Workshop on Earth Sciences Researches - New Perspectives
Organized by the Geophysics Centre of Évora, University of Évora
Seismolitos group- Seismotectonics and Processes of Lithospheric Deformation

PROGRAM

Wednesday 4th June 2008

University of Évora, Colégio L.A. Verney, Anfiteatro 1

Morning

Opening
09:45 – **Ana Maria Silva** (Direction of the Geophysics Centre of Évora, University of Évora)
- Welcome and Introduction

Lectures
Chair: **José Fernando Borges** (Geophysics Centre of Évora, University of Évora)

10:00 – **Nuno Lourenço** (Estrutura de Missão para a Extensão da Plataforma Continental, EMEPC, Lisboa and Centro de Investigação Marina e Ambiental da Universidade do Algarve)
- EMEPC Presentation (10 mn)
- Tectono-magmatic processes in the Azores Triple Junction

10:45 – **Claudia Adam** (Geophysics Centre of Évora, University of Évora)
- Plume lithosphere interaction

11:15 - *Coffee break*

11:30 – **Matthieu Ferry** (Geophysics Centre of Évora, University of Évora)
- Late Pleistocene behavior of the Dead Sea Fault in the Jordan Valley from historical, archeological and paleoseismological data

12:00 – **Discussion**

12:30 - Lunch

Afternoon

Lectures
Chair: **Maria João Costa** (Geophysics Centre of Évora, University of Évora)

14:30 – **André Jalobeanu** (Geophysics Centre of Évora, University of Évora and CNRS, France)
- The SpaceFusion* project and its applications to Earth Sciences

15:00 – **Delphine Fitzenz** (Geophysics Centre of Évora, University of Évora)
- Probabilistic Modeling of Earthquake Occurrence: First examples of data integration within a Bayesian framework

Closure
16:00 – **Mourad Bezzeghoud** (Geophysics Centre of Évora, University of Évora)
- Final comment

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ABSTRACTS

Tectono-magmatic processes in the Azores Triple Junction

Nuno Lourenço, Estrutura de Missão Para a Extensão da Plataforma Continental, Lisboa and Centro de Investigação Marina e Ambiental da Universidade do Algarve

Multi-disciplinary results on the spatio-temporal interaction between the Azores hot-spot (AHS) and the Azores Triple Junction (ATJ) during the Azores plateau evolution, are presented. In addition a tectono-magmatic model of the ATJ for the present day is summarized.
Since 33.4 Ma, the dominant tectonic regime is transtensional with progressive rotation of the Eurasia-Africa opening directions from ca. N-S to ca. ENE-WSW. Since that early age, the Azores present a kinematic behavior which is independent from that of the larger plates and possibly dominated by distributed deformation.
The maximum interaction between the AHS and the ATJ occurs between the 20 and 10 Ma. Consequently, between 33.4 and 20 Ma the evolution of the Azores has been prominently a result of tectonic controls and had little influence of the AHS.
The growth of the linear volcanic ridges (LVR) is interpreted as the result of the progressive migration of the ATJ, since ca. 15 Ma, from an intra-transform context, towards NW. Their propagation subsists in the present day, now towards WNW.
The modeling of GPS data has allowed to constrain in the present day, the Eurasia-Nubia plate boundary along the Terceira axis and in the Pico-Faial alignment. It is suggested that the inter-plate zone adjoining this two active axis, corresponds to a domain of non-coaxial distributed deformation dominated by transtension. In this zone there is a partition between rifting processes (dominated by magmatism) in pure tension, normal to the LVR axis, and shear processes characterized by left lateral strike slips (along NNW-SSE) and relay zones (along WSW-ENE). Contrastingly, the faulting pattern, east of Terceira Island suggests prevalence of co-axial oblique extension, focalized within the Terceira axis, and a stress field with maximum compressive axis vertical, and minimum compressive axis sub-parallel to the opening directions predicted by NUVEL-1A or GPS based (e.g REVEL, DEOS2K) kinematic models.

Plume lithosphere interaction

Claudia Adam, Centro de Geofísica de Évora, University of Évora

Many open questions remain on the dynamics of mantle plumes, their origin and their interaction with the lithosphere. I will show here how these processes can be studied through the use of geophysical observations. I will illustrate with a few examples how the precise determination of the swell morphology (obtained through a new filtering method especially adapted to the characterization of depth anomalies) constraints the plume trajectory and the origin of the volcanic chain (deep mantle plume or weakness zones in the lithosphere). A precise swell characterization also allows the study of the temporal evolution of plume buoyancy and magma production along long-lived plumes tracks. I will illustrate this with the study of Walvis and St. Helena chains. As they are the only long-lived hotspot chains in the South Atlantic, their characterization is important to constrain the processes associated with mantle plume formation, their temporal evolution, and the interaction with plate and mantle

dynamics. The compensation aspects (isotatic and dynamic) based on gravity fields will also be developed.

Late Pleistocene behavior of the Dead Sea Fault in the Jordan Valley from historical, archeological and paleoseismological data

Matthieu Ferry, Centro de Geofísica de Évora, University of Évora

The Dead Sea fault is one of the major active strike-slip faults in the world. The Jordan Valley segment, defined by the Sea of Galilee to the north and the Dead Sea to the south is capable of producing large and destructive earthquakes (Mw > 7.2), the most recent having occurred in A.D. 1033.

Taking advantage of the long and complete historical record, a rich archeological heritage and well-preserved geomorphology, we apply an integrated approach to decipher the faulting behavior of the Dead Sea Fault for the last 50 ky.

Along strike, the fault is outlined by small-scale releasing and restraining step-overs and systematically offsets streams in a left-lateral manner. The identification of six stages of incision, along with age correlations and offset measurements lead to the reconstruction of slip rate variations for the last 48 ky. In parallel, trench investigations at two sites reveal a total of 13 Mw ~7 earthquakes for the last 14 ky.

Both slip rate and earthquake history point to an episodic behavior of the Dead Sea Fault with episodes of high seismic activity separated by periods of quiescence.

The SpaceFusion* project and its applications to Earth Sciences

**(funded by the French Research Agency)*

André Jalobeanu, Centro de Geofísica de Évora, University of Évora and LSIIT Strasbourg, France

The originality of the project lies in considering data fusion as the estimation of a single model, of arbitrary spatial and spectral resolutions. The model is to be inferred from a number of observations, possibly from different sensors under various conditions. It is all about reconstructing a geometric and radiometric object that best relates to the observations and integrates all the useful information contained in the initial data. In order to minimize the loss of information, model uncertainties must be included in the final fusion product. Thus, our project also aims at computing quantitative error estimates, which are essential when one needs to measure physical quantities such as terrain height, slope or reflectance.

In Earth and planetary imaging, both terrain topography and image acquisition parameters must be taken into account to efficiently combine several images. Therefore, digital elevation model (DEM) generation is the first step towards data fusion. The topography is decoupled from the reflectance field that relates to the texture and color of the terrain.

We start by defining a generative model, enabling us to describe the image formation from a single 3D surface. The estimation of the model parameters and related uncertainties will be performed through hierarchical Bayesian inference. This enables us to integrate the physics of the studied objects by including all available a priori knowledge. It also involves observation models describing the data acquisition process (image formation and degradation). This approach will remain open since it will allow for model updating, in order to include new data into the model as soon as they become available.

The first stage of the method under development consists of Bayesian stereo vision: (1) infer a dense deformation map, (2) use it to calibrate the push-broom satellite geometry, (3) convert the disparities into a height field. The second stage will perform the actual data fusion, producing a compound object combining the radiometries from the initial data set and the estimated DEM. The fusion product features a DEM, a set of orthoimages and all the related uncertainties.

The result of the first step (disparity field) can also be used alone, to provide a robust way to measure the ground deformation from two images at different dates, despite the radiometric variations due to lighting and seasonal changes.

Probabilistic Modeling of Earthquake Occurrence: First examples of data integration within a Bayesian framework

Delphine Fitzenz, EOST Strasbourg, now at Centro de Geofísica de Évora
Steve Hickman, U.S.G.S. Menlo Park
Andre Jalobeanu, LSIIT Strasbourg, now at Centro de Geofísica de Évora
Chris Spiers, HPT lab Utrecht University
Yves Bernabé, EOST, now at MIT

Constraints on the recurrence times and the potential sizes of earthquakes on a fault are crucial pre-requisites for seismic hazard assessment. The recovery of fault strength as well as changes in effective stress after a large earthquake depend on the time-evolution of the hydraulic, frictional, creep and poro-elastic properties of the healing fault zone. The underlying physical and chemical processes determine how long it will take for different parts of the fault to reach failure again, thus controlling both the timing and size of the next rupture. We therefore propose to study these processes, from the micro-scale to their effect on macroscopic fault behaviour to contribute to a better understanding of seismic hazard.

In this context, the questions that we will try to address are therefore:

(1) Can we use lab experiments to constrain large-scale fault models? what are the limitations?

(2) What is the best way to infer microphysical processes from macroscopic measurements?

(3) How can we account for observational errors, model uncertainties, and potential deformation regime changes during each experiment?

(4) How and why build physics-based “renewal” models.