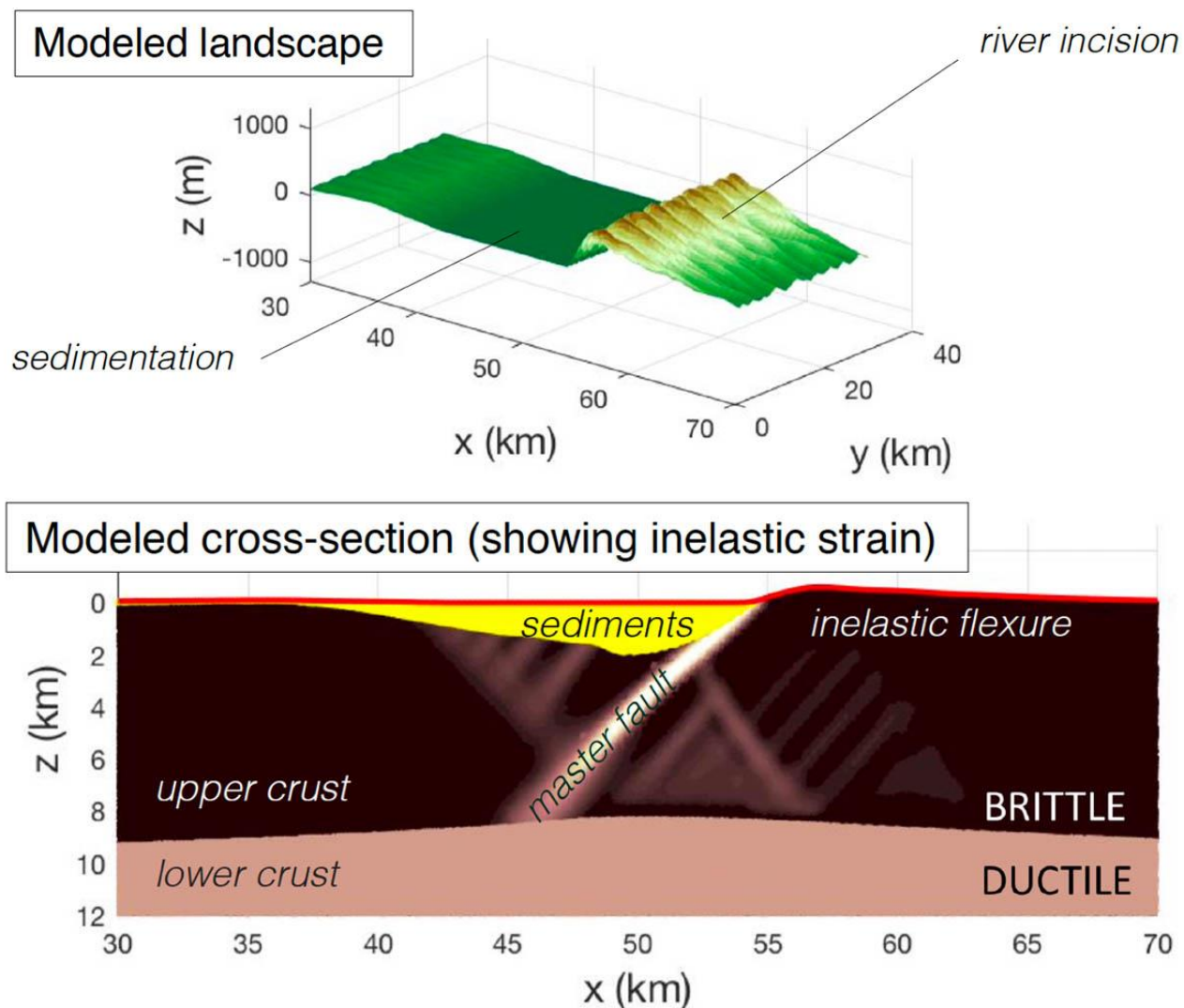


Figure 7: Numerical model of half-graben formation subjected to surface processes. This simulation predicts both the finite deformation of the footwall and hanging wall (2-D cross-section), and the resulting landscape (2-D map view) which integrates the effect of river incision and sediment deposition. These types of simulations can be used to assess the sensitivity of half-graben stability to the intensity of surface processes.



Carlo Laj

Ecole Normale Supérieure
 Département de Géologie
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 &
 Committee on Education
 European Geosciences Union

Education:

Secondary school in Italy and the USA (American Field Service Exchange Student.) University studies at the University of Paris, PhD in Solid State Physics.

Career

I have done all my scientific career as an employee of the French Atomic Energy Commission, first as a researcher in the Physics Department then in the field of geophysics.

In 1985, I was appointed as Deputy Director of the Centre des Faibles Radioactivités and Head of the Department of Earth Sciences. I created and was first director of the Laboratoire de Modélisation du Climat et de l'Environnement, which was later united with the Centre des Faibles Radioactivités to form the present Laboratoire des Sciences du Climat et de l'Environnement (LSCE). After 3 terms as Head of Department (12 years) I stepped down to a researcher position again, until I retired. I have been an “emeritus” researcher since then, and gradually reoriented my activities towards education.

Research Interests:

After my PhD I spent a few years working with critical phenomena (scattering of laser light by critical fluids) then moved into the field of geophysics.

My main interests in this new field has always been linked to the magnetic properties of sediments and igneous rocks (paleomagnetism), used with several objectives: geodynamical reconstructions (particularly in the Eastern Mediterranean and the Andean Cordillera), reconstruction of the history of the Earth's magnetic field (including the morphology of field reversals) and more recently reconstructions of environmental and climatic changes on a global scale.

I have published over 200 articles in international scientific journals and a few general popular articles in different journals.

Supervisor of 12 PhD students, and 8 Masters of Science

Educational activities and Honors:

Founder and Chairman, Education Committee of the European Geosciences Union

Participant to different National and International Education Committees

Union Service Award for creating the Committee on Education of EGU

Excellence in Geophysical Education Award of the American Geophysical Union

Fellow of the American Geophysical Union (AGU).

F. Holweck prize of the French Academy of Science

Holmes Medalist of the European Geosciences Union



Kissel Catherine

Research scientist

Laboratoire des Sciences du Climat et de
l'Environnement (LSCE), Gif-sur-Yvette, France

Catherine.kissel@lsce.ipsl.fr

Tel +33 (0)1 69 82 43 28

EDUCATION

Dec. 1986 PhD (Paleomagnetism applied to Geodynamical studies in the Mediterranean)

May 1984 MsC (Paleomagnetism)

CAREER

- 1987- Research Scientist, French Atomic Energy Commission
2007: Promotion E7 - position Eq. to Directeur de Recherche 1
2012: Honorary position of Directeur de Recherche CEA
- 2015- Head of the CliMag team at LSCE
- 2011-2015 Deputy responsible for the Theme « Climate archives » of LSCE
- 2008-2011 Head of the ChronoMag team (Environmental Magnetism and Chronology) at LSCE
- 1997-2007 Head of the Environmental Magnetism team at LSCE
- 1987-1997 Head of the Paleomagnetic team of the Centre des Faibles Radioactivités.

RESEARCH INTERESTS

Paleomagnetism, Earth magnetic field, Environmental Magnetism, Rock Magnetism, Paleooceanography

PUBLICATIONS AND SERVICES

About 170 publications among which:

Kissel, C. and Laj, C., The Tertiary geodynamical evolution of the Aegean Arc: a paleomagnetic reconstruction, *Tectonophysics*, 146, 183-201, 1988.

Kissel, C., Van Toer, A., Laj, C., Cortijo, E., Michel, E. Variations in the Strength of the North Atlantic Bottom water during Holocene. *Earth Planet. Sci. Lett.* 369-370, 248-259, 2013.

Kissel, C., Sarnthein, M., Laj, C., Wang, P.X., Wandres, C., Egli, R., Magnetic fingerprints of modern sediments in the South China Sea resulting from source-to-sink processes. *Geochem. Geophys. Geosystems*, accepted.



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Massimo Mattei

Full Professor in Geology

Department of Sciences, Roma TRE University

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EDUCATION

Ph.D Geology 1992, University La Sapienza (Rome)

M.Sc Geology 1986 University La Sapienza (Rome)

Ph.D Supervisor: Prof. Renato Funicello

CAREER

Jan. 2011 Full Professor, University of Roma TRE, Rome, Italy

Nov. 2011 Associate Professor, University of Roma TRE, Rome, Italy

Nov. 2008 Associate Professor, University of Basilicata, Potenza, Italy

Jul. 2004 Visiting professor at the Institute of Geophysics ETH Zurich

Dec. 1998 Visiting professor at the University of Cergy-Pointoise (France)

Nov. 1992 Ricercatore Universitario (Lecturer), University of Roma TRE, Rome, Italy

Jun. 1992 Ricercatore Universitario (Lecturer), University La Sapienza, Rome, Italy

RESEARCH INTERESTS

Field geology

Structural geology

Paleomagnetism

Tectonics

Geodynamics

PUBLICATIONS AND SERVICES

Author or co-author of more than 100 research papers (most of them in peer-reviewed international Journals) mainly about tectonic evolution and paleomagnetism of Central Mediterranean, Iran, Anatolia Plateau, Gibraltar Arc, Greece, Andes.

Associate Editor of Geological Society American Bulletin since 2013.

Coordinator of the Italian Group of Structural Geology since Jan 2017

SUGGESTED READINGS (WEB RESOURCES OR SCIENTIFIC JOURNAL PAPERS)

Naomi Oreskes - "Plate Tectonics: An Insider's History Of The Modern Theory Of The Earth"

Allan Cox – "Plate Tectonics and Geomagnetic Reversals" W H Freeman & Co. 1973.

<https://www.sciencenews.org/article/remnants-earths-original-crust-preserve-time-plate-tectonics>

Brown, M., 2006. Duality of thermal regimes is the distinctive characteristic of plate tectonics since the Neoarchean. Geology 34, 961–964. ^[1] _[SEP]

Paleomagnetic studies of rotational deformations in western Greece: at large and small geographic scale.

M. Mattei, C. Kissel and C. Laj

The geometry of the Mediterranean Alpine belt arises from the Upper Cretaceous-Cenozoic collision between the African and European plates. Large and small-scale deformations took place, among which, rotations around vertical axis. The role played by the latter in the edification of the Dinarides-Hellenides belts can only be approached by paleomagnetic studies. Indeed, most of the rocks fossilize the earth magnetic field vector at the time of their formation (cooling or sedimentary deposition). Averaged on sufficient time interval, the fossilized direction should be northward (or southward) directed. After applying adequate laboratory and field tests to check that the measured magnetization is the primary one, any deviation of the declination with respect to the north/south axis reflects a tectonic rotation of the block/structure/region (the scale depends on the geographical/structural extent of the statistical coherency of the rotation).

The Aegean area is a seismically very active zone where we can expect large amplitude movements to occur in a short time interval. Two types of studies were conducted: one, focused on the external zones of the orogens and considering the large-scale rotations and their role in the acquisition of the curvature of the Aegean-Tauric arcs and the other one, focusing on the close surroundings of the Corinth gulf, considering the small-scale block rotations in this very tectonically active area.

On the large scale, an extensive paleomagnetic study has been conducted in the external zones of the Dinarides and Albano-Hellenides. Our approach was pioneer, starting from the most recent formations and extending back in time in order to, retrotectionally, reconstruct and quantify the eventual successive rotation phases during the Cenozoic/Quaternary period. The sampling of the external zones of the Dinarides and the Albano-Hellenic belts (175 sites) has been distributed in space in structures presenting the regional trend (120° for Dinarides and 150° for Albano-Hellenides) and in time from Eocene to Plio-Quaternary. More than 2500 cores were distributed all over the outcrops and at least two samples were fully treated in the laboratory.

The first upper Miocene to Quaternary sampled sites, are located in the Ionian islands of Kerkira, Kefalonia and Zakynthos. The results showed that the upper Miocene formations had rotated clockwise by 25° while the Plio-Quaternary sites showed various clockwise rotation angles. The results, when reported versus age, showed that the upper Miocene was a rather stable period until the 25° clockwise rotation started at the onset of Pliocene and occurred continuously since then at rate of $\sim 5^\circ/\text{Myr}$. In addition to this temporal reconstruction of the rotation, the important point is that the 25° rotation was observed in sites located both in the pre-Apulian and in the Ionian zones. It therefore could not be attributed to a shallow movement of the Ionian zone over the pre-Apulian one and the origin of this rotation was necessarily deeper. Quaternary sites from Albania were not suitable for paleomagnetic study but the 26 upper Miocene and 15 lower Pliocene marly sites showed the same pattern as the sites from the Ionian Islands indicating that the active 'Aegean' compressive front extends much farther north than hitherto believed.

Back in time, upper Eocene to upper Oligocene/lower Miocene marls were sampled in the Ionian zones in continental Greece (29 sites) and later on, in the same structures farther north in Albania (47 sites). These sites revealed quite homogeneously, a $45\text{-}50^\circ$ clockwise rotation, therefore twice as that measured in upper Miocene sites. This is calculated with respect to Africa. Two phases of clockwise rotation therefore successively affected these regions. They were attributed to the middle Miocene (Langhian) and lower Pliocene tectonic phases recognized in this area on the basis of structural analyses. These results showed that the external zones of the Albano-Hellenic Belt appear to have rotated virtually as a single entity from the Peloponnesos to northern Albania over a deep decollement level probably involving the basement itself. In the mean time, the 43 Eocene to Mio-

Pliocene sites sampled in the external Dinarides, did not show any significant rotation.

The pivot point of the clockwise rotation is certainly located at the vicinity of Scutari-Pec (S-P) transverse zone, immediately north of the rotating region. The strong seismic activity recorded in this region and the anomalously high positive heat flow (documented by other authors) are also evidence for the recent activity of the S-P transverse zone. Moreover, it has been shown that both the basement and the nappes are involved in the Albano-Hellenic rotation, implying that the tectonic deformation within the S-P transversal zone certainly affects the deep crust. Considering, as a first approximation that the rotation is a semi-rigid one, as suggested by the remarkable consistency of the paleomagnetic results over the Albano-Hellenic belt and the absence of large-scale strike-slip faults, a simple triangulation, around the pivot pole at the S-P zone, indicates that the observed rotations imply a horizontal displacement of about 300 km over the last 15 Ma at the latitude of the Corinth Gulf.

These data thus bring the first experimental proof that the S-P line, considered until that time as a Mesozoic tectonic boundary on the basis of geological observations, is, in fact, a very important tectonic feature during the Cenozoic and probably until the late Pleistocene time acted as a wide and deep decoupling zone between two major orogens of the central Mediterranean.

In parallel, Cretan formations did not reveal any significant rotation since Miocene while the easternmost units of the Aegean arc (23 sites from the Bey Daglari massif in southern Turkey) underwent a 25° post mid-Miocene counterclockwise rotation. This rotation did not affect the Antalya basin deposited on top of the Bey Daglari. Indeed, no post mid-Miocene rotation was observed from the 13 sites sampled in this basin.

The reconstruction of the Cenozoic evolution of the orientation of the different analyzed structures is possible on the basis of the paleomagnetic results obtained in this area. The Lower Miocene arc was almost rectilinear with an E-W trend. Its curvature has been acquired tectonically in two major phases. During the Middle Miocene a first phase of deformation is characterized by rotations occurring at the two terminations of the arc, clockwise in the west (Epirus) anticlockwise in the east (southeastern Anatolia). This phase brought the Dinarides and the Albano-Hellenides along the same axis. A second phase of rotation occurring in the last 5 Ma about a pole situated around the S-P line affected only the northwestern part. The data also indicate that the Dinarides on the western part and the Antalya basin on the easternmost part have not been involved in the geodynamical evolution of the arc.

On smaller scale, paleomagnetic data from Plio-Pleistocene sedimentary units from Corinth and Megara basins (Peloponnesus, Greece) show that Megara basin has undergone vertical axis clockwise (CW) rotation since the Pliocene, while Corinth has rotated counter-clockwise (CCW) during the same period of time. Conversely, published GPS results show that these two basins belong today to the same crustal block (Peloponnesus), which is presently rotating CCW respect to the Beotia-Locris block. The boundary between the two blocks is represented by a E-W oriented normal fault system which bounds the Corinth basin and the Megara basin to the north.

These results indicate that the overall deformation in central Greece has been achieved by complex interactions of mostly rigid, rotating, fault bounded crustal blocks. The comparison of paleomagnetic results and existing GPS data shows that the boundaries of the rigid blocks in central Greece have changed over time, sometimes changing in orientation. The Megara basin belonged to the Beotia-Locris block in the past but has now been incorporated into the Peloponnesus block, possibly because the faulting in the Gulf of Corinth has propagated both north and east (Fig. 8). Paleomagnetic and GPS data from Megara and Corinth basins have significant implications for the deformation style of the continental lithosphere. In areas of distributed deformation, the continental lithosphere behaves instantaneously like a small number of rigid blocks with well-defined boundaries.

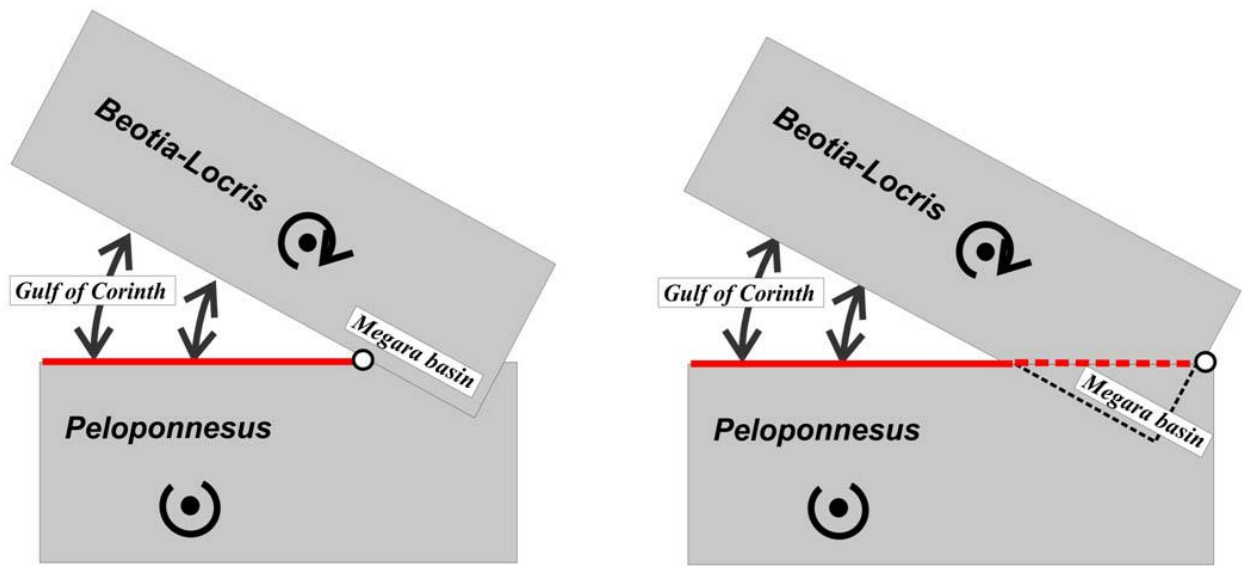


Figure 8: Schematic representation of the tectonic evolution of Central Greece. During the Plio-Pleistocene the Megara basin belonged to the CW rotating Beotia-Locris block. As a consequence of the eastward migration of the E-W oriented normal fault system the Megara basin was incorporated into the Peloponnesus block, as demonstrated by GPS data.



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Tel: +30-210-7274841
personal webpage: http://dggs1.geol.uoa.gr/cv/en_kaviris.html

EDUCATION

1994: Graduated from the Faculty of Physics, National and Kapodistrian University of Athens (NKUA)

2003: PhD of Seismology, Department of Geophysics and Geothermics, Faculty of Geology and Geoenvironment, NKUA. Thesis subject: “Study of Seismic Source Properties of the Eastern Gulf of Corinth”.

CAREER

2016 – today: Assistant Professor of “Seismology – Seismic Anisotropy”, Department of Geophysics and Geothermics, Faculty of Geology and Geoenvironment, NKUA

2013-2016: Lecturer of “Seismology”, Department of Geophysics and Geothermics, Faculty of Geology and Geoenvironment, NKUA

2006-2013: Research Associate (IDAX) at the Laboratory of Seismology, Department of Geophysics and Geothermics, Faculty of Geology and Geoenvironment, NKUA.

2004-2007: Post-Doc Researcher in the Research Project “Pythagoras” entitled: «Identification of Anisotropic Media in Greece using body and surface waves».

RESEARCH INTERESTS

My primary research interest is Seismic Anisotropy, both of the upper crust and mantle. In addition, Seismotectonics, Seismic Hazard, Seismic Risk, Receiver Functions, Ambient Noise, Slip Distribution and Seismic Swarms.

PUBLICATIONS AND SERVICES

Supervisor of 12 MSc and 14 BSc students

I have more than 120 publications in international scientific journals and congress proceedings.

Publications for the Gulf of Corinth:

G. KAVIRIS, I. Spingos, V. Kapetanidis, P. Papadimitriou, N. Voulgaris and K. Makropoulos, 2017. Upper crust seismic anisotropy study and temporal variations of shear-wave splitting parameters in the Western Gulf of Corinth (Greece) during 2013. *Phys. Earth Plan. Int.*, 269, 148-164, <https://doi.org/10.1016/j.pepi.2017.06.006>.

G. KAVIRIS, Ch. Millas, I. Spingos, V. Kapetanidis, I. Fountoulakis, P. Papadimitriou, N. Voulgaris and K. Makropoulos, 2018. Observations of shear-wave splitting parameters in the Western Gulf of Corinth focusing on the 2014 Mw=5.0 earthquake. *Phys. Earth Plan. Int.*, accepted.

AWARDS AND HONORS

January 2017: Highly cited Research Award for the publication "Karst collapse susceptibility mapping considering peak ground acceleration in a rapidly growing urban area" in which I was a co-author. This publication was awarded being among the five (5) most cited works of the international journal "Engineering Geology" for the period January 2014 - June 2016. The award was given in recognition for the contribution of this work to the quality of the scientific journal "Engineering Geology". A certificate has been issued by Elsevier.

Corinth Rift Seismicity and Applications

Dr. George Kaviris

Section of Geophysics and Geothermics, Department of Geology and Geoenvironment, National and Kapodistrian University of Athens

The Gulf of Corinth (GoC) can be considered a “natural laboratory” for seismology, given that it is characterized by high tectonic activity. The dominant structural feature is normal faulting. Regarding the morphology of the gulf, it is an E-W trending asymmetric graben, with the major active faults outcropping at the southern coast and dipping north, resulting in a long record of rifting in the centre of the gulf. GPS measurements in the GoC have revealed a high extension rate in a NNE-SSW direction, increasing from east to west.

Moderate to strong historical earthquakes (Fig. 9) have occurred in the western part of the Gulf (WGoC), including destructive ones, such as the 373 BC Helike earthquake, as well as during the instrumental period, with some causing severe damage to urban areas in the broader region, e.g. Eratini, $M = 6.3$, 1965; Antikyra, $M=6.2$, 1970; Galaxidi, $M = 5.8$, 1992; Aigion, $M_s = 6.2$, 1995. Regarding the eastern part of the Rift (EGoC), on February 24, 25 and March 4, 1981, a seismic sequence consisting of three major earthquakes of magnitudes $M_s = 6.7$, 6.4 and 6.4 occurred in Alkyonides Gulf causing significant damage to Athens. In addition, seismic swarms, such as the one that occurred in Helike in 2013, are a common phenomenon in the western part of the rift.

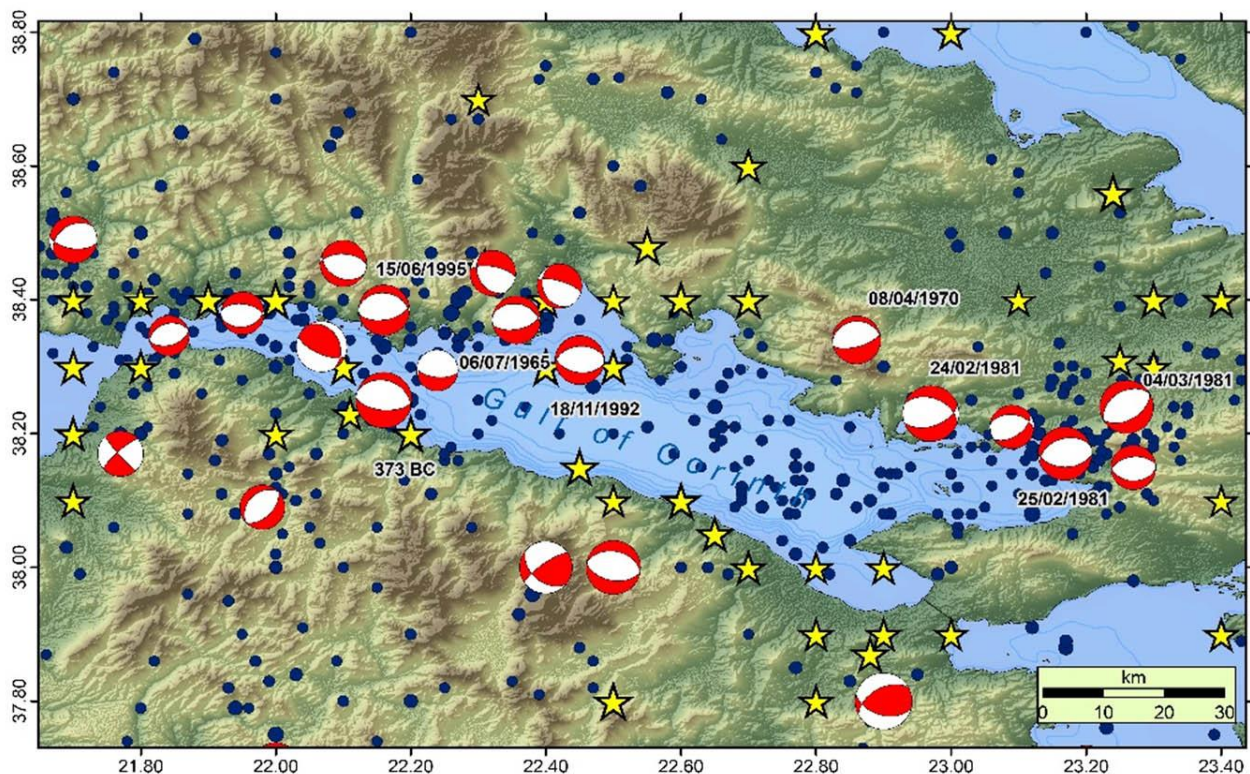


Figure 9: Seismotectonic map of the GoC. Stars represent epicenters of historical ($M > 6$) and blue circles of instrumental ($M_w > 4$) earthquakes. Beachballs are focal mechanisms of strong earthquakes.

The forementioned seismic activity has piqued the interest of several Greek and International research efforts. As a result, Hellenic Institutions have installed several seismological stations in the area, belonging to the Hellenic Unified Seismological Network (HUSN). Furthermore, the multinational initiative of the Corinth Rift Laboratory (CRL) has greatly increased the density of local station coverage and has led to the prompt provision of seismological data to the scientific community.

Waveforms recorded in the GoC have been utilized in locating earthquakes with high resolution, which permits the identification of seismogenic faults through seismological observations. The obtained data are also used in the determination of focal mechanisms, either with the method of first-motion P-wave polarities (enabled by the dense station coverage) or through moment tensor inversion (for the stronger events). Thus, we can infer the seismotectonic state of the GoC. The vast majority of the reliable fault-plane solutions indicate normal faulting in an approximate E-W direction (Fig. 9), in accordance to the major active faults. It is worth noting that focal mechanisms in NW Peloponnesus indicate strike-slip faulting.

Reliable estimation of seismic hazard parameters, in terms of maximum expected earthquake magnitude and acceleration, velocity and displacement, is vital for earthquake resistant planning and risk mitigation, especially for earthquake prone regions as the GoC. According to the current Greek Building Code, determined using Probabilistic Seismic Hazard Assessment (PSHA), the GoC belongs to Zone II, to which Peak Ground Acceleration (PGA) equal to 0.24g is assigned for a return period of 475 years.

Conditions in the GoC have permitted detailed shear-wave splitting studies of the upper crust. The dense seismological networks, especially CRL, in combination with the intense seismicity, provide an optimal environment for such studies, where high rejection rate of data is common place. Exploring seismic anisotropy can lead to constraining fault-plane solutions and to understand the mechanisms that drive the phenomenon.

Most of the stations in the GoC showcase polarization directions of the fast shear-wave (S_{fast}) in a general WNW – ESE orientation (Fig. 10), in agreement with the direction of extension of the Gulf. The results are interpreted with the existence of microcracks, in accordance to the Extensive Dilatancy Anisotropy (EDA) and the Anisotropic Poro-Elasticity (APE) models.

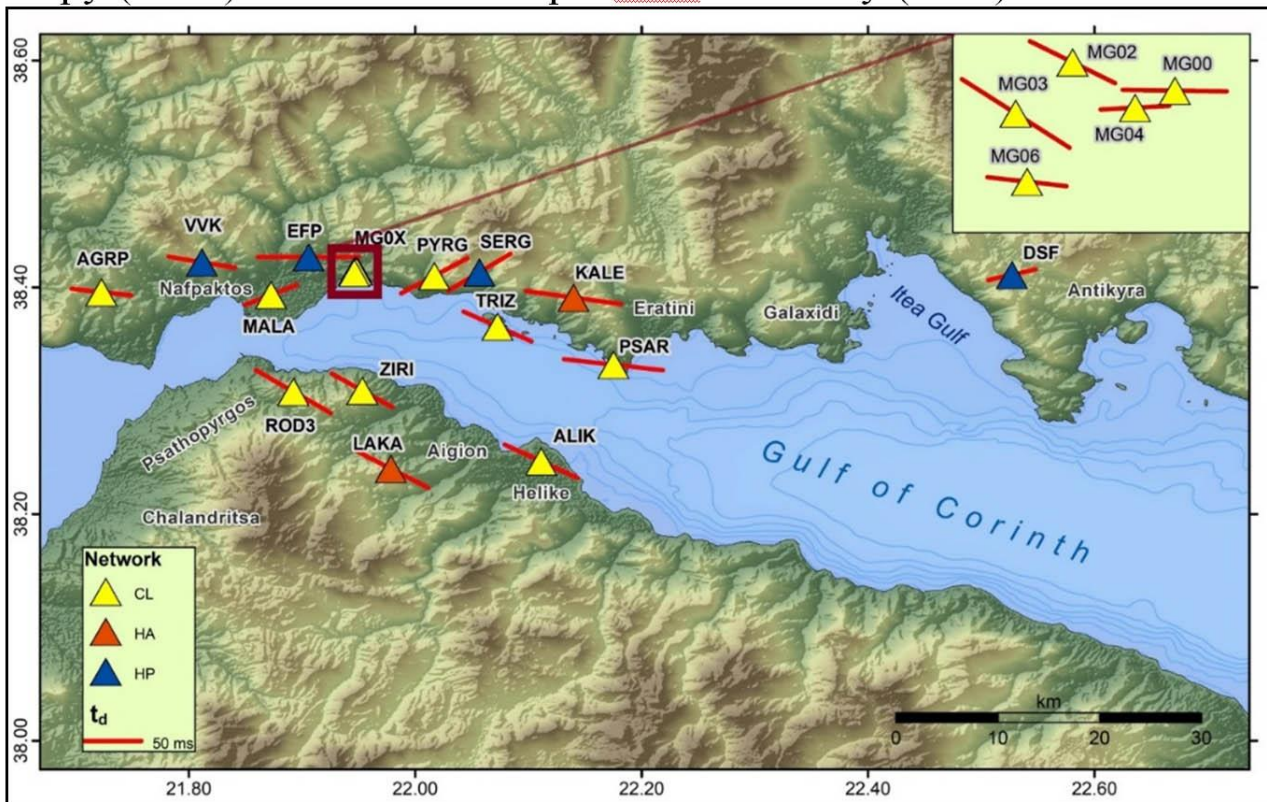


Figure 10: Map of the mean anisotropy direction in the WGoC. Stations are represented by triangles. Red lines indicate mean anisotropy directions and their length is proportional to the mean time-delay.



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Education:

Secondary school in Athens, BSc in Geology at Dept. of Geology, National & Kapodistrian University of Athens (NKUA), PhD in Seismology at Dept. of Geology, National & Kapodistrian University of Athens

Career:

- July 2013 - today: Assistant Professor of Seismology, Dpt. Geophysics-Geothermics, NKUA.
- January 2009 - July 2013: Lecturer of Seismology, Dpt. Geophysics-Geothermics, NKUA.
- 2003-2009: Laboratory Teaching Staff, Dpt. Geophysics-Geothermics, NKUA.
- 1995-2003: Research, Technical and Administrative Staff, Dpt. Geophysics-Geothermics, NKUA.
- 1993-1995: Research Fellow, Dpt. Geophysics-Geothermics, NKUA.
- 1991: Research Fellow at LGIT (Grenoble, France).
- 1989-1991: Research Fellow, Dpt. Geophysics-Geothermics, NKUA.

Research Interests:

- Earthquake source properties
- Seismotectonics and active deformation
- Seismic structure of the Earth's interior, surface waves
- Engineering seismology, microzonation
- Seismic Risk analysis

Educational activities:

Undergraduate courses

- Seismology
- Plate Tectonics, Seismology of Greece
- Engineering Seismology
- Earth structure

Postgraduate courses

- Advanced Seismology
- Signal processing
- Data analysis
- Supervision of MSc and PhD dissertations

Publications (of educational purpose):

Kassaras I. & Kazantzidou-Firtinidou D. 2017. "Earthquakes", Chapter in N. Dalezios (Ed), "Environmental Hazards Methodologies for Risk Assessment and Management", IWA Publishing, Water Intelligence Online, 16, doi: 10.2166/9781780407135.

Kassaras I. & Kapetanidis V., 2018. Resolving the tectonic stress by the inversion of earthquake focal mechanisms. Application in the region of Greece. A TUTORIAL, Chapter in: "Moment Tensor Solutions A Useful Tool for Seismotectonics", D'Amico, S. (Ed.), Springer Natural Hazards, ISBN 978-3-319-77359-9.

Deterministic seismic risk assessment with the use of stochastic simulation of strong ground motion taking into account site-effects and empirical vulnerability. A TUTORIAL. Case study the city of Aigion (W. Corinth Gulf)

Ioannis Kassaras

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Earthquake hazards caused the most deadly natural disaster in the last two decades, resulting in over 800,000 deaths and 1.7 million injuries. The issue is particularly crucial nowadays, as manifested by extremely high losses during several recent seismic crises (i.e. Sumatra, 2004; Haiti, 2010; Christchurch, 2011; Japan, 2011; Nepal, 2015). Reason for this is in particular (a) the rapid urbanization of large parts of the population, resulting in growth of cities towards areas susceptible to earthquake hazards, (b) the economically driven reduction of the suburban construction behaviour, as largely viewed in less-developed countries, (c) the increasing exposure into technological hazards in the developed countries, i.e. nuclear power plants (as it happened in the Fukushima nuclear plant during the 2011 Japan earthquake).

Such disastrous earthquake phenomena have proven that the generic provisions of the seismic codes, underestimate the seismic hazard potential in earthquake prone areas, and so, crisis management planning is often unrealistic, thus ineffective. Remedy to this is the reconsideration of seismic codes on the basis of small-scale risk models taking into account the local seismic potential, the site's structural and societal vulnerability, and also site conditions. In other words, site-specific estimates are prerequisite towards a tailored seismic risk assessment that will guide through effective risk mitigation policies and disaster management measures.

During the last years, our working group has elaborated intense work on seismic risk assessment in several Greek cities, targeting site-specific models and allowing for tailor-made management actions in case of a crisis. We present the core and the outcome of the applied methodologies, indicating pros and cons, and highlighting future perspectives. Our approach includes: (a) Deterministic seismic hazard assessment based on the stochastic simulation of ground motion taking into account the areas' seismotectonics and site conditions. To this, new data concerning the location, geometry, and the seismic potential of faults, together with free-field ambient noise recordings have been collected through numerous field surveys; (b) Vulnerability assessment of elements at risk informed by newly created observed damage databases and in-situ observations; (c) Development of physical risk models including structural damage, and economic loss for several earthquake scenarios.

Case study

Our basic example is a scenario-based seismic risk assessment for the earthquake prone city of Aigion (W. Corinth Gulf). Within this approach, the stochastic finite-fault method is applied towards simulation of strong ground motion for three near-field earthquake scenarios, capable of occurring given the well-established seismotectonics of the area. The three scenarios are: (a) a repetition of the June 15th 1995 ($M_w = 6.4$) devastating earthquake, (b) a repetition of the December 26th 1861 historical earthquake of $M_w = 6.7$, and (c) an earthquake of $M_w = 6.0$ on the nearest Aigion Fault, underlying the city. The stochastic model parameterization is validated by comparisons with available recordings from permanent accelerometric stations. Site amplification is approximated by the use of ambient noise Horizontal-to-Vertical-Spectral-Ratios (HVSr) derived from in-situ free-field measurements in Aigion.

The structural exposure model of the city is developed on a building-by-building level through in-situ inspection, census data, and satellite navigation tools. The macroseismic method of RiskUE-LM1 is applied for the estimation of the structural vulnerability of 3216 inspected buildings in Aigion, based on the vulnerability classes per EMS-98 and semi-empirical indexes, accounting for the buildings' typology and structural characteristics.

Three scenarios of structural damage are presented on a building block scale, in terms of EMS-98 Damage Grades and their probability of occurrence. The obtained risk assessment indicates that the northeastern and partly the southern part of Aigion are more susceptible to damage, in accordance with

the real damage distribution from the most recent devastating M6.4 1995 earthquake, the site amplification inferred from HVSr, and the macroseismic vulnerability of the constructions.

In conclusion, the current building stock of Aigion demonstrates significantly enhanced seismic behavior compared to the pre 1995-era, due to rehabilitation after the 1995 earthquake, strengthening post-earthquake interventions to damaged buildings of 1995 and replacement of vulnerable ones with new constructions. Despite unavoidable uncertainties intrinsic to both the method and data, being open to future improvements, the inferred seismic risk assessment provided realistic and consistent results, thus allowing its exploitation towards loss evaluation and mitigation purposes for the city of Aigion.

Perspectives

Future improvements that fall in with, and/or are beyond the global state-of-the-art, include: (a) Implementation of technological capabilities of remote sensing towards buildings' inventory and vulnerability assessment; (b) Socioeconomic impact analyses towards the mitigation of risk, enhancement of preparedness and resilience of the social and economic fabric, and (c) Applications for near real-time damage assessment.

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- Kassarar I. & Kazantzidou-Firtinidou D. 2017. "Earthquakes", Chapter in N. Dalezios (Ed), "Environmental Hazards Methodologies for Risk Assessment and Management", IWA Publishing, *Water Intelligence Online*, 16, doi: 10.2166/9781780407135.
- Milutinovic Z. & Trendafiloski G. 2003. An advanced approach to earthquake risk scenarios with applications to different European towns. *Report WP4: Vulnerability of Current Buildings*, Risk-UE. E.C., Brussels, DOI: 10.1007/978-1-4020-3608-8_23.
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https://isterre.fr/spip.php?page=auteur&id_auteur=136&lang=fr

EDUCATION

+ Master Sc. in Geology (1971, *Ecole Normale Supérieure de Saint-Cloud* and Pierre et Marie Curie University, Paris.), and *Agégation des Sciences de la Vie et de la Terre* (1972)

+ PhD (1975) and *Habilitation* (1985) (University of Lille)

CAREER

+ Assistant Professor (University of Lille, 1978-1987)

+ Professor (Savoie-Mont-Blanc University, 1988 to 2013)

+ Advisor in Ministry of Research and Higher Education (*M.E.S.R.-D.G.E.S.I.P.*, 2010-2013)

RESEARCH INTERESTS

C.B. focused his research on the **sedimentary recording of tectonic processes at different space and time scales**, for long term processes as well as for instantaneous events as earthquakes (based on field work, coring, high-resolution seismic imagery, and laboratory analyses). Since 1991, he is dedicating his work to **recent paleoseismic sedimentary archives** (lacustrine and marine) within integrated projects dedicated to major seismogenic active faults systems, developing sedimentological tools to characterize earthquakes and tsunamis imprints and provide long term archives for hazards estimation.

Main investigated areas are: south-eastern Caribbean Margin (Boconó-San Sebastian-El Pilar transform boundary and Lesser Antilles subduction), Sea of Marmara (North Anatolian Fault), Gulf of Corinth. C.B. participated to different International Oceanographic Surveys: **Ocean Drilling Project**, Leg 110 (Barbados Accretionary Complex) aboard R/V JOIDES RESOLUTION, Turkish/French MARMACORE and MARMARASCARPS projects. C.B.'s last cruise participations were dedicated to earthquakes and tsunami hazards assessment in Lesser Antilles forearc (GWADASEIS and CASEIS Cruises, 2009 and 2014). Beside, he designed and conducted lacustrine coring campaigns (Chile, French Alps, Venezuela, Albania). Within the frame of SISCOR Project (2011-2013) C.B. conducted two offshore surveys on the western Gulf of Corinth.

PUBLICATIONS AND SERVICES

Beck, C., 2009. Late Quaternary lacustrine paleo-seismic archives in north-western Alps:

Examples of earthquake-origin assessment of sedimentary disturbances. *Earth-Science Reviews*, 96:327–344.

Beck, C, et al., 2007. Late Quaternary co-seismic sedimentation in the Sea of Marmara's deep basins. *Sedimentary Geology*, 199:65–89.

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Chapron, E., Beck, C., et al., 1999. 1822 earthquake-triggered homogenite in Lake Le Bourget (NW Alps). *Terra Nova*, 11:86-92.

Campos, C., Beck, C., et al., 2013. Late Quaternary paleoseismic sedimentary archive from deep central Gulf of Corinth: time distribution of inferred earthquake-induced layers. *ANNALS OF GEOPHYSICS*, 56, 6, S0670:1-15; doi:10.4401/ag-6226.

Beckers, A., Beck, C., et al., 2016. Sedimentary impacts of recent moderate earthquakes from the shelves to the basin floor in the western Gulf of Corinth. *Marine Geology*, 384:81–102, doi.org/10.1016/j.margeo.2016.10.018

Field teaching: « Sedimentary chronometers: a short overview of a few rich outcrops near Nafpaktos” (1st group)

Christian Beck
Université de Savoie, France

Most of sedimentary accumulations (often looking monotonous!) display a rhythmicity involving two (or more) types of layers, a pattern which may correspond to an actual cyclicity. The time elapsed for the deposition of a single strata, or a repeated group of strata, may vary - for similar thicknesses - from few minutes to several hundred thousand years. The Mesozoic-Tertiary series of the **Pindos** Mountains (here along the northern edge of the Corinth Rift) offers outcrops illustrating two totally opposite sedimentary processes: 1) turbidity currents and 2) pure pelagic settling.

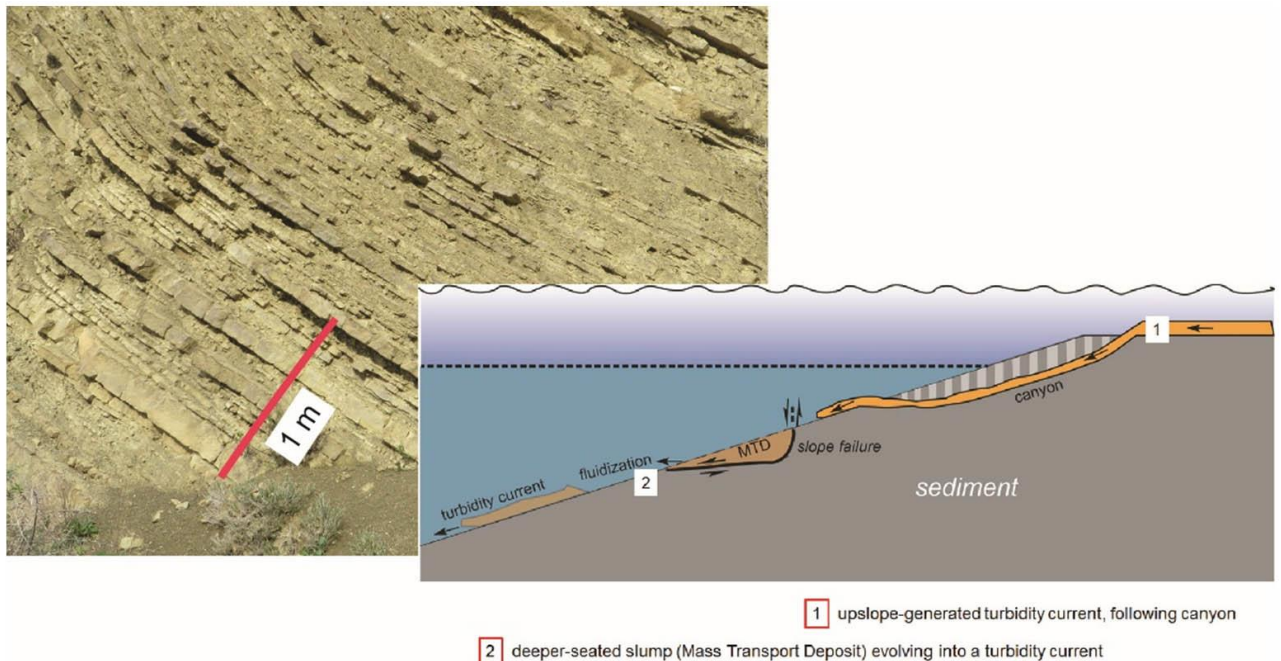


Figure 11

The first one will be observed and discussed in the so-called Tertiary “Pindos **flysch**” (close up: few meters of a 1500 m thick pile) which coarse layers represent **turbidites**, “instantaneous” deposits resulting from submarine landslides often triggered by seismic shocks. Detailed depositional mechanism will be discussed.

The second will be observed through Jurassic **radiolarites** (or radiolarian cherts) and Upper Cretaceous fine-grained **thinly stratified limestones (calcareous mudstones)**. Both represent very low sedimentation (< 1mm/1000 yr) rate and their compositions are driven by paleoenvironmental conditions (clay supply, siliceous and calcareous plankton productions). Thus climatic cycles (orbital forcing, Milankovic cycles) and oceanic circulation changes may represent the driving factors of the stratification pattern. The time significance can be discussed following this interpretation.

Field Teaching “Paleomagnetic Sampling at sites near Aegion” (2nd group)
Massimo Mattei, Catherine Kissel, Francesca Cifelli and Carlo Laj

Among the outcrops suitable for paleomagnetic studies around the Gulf of Corinth, one will be chosen to show the participants how a paleomagnetic sampling is done for tectonic studies. We will make a demonstration of how to drill a core of sufficient length to avoid the eventual surface weathering (i.e. risk of secondary magnetization). We'll then show how to orient a core and to measure the bedding plane in order to use these numbers to reconstruct in the geographic system the declination and inclination measured in the laboratory in the reference frame of the magnetometer. The drilling equipment will be available and after this short demonstration, each participant who volunteers will be able to drill a core, to orient it and to label it.



Figure 12: Paleomagnetic sampling and orientation



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EDUCATION/CAREER

- 1997: Master degree in Geological Sciences at La Sapienza University, Rome
- 1999-2003: Ph.D. in Geological Sciences at Roma TRE University, Rome
- 2003–2006: Post-doc at the Department of Geological Science, Roma TRE University
- 2006-2015: Non-permanent researcher in Structural Geology at the Department of Geological Science, Roma TRE University
- 2015: Associate Professor at the Department of Geological Science, Roma TRE University

RESEARCH INTERESTS

- Paleomagnetic rotations and structural evolution of curved mountain chains
- Extension and dynamics of back-arc spreading in Mediterranean region
- Recent tectonics in Central Iran
- Seismic effects in urban areas
- Science education and outreach

TEACHING AND EDUCATIONAL ACTIVITIES

- Teaching activity includes support in the first year classes and field assistance in structural geology classes
- Tutor and co-tutor of Master theses and PhD theses
- High-school teacher training activity
- Italian responsible of Educational Committee of Education of the European Geosciences Union (EGU) for the organization of the GIFT (Geophysical Information for Teachers) workshops

Earthquakes in the classroom: the seismo-box educational kit

Francesca Cifelli

Università degli Studi Roma TRE

To prevent population against seismic risk, people must be aware **where** earthquakes take place, **when** earthquakes occur and **how** much is the released energy. The seismo-box (Fig. 13) has been projected with the main goal to answer these main questions.

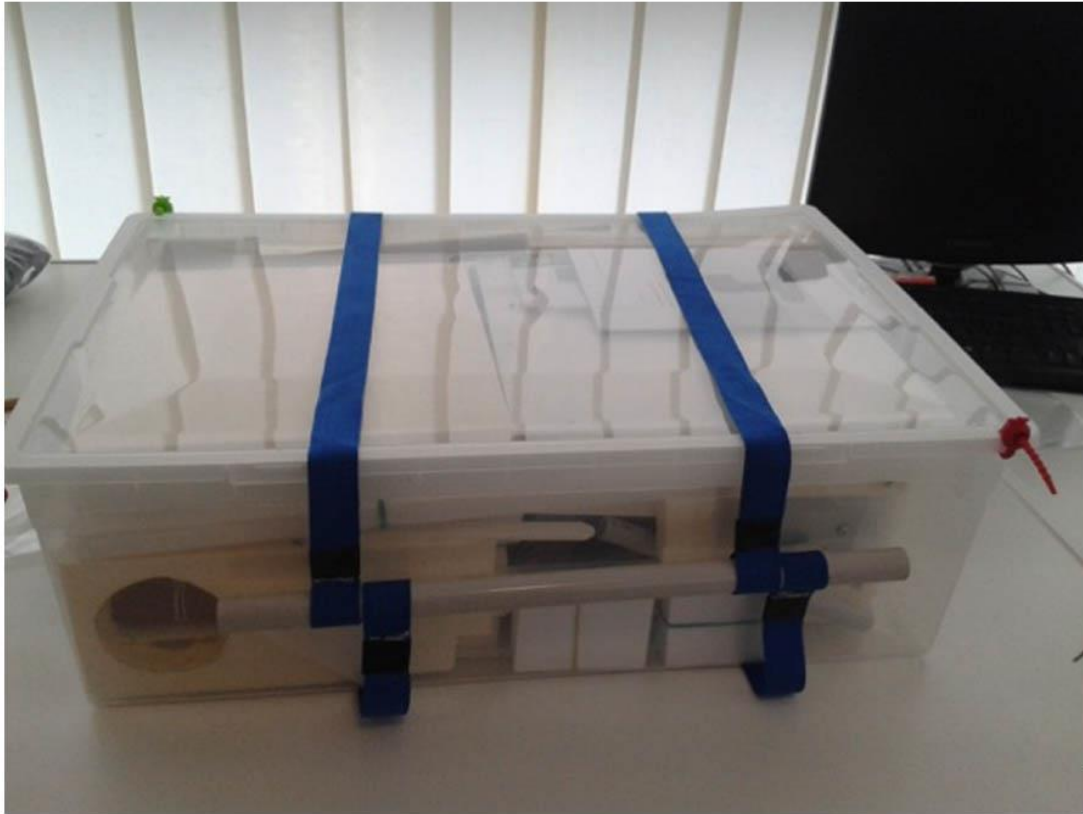


Figure 13: The educational kit seismo-box

Experiments that can be made with the seismo-box allow understanding some important aspects of earthquakes: what is the origin of an earthquake, how to record and locate it (Fig. 14), the impossibility to predict it (Fig. 15), and what its consequences on buildings are. Moreover, it is possible to better understand the difference between seismic hazard (that man cannot control) and seismic risk (that man can and must minimize).

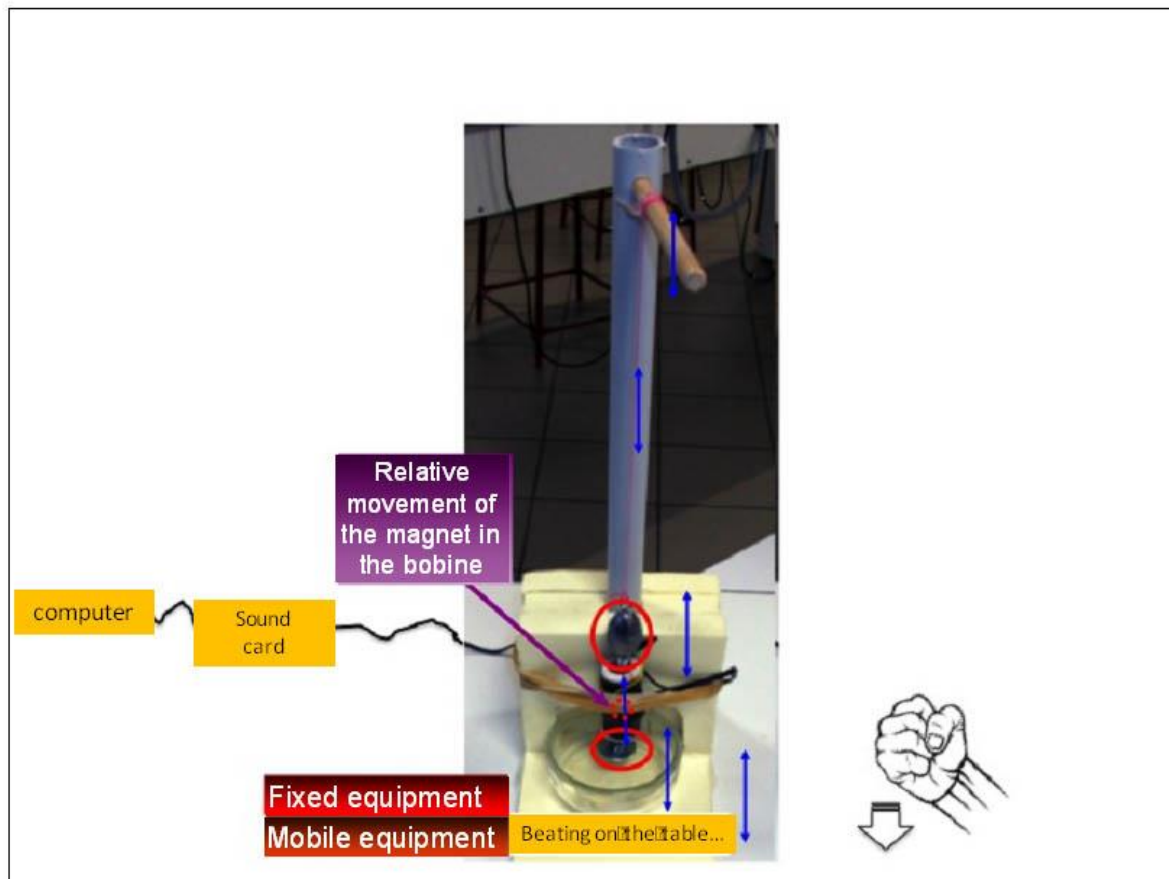


Figure 14: Recording an 'earthquake' using a hand-made seismometer.

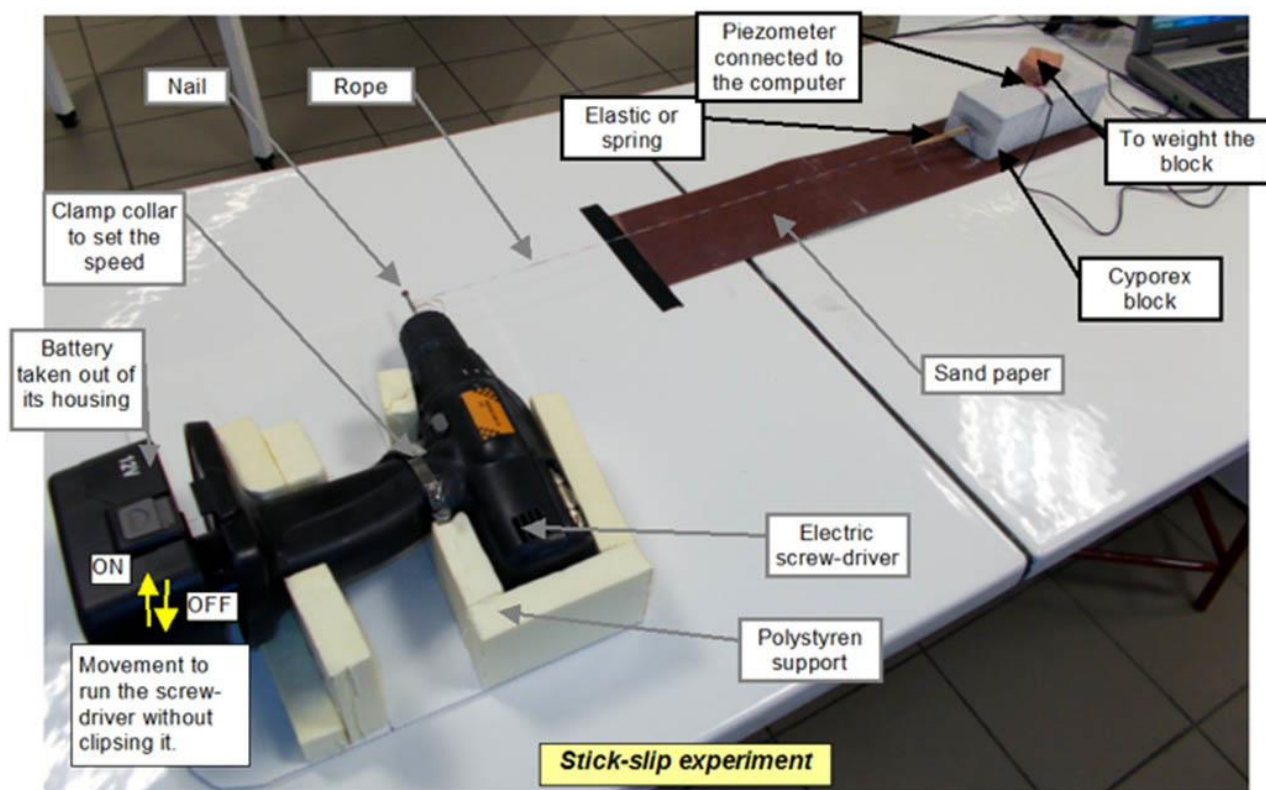


Figure 15: The stick-slip experiment to understand if it is possible to predict earthquakes.

This Seismo-box kit is made with very simple and cheap (and even recycled) materials. Among the most popular experiments possible with the seismo-box: the record of micro-earthquakes (Fig. 14), the simulation of vibrations on small buildings (Fig. 16), the liquefaction (Fig. 17) and the stick-slip experiments (Fig. 15).

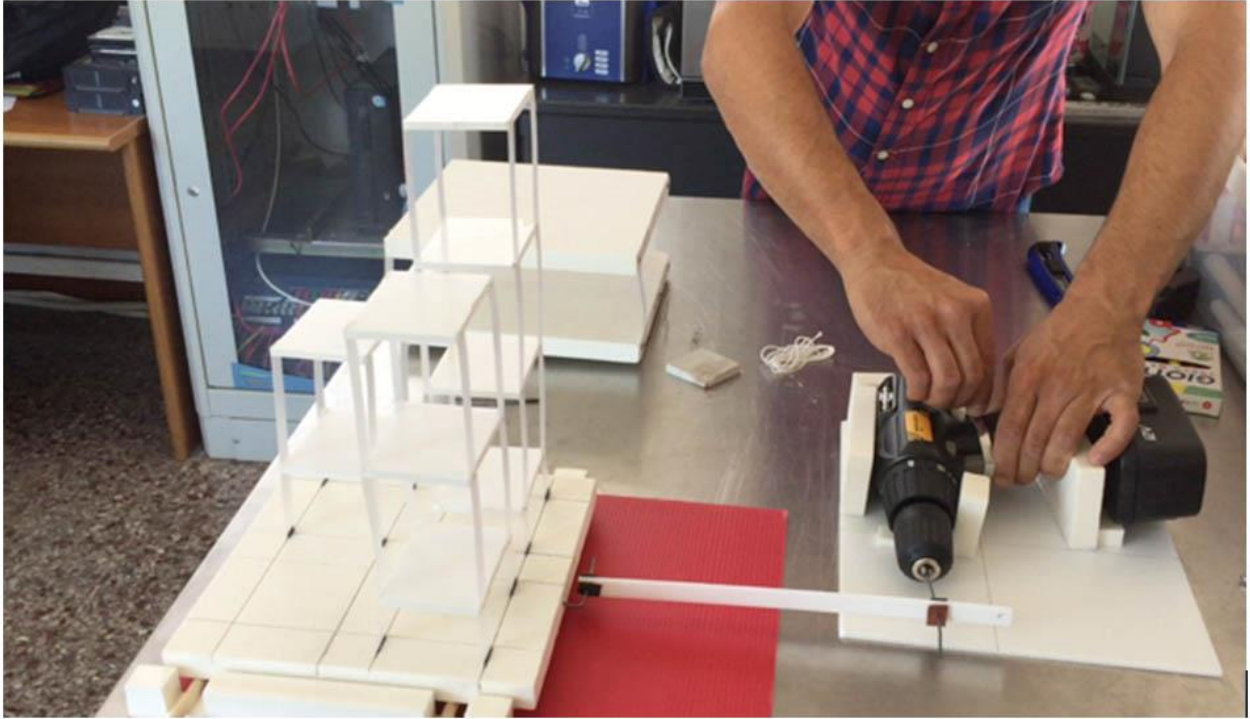


Figure 16: The resonance of buildings.

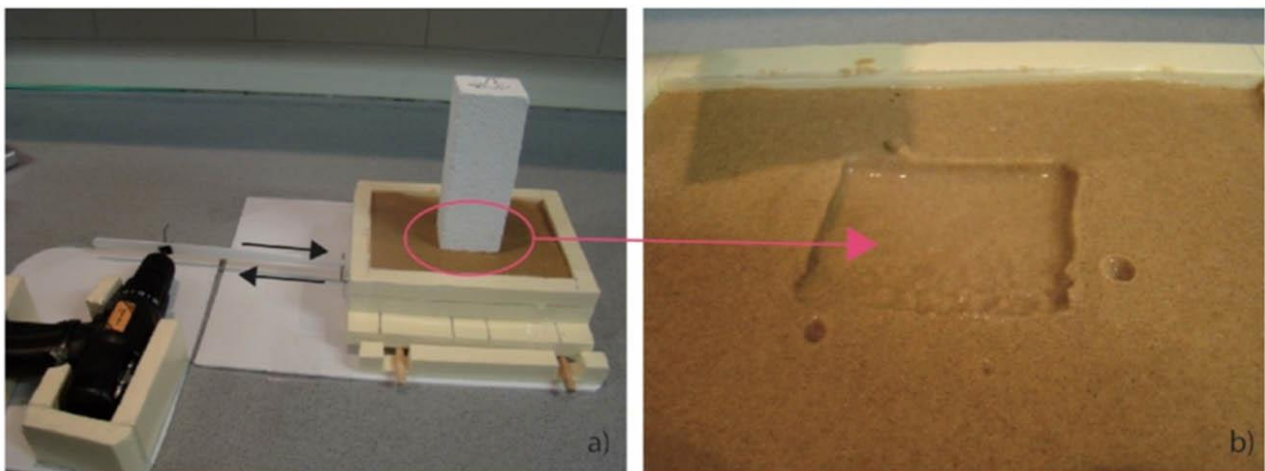


Figure 17: The ground liquefaction experiment.