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I GEOPHYSICS

Oral presentations

1 A bayesian exploration of the 1992 Landers earthquake
Baptiste Gombert, Z. Duputel, R. Jolivet, C. Doubre, L. Rivera and M. Simons

The 1992 Landers earthquake (Mw = 7.3) is one of the two largest events recorded in continental United States over the last 50 years. While several studies have investigated this earthquake, published co-seismic slip models show sig-nificant dissimilarities. These discrepancies can primarily be attributed to the ill-posed nature of the slip inversion problem and to the use of various regularization constraints. Going forward, we propose a new co-seismic model obtained from the joint inversion of multiple observations in an unregularized and fully Bayesian framework. We use a comprehensive dataset including GPS, terrestrial geodesy, multiple SAR interferograms and co-seismic offsets from correlation of aerial images. These observations provide a dense coverage of both the fault vicinity and far-field deformation. To limit the impact of modelling uncertainties, we elaborate a 3D fault geometry designed from field observations, co-seismic offsets and the distribution of aftershocks. In addition, we account for uncertainty in the Earth model used to compute the Greens functions. Our solution includes the ensemble of all plausible models that are consistent with our prior information and fit the available observations within data and prediction uncertainties. Previous studies of the Landers earthquake pointed out the eventuality of a slip deficit at shallow depth (¡5km) that is not relieved by post- or inter-seismic deformation. We address this question in a probabilistic way and investigate the possibility of a biased slip deficit due to inelastic deformation at shallow depth reducing the co-seismic strain near the fault.
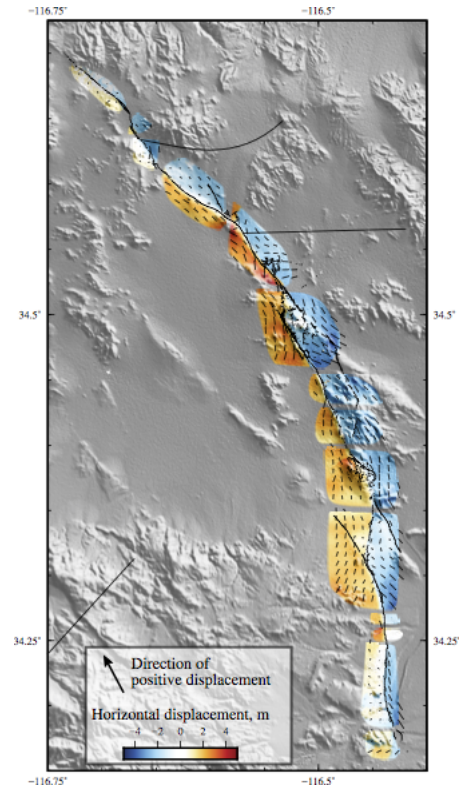
Figure: Coseismic near-field deformation of the 1992 Landers. The horizontal ground deformation is obtained through correlation of pre- and post-earthquake optical images.

2 Thermal microcracking in rock
Luke Griffiths

Thermal stressing induces changes in the physical and mechanical properties of rocks. These changes are generally considered to be a consequence of the generation of thermal microcracks and debilitating chemical reactions. The generation of cracks during thermal stressing has been monitored in previous studies using the output of acoustic emissions (AE), a common proxy for microcrack damage, and from microstructural observations. Here we present a new experimental setup that is optimised to record AE from a rock sample at high temperatures and under a servocontrolled uniaxial stress. We show the results of various tests on different rock types, to better understand the formation of microcracks under thermal (and mechanical) stressing, before exploring the effects of microcracks on the rocks physical properties.

Figure: Schematic drawing of the experimental setup at IPG Strasbourg.

3 Seismotectonics of the Bengal-Assam region, active faults, large earthquakes (Shillong plateau and Indo-Burmese fold and thrust belt)

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The Bengal basin and east Himalayan syntaxis need to be better understood in terms of active faulting and seismicity as this region is known for several major earthquakes during last 500 years (e.g. 1548 Bengal, M>8?; 1762 Arakan, M>8?; 1897 Shillong, Ms 8.7; 1918 Srimangal, Ms 7.6). The Eastern boundary of Bengal basin is marked by numerous NS trending folds of Indo-Burma Ranges. We focused on the Raghunandan Anticline, NE Bengal basin, a broad, asymmetric, growing ramp anticline, steep west-facing front and bounded westwards by a steep tectonic scarp truncating gently east dipping Quaternary sandstone beds. The scarp morphology is suggestive of a still preserved co-seismic free face above a colluvial wedge. More than 20 topographic profiles in the field and high resolution Pléiades DEM observation document a 12-15 m high scarp (above alluvial surface) and presence of 5 alluvial terraces hanging 3 m to 19 m above Shahapur River bed. C14 and Be 10 ages tell the story that the youngest T1 has been uplifted 3.5 ka cal BP. The western most exposed anticline in Bengal basin, the Lalmai anticline is also an asymmetric anticline. Evidences of tectonic geomorphology like steep scarp, perched and hanging valleys and uplifted terraces from Pléiades DEM (1 m resolution) studies suggest that the western border of this anticline has been cut by a thrust fault. The blanket of Quaternary sediment on top of this anticline indicates the anticline has been evolved in recent time. We also mapped major faults, rivers and Quaternary surfaces of the southern part of Shillong Plateau. Uplifted terraces identified on Pléiades DEM and noticeable knickpoints along the river longitudinal profiles will help to constrain fault activities. Hence, as a step towards a better understanding of fault activity, we began a detailed seismotectonic study of the eastern Himalayan syntaxis.

4 2D potential theory using complex algebra: new perspectives for interpretation of aeromagnetic data

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Source parameters determination using gravimetric or magnetic data is most often a qualitative exercise. For example, determination of the apparent inclination of magnetization is most often estimated by a trial and error approach. The development of potential field theory using complex algebra enable to better understand the effect of source parameters and to improve interpretations. 2D potential field equations can be written as complex functions of the complex variable outside bodies. This fundamental property in potential theory is the consequence that the corresponding functions are harmonic. In gravity and magnetism, potential, field and their derivatives are simple mathematical expressions and correspond to powers of the inverse of the distance for simple sources geometry. The attractive facet of this study is the graphical representation of the anomaly in the complex plane and the determination of the source parameters such as the geometry, the dip, and the apparent inclination. Gravimetric and magnetic anomalies correspond to loops passing through the origin. The shape of these curves only depends on the geometry of the source. For example, the complex magnetic anomaly of a cylinder has a power of -2 and the loop is a cardioid. For a dyke, the power is -1 and the loop is a circle. To use these new complex functions for real gravimetric or magnetic datasets, we compute data spectra and set them equal to zero for all negative frequencies.
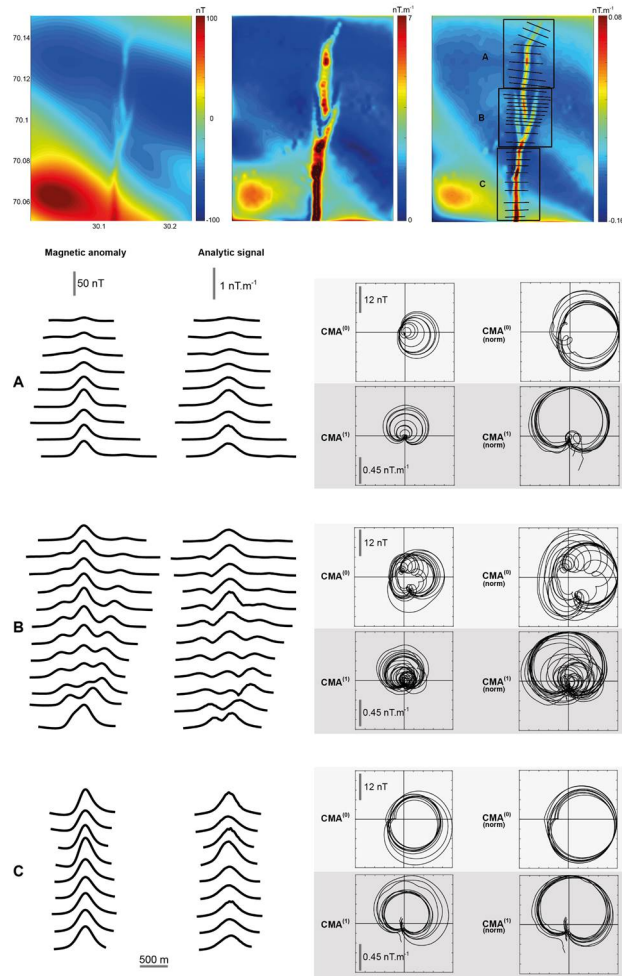
Figure:(a) Magnetic anomaly intensity of a Late Devonian dolerite, Store Ekkeroya, Norway; (b) Analytic signal; (c) vertical derivative. Lines indicate the location of extracted profiles and boxes the 3 area.

5 Automatic classification and location of seismic events triggered by clayey landslides

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Most of the detected seismic signals in clayey landslides could be associated to different sources such as rockfalls, micro-earthquakes, fissure openings or even fluid pressure transfers. Some recorded signals remain however not fully understood in terms of location and source mechanism. The need of large datasets is crucial to study a sufficient number of seismic events of the same type with high SNR. However, the analysis of long time series is time consuming as few automatic processing chains have been proposed until now for this kind of studies. In this work, we present the results obtained for classifying and locating seismic events from long seismological time series acquired at the Super-Sauze clay-rich landslide. We implemented an automatic classifier based on the Random Forests algorithm together with 71 attributes describing the signal features. The detected events were accuratly classified with more than 90% into four classes : micro-earthquakes, rockfalls, earthaquakes (regional and global) and natural and anthropogenic noise. The classified micro-earthquakes are then located automatically using beam-forming method with travel-time tables derived from a 3D P-velocity model. The results indicate that the seismic sources can be located with a mean epicentral error of 50m and the depth of the event can not be determined.

Poster presentations

6 Pore-scale study: Interface dynamics during drainage

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We experimentally study the interface dynamics of an immiscible fluid as it invades a monolayer of saturated porous media confined by a Hele-Shaw cell. The seemingly stable and continuous motion of the interface at macro-scale, involves numerous abrupt pore-scale jumps and local reconfigurations of the interface. As the system is drained potential surface energy is stored at the interface up to a given threshold in pressure, at which an instability occurs as new pores are invaded, the radius of curvature increases locally and energy is released. The energy released generates elastic waves in the confining plate, we detect the transversal mode of these waves using piezoelectric type acoustic sensors. By detecting pore-scale events emanating from the interface at various points, we look to develop techniques for localizing the displacement front. To assess the quality, optical monitoring is made using a high speed camera. In our study we also aim to gain further insight into the interface dynamics by exploring parameters such as the effective gravity, cell width and the invasion speed. Further investigation of the system involves using other methods for probing the system such as active tomography.

7 Magnetic signature of ships and magnetization predictions

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A ships hull is generally made in steel, and such amounts of ferrous material results in a large amplitude magnetic signature. It is important for a ship to control its magnetic signature because it can increase its vulnerability, to marine mines for example. This control implies ranging and magnetic field reducing systems called a degaussing system. The general goal of this PhD is to apply the algorithms and knowledge developed by IPGS for magnetic measurements to the problematics encountered by ECA EN in its activities of naval magnetism. The first axis of work concerns the ranging part. In naval magnetism, more often magnetometers are installed underwater at a small depth (10-30 m). In our approach, an unmanned aerial vehicle (IT-180 of ECA-Robotics) is used and measures the magnetic files of the ship above it instead of below. We show how this system called STERNA is used to obtain good measurements and to produce a model of the ship signature. The second part of the work concerns the degaussing system. We are designating an automated system to reduce in the best possible way the magnetic field due by the ship using electrical currents running inside loops installed inside the ship. Based on a few magnetic sensors installed inside the ship, this system should evaluate in real time the magnetic risk. Finally, we discuss the theory, synthetic cases and a scaled model (1/150) to improve the methodology usually used.

8 Radiation efficiency during a crack propagation: An analogical study

Camille Jestin

An earthquake is generated by a rapid release of the elastic potential energy along a fault, inside the Earth. Estimation of the radiation efficiency, the ratio between radiated seismic energy and dissipated surface energy, has long been a challenge for the seismology community. In the present study, we developed an analogic model which provides direct measurements of acoustic events, an optical monitoring of the surface energy and the loading forces necessary to sustain the crack propagation. This model is made of two Plexiglas plates anealed together. Heterogeneities are introduced along the interface between the two plates to make the fracture toughness fluctuates spatially. This sample is next submitted to a normal loading in mode I. The transparent material used (PMMA) allows for an optical imaging of the fracture front position at each time step. A synchronized acoustic monitoring enables the computation of radiated seismic energy under various conditions of toughness fluctuations and average crack velocity. Radiation efficiencies have been estimated and range from 107 to 102. The crack propagation velocity is shown to control the radiation efficiency as a power law observed in figure 1. Obtained values are in agreement with previous studies achieved both in laboratory: for instance, F. M. Boler and H. Spetzler, 1986, get values from 105 to 103; and at field scale: for example, G. G. Kocharyan et al., 2014, found, for 1308 events with magnitudes from 3.5 to 9.2, efficiencies going from 106 to 103.
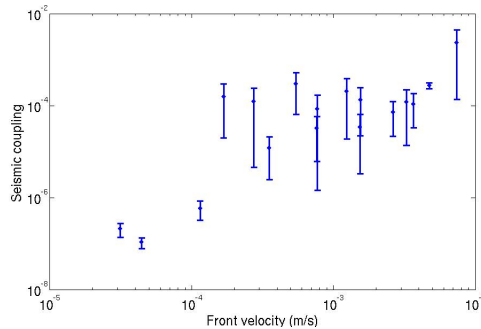
Figure: Radiation efficiency confronted to fracture front velocity.

9 Gravimetric observation of gravitational relativistic effects: synthetic tests on seismic modes analysis
Josipa Majstorovic

The unprecedented accuracy of the recorded time fluctuations of the Earths gravity field and the reached precision of the geophysical modelling nowadays open new frontiers in the geophysical research and also in the observation of gravitational effects on Earths deformation. The Earth is a large elastic body with infinite normal modes that will oscillate when a gravitational wave passes. Precise measurements of vibration amplitudes of the Earths free oscillations are necessary to search for the elusive gravitational wave signals. To estimate the gravitational effects in our data we have to be aware of the noise levels of the used instruments and the limitations of the analysis methods. The first step in our research will be to perform various synthetic tests. We will compute synthetic seismograms for a 3D Earth model, which take into account normal mode splitting, self-coupling and multiplet-coupling through lateral heterogeneities to quantify the limits and effects of the analysis methods (auto-regressive analysis, least-squares fit of a Lorentzian), the station distribution and the errors associated with the source.

10 Magnetic mapping around Les Saintes islands (Lesser Antilles, Guadeloupe) for structural interpretation

Jeanne Mercier de Lépinay[1,*], *M. Munschy*[1], *Y. Géraud*[2], *M. Diraison*[1] *V. Navelot*[2], *C. Verati*[3], *M. Corsini*[3], *J.-M. Lardeaux*[3]

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In Les Saintes archipelago, the outcrop analysis of Terre-de-Haut Island allows to point out several fault systems and geological objects such as lava domes and lava flows. Moreover, an exhumed geothermal paleo-system was identified. It is thought to be an interesting analogue of the active geothermal system of Bouillante, Guadeloupe [Verati et al., 2016]. To fully understand this area, the offshore continuation of the geological features is a major concern. The previously observed onshore features are visible on airborne magnetic maps due to the highly magnetized material in Les Saintes archipelago. Moreover, hydrothermal processes alter the magnetized minerals of volcanic rocks, creating a significant variation in the magnetic measurements.Therefore an adapted marine magnetic study can help the geological understanding of this particular area. In order to correctly link the offshore and onshore structures, the magnetic survey must be close enough to the shoreline. It must be also detailed enough so as to correctly outline the tectonic structures. An appropriate solution for such a survey was to use a magnetometer aboard a speedboat.

Fig.: Total magnetic intensity of the new high resolution magnetic survey around Terre-de-Haut Island, les Saintes, Guadeloupe.

Such a boat allows more navigation flexibility than a classic oceanic vessel towing a magnetometer; it can sail at higher speed on calm seas and closer to the shoreline. The use of magnetic field transformations allows a large variety of structures to be highlighted and help to build a general understanding of the nature and the distribution of the magnetic sources.

9

11 Two and three dimensional THM modelling of the Soultz-sous-Forêts geothermal reservoir : a comparison

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Many numerical models have been developed in geothermal reservoir engineering to reproduce field measurements of the natural state or to predict exploitation scenarios. The models of geothermal reservoirs often include hydrological and mechanical processes or thermo-hydrological coupling. However, few geothermal models study the three coupled processes at the time and their geometry remain simple or two-dimensional. We propose a comparison between two models with thermo-hydro-mechanical coupling. The first model is two dimensional and based on an idealized cross-section of the Soultz-sous-Forts reservoir. The second one is an extension of the latter in the third dimension. We compare the simulated natural state for similar physical configuration and the dimensions. Here, the two and three dimensional results show that the dimensionality of the model can be a sensitive parameter. For the conductive case, no significant variations are observed between the two and three dimensional models on temperature and Darcy velocities profiles. Some differences are observed for the natural convective state : the temperatures and Darcy velocities from the three dimensional model are respectively about 10 degrees and 70% higher than those obtained by the two dimensional model. Consequently,

Figure: Calculated Darcy velocities from the 2D and 3D models for the convective case. The maximum norm of Darcy velocity is about $2,04.10^{-9}$ m/s in 3D and $1,21.10^{-9}$ m/s in 2D.

resorting to a two dimensional model for the conductive state would be a great saving of CPU time. However, the discussion of the observations is limited by the important assumptions of our models : the radioactive heat sources have been neglected and no regional fault has been considered. Further works are currently in progress to these issues.

12 Fiber Optics Distributed Temperature Sensing (FO-DTS) for long-term monitoring of soil water changes in the subsoil

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The tracing of water infiltration and the monitoring of soil water content at high spatial and temporal frequency in the vadose zone is a key element of various hydrological, agronomical, ecological and environmental studies. In this work, we develop a processing method for the quantification of soil water content changes from the measurements of soil temperature using Fiber-Optics Distributed Temperature

Sensing. The monitoring site is the Draix-Bleone catchment in the South French Alps, mainly composed of weathered clay-shales and characterized by a heterogeneous clay-rich soil. A 350 m length of reinforced fiber optic cable buried at 0.05, 0.10 and 0.15 m of depth and at the soil surface along a 60 m profile is used. The monitoring profile crosses three different soil units consisting of argillaceous weathered black marls, silty colluvium under grass and silty colluvium under forest. Soil temperature is measured every 6 minutes at a spatial resolution of 0.5 m using a double-ended configuration. Passive and active measurements are carried out. First, pre-processing of the temperature data is presented using controlled reference baths. Second, we show that the spatial and temporal variation, although first linked to the air temperature variations are related at the second order to the occurrence of rainfall events. The changes of soil temperature for the three units are compared for a period of six months. They indicate different processes of water infiltration at different velocities in relation to the presence of roots and the soil permeability. This indirect measurement technique is promising for the future; some limitations in the measurements are also discussed.

II GEOLOGY

Oral presentations

1 Magmatic intrusions in exhumed mantle of magma-poor rifted margins:evidences for the close assoctiation between deserpentinization, chloritization and rodingitization processes.

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Deserpentinization, Ocean-Continent Transition (OCT), chloritization, Sr-Nd-B isotopes. Recent studies have demonstrated that tectonic, magmatism and hydration are key features that control the oceanization process from the rifting to the establishment of the first oceanic crust. In this frame, studying Ocean-Continent Transitions (OCTs) offers a unique opportunity to investigate the interactions between magma, mantle and fluids and assess their feedback mechanism and enhancers. The Upper Penninic Platta nappe (Southeastern Swiss Alps) is probably the best example of fossil OCT documented so far: This unit corresponds to the exhumed mantle section of the Liguro-Piemont magma-poor-rifted margin that has been well-preserved and only weakly affected by alpine metamorphism (prehnite-pumpellyite facies). This section is characterized by numerous rondingitized gabbroic dikes and bodies intruding the present-day strongly serpentinized peridotites. The aim of this study is to estimate whether the magmatic intrusions occurred before, during and/or after the mantle serpentinization on the basis of petrological and geochemical approaches. Mineralogical observations and Raman spectroscopy show that rodingites consist of an assemblage of chlorite and multiple generations of clinopyroxene, while the mantle section away from the contact is mainly composed of serpentines (lizardite chrysotile) and relics of primary minerals (olivine + pyroxenes). At the contact with dikes, the mantle is turned into a chlorite reaction zone where clinochlore has almost completely replaced the serpentine, suggesting a process of deserpentinization and subsequent chloritization of the mantle rocks. Radiogenic (Sr, Nd) and stable (B) isotopic data show that magmatic intrusions and their contacts have very similar compositions. This demonstrates that rodingitization and chloritization

processes occurred after the circulation of fluids of a single origin. We argue that fluids released during the mantle deserpentinization in response to the magmatic intrusions are responsible for both rodingitization and chloritization processes.

2 Termination of the Pan African strike-slip shear zones of the Illizi-Berkine area of Algerian Saharan Platform: insights from aeromagnetic data
Sonia Brahimi

The Berkine and Illizi are intracontinental basins, occupying the southeastern part of the Algerian Sahara Platform, at the northeastern junction of the Hoggar terranes with the East Saharan Metacraton. The basement underlying the basins is regulated by a Pan-African structuration extending northwards as far as the Saharan Atlas. During the late pan African orogeny, the terranes of central Hoggar were squeezed between the West African Craton and the Saharan Metacraton. This collision generated a large horizontal movement along the north-south 4°50E and 8 °30E shear zones. Aeromagnetic data covering an area of about 300.000 km^2, including the Illizi, Berkine, Tassili and northeastern part of the Hoggar, are compiled to obtain a magnetic map with a special resolution of 800 m and interpreted in the light of that of the adjacent Hoggar Shield, the structural geology of which is well documented. The interpretation of the magnetic map uses potential field transformations like reduction to the pole, fractional vertical derivatives, analytic signal and tilt-depth. These transforms allow improving the knowledge of the basement structures of the Illizi-Berkine beneath the thick sedimentary cover: shear zones, plutons and granitods; and especially to identify the northern termination of the main North-South shear zones. The 8°30 and the 4°50 shear zones terminate in arc curvature and the 7°30 terminates in a fan-like structure, bifurcating from the main shear zone.

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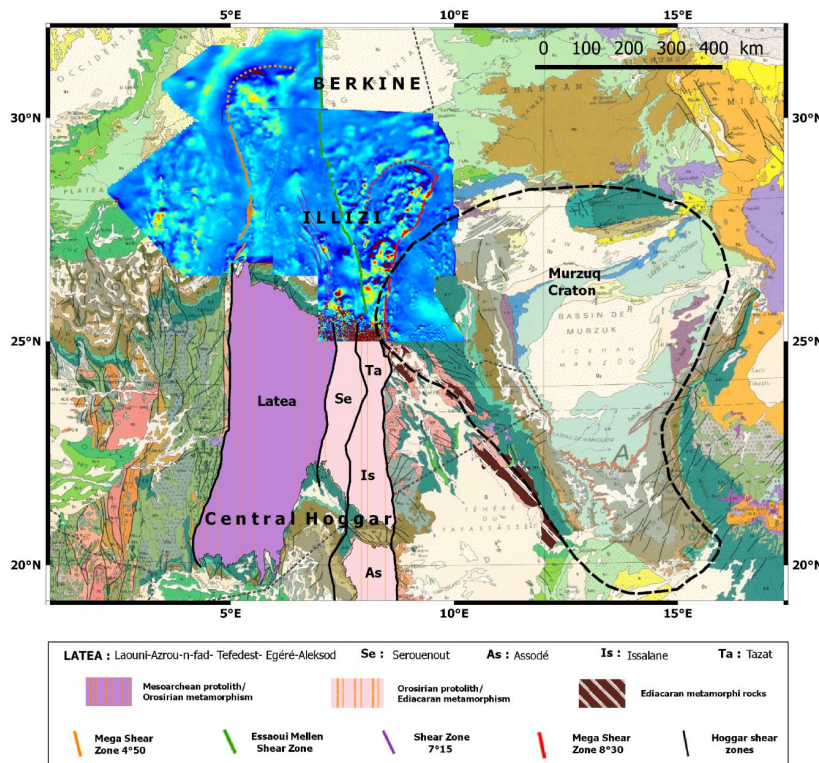
3   3D architecture of ultra-distal magma-poor rifted margins: the example of the fossil Err and Platta Ocean Continent Transition exposed in the Central Alps in SE Switzerland

Marie-Eva Epin, Gianreto Manatschal, Méderic Amann, Robin Walter, Marc Lescanne

Despite the fact that many studies have investigated magma-poor rifted margins, there are still numerous questions concerning the 3D architecture of the Ocean-Continent Transitions (OCT) and the tectono-magmatic processes related to lithospheric breakup. Indeed, it has been observed that the top basement morphology of OCTs at magma-poor rifted margins is heavily structured and complex. The aim of this study is to describe the 3D top basement morphology of OCTs and to define the processes and the timing of their formation. To do this, we focuse on field observations in the Err-Platta nappes (SE Switzerland) which expose over about 300 km little overprinted remnants of the fossil Jurassic OCT of the Alpine Tethys. First the results of the study show spectacularly exposed structures of the OCT, highlighting the important 3D architecture of the hyperextended crustal and exhumed mantle domains. The key structures are a set of fossil detachment systems showing a complex polyphase tectono-magmatic evolution. The overall observations provide important information on the temporal evolution and spatial organization of the structural and magmatic systems in ultra-distal magma-poor rifted margins. These systems are at the origin of the creation of the ultra-distal parts of rifted margins and are important for the understanding of the processes controlling lithospheric breakup and creation of a new plate boundary. In this context, our field observations can help to better understand the tectono-magmatic processes for the not yet drilled ultra-distal magma-poor rifted margins.

4   Coastal large earthquakes and evidence for paleotsunami deposits along the Mediterranean coast of Egypt

Asem Salama and Mustapha Meghraoui

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Tsunami deposits and large dragged boulders are investigated along the Mediterranean coast of Egypt in the framework of the EC-Funded ASTARTE project (Assessment, Strategy And Risk Reduction for Tsunamis in Europe - FP7-ENV2013 6.4-3, Grant 603839) and the French-Egyptian IMHOTEP project. The targeted zones located west of Alexandria are selected according to historical earthquakes and related inundation events as recorded in archives. Field investigations include: 1) Coastal geomorphology along estuaries, wedge-protected and dune-protected lagoons, and terrace-platforms as potential sites for paleotsunami and boulder records and 2) Investigations of paleotsunami deposits and their spatial distribution using trenching and coring. The two selected sites at Kefret Saber (immediately west of Marsah Matrouh town) and near El Alamein village are inner lagoons protected by 2 to 40 m high dunes parallel to the shoreline. Five trenches and six cores dug in Kefret Saber revealed 5 to 10 cm thick white sand unitwith highly reworked fossil-rich and shells at about 20 to 40 cm depth, intercalated in light brown laminated sandy and sandy-clay deposits. An almost identical white sand observed in a trench and 12 cores at Alamein show a succession of coastal sedimentary units with catastrophic deposits with mixed sand, gravel and broken shells among others. A total of 50 samples of organic deposits and charcoal fragments were collected from both sites, among which 20 samples have been dated. Dated charcoal in deposits above and below the white sand unit lead us to correlate with the 24 June 1870 major earthquake (M 7.5 - 8.0?) that generated a tsunami with the inundation of Alexandria harbor. Major seismic sources being along the Hellenic subduction zone and Cyprus arc, our progress study of paleotsunami deposits and their distribution along the Egyptian coast will help to better constrain the size and recurrence of tsunamis, and their propagation over the east Mediterranean regions.

5 Permeable fracture zones observed from well-logging data in deep geothermal boreholes of Rittershoffen, France

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The Upper Rhine Graben is a Cenozoic rift characterized by a series of geothermal anomalies such as the ones at Soultz-sous-Forêts, Rittershoffen and in the surrounding area of Strasbourg in France, and also in Landau, Insheim and Brhl in Germany. These geothermal anomalies are interpreted as the hydrothermal circulations through the multi-scale fracture network at the sediment-basement interface. Between 2012 and 2014, a geothermal doublet was drilled at Rittershoffen (Alsace, France) in order to exploit the local geothermal anomaly. The geothermal target was the local Rittershoffen fault striking N-S and highly dipping westward with a 200 m apparent vertical offset. Acoustic image logs were analyzed in open-hole section of the wells GRT-1 and GRT-2 and correlated with permeability indication such as temperature anomalies and/or mud losses during drilling operations in order to identify permeable fracture zones. The main fracture orientation in GRT-1 is N10°E to N20°E dipping westward. In GRT-2, the main fracture orientation is N160°E to N-S dipping eastward or westward. Less than 3% of fractures present natural permeable indication at borehole scale. One permeable fracture zone was observed in the granitic basement of GRT-1 whereas no obvious evidence of permeability was observed in Triassic sandstones. Four permeable zones were observed in the granitic basement of GRT-2 and two in sandstones. Permeable fracture zones present complex cluster organization with major permeable fracture surrounded by an alteration zone. They are all associated with positive or negative temperature anomalies. This study provides a first approach of the geometrical model of permeable fracture network in the vicinity of geothermal boreholes.

Poster presentations

6 Research on the traces of earthquakes in the sedimentary series of the Quaternary of the Tell Atlas (northern Algeria)

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Due to the compressive regime related to Africa-Eurasia rapprochement, geological structures in northern Algeria (southern margin of the western Mediterranean sea), and the Tell Atlas in particular, have been the source of large earthquakes during the Quaternary. This is evidenced by the visible active deformation in Neogene and Quaternary sedimentary basins (coastal and intra-mountainous). In 1980, an earthquake with magnitude Mw 7.1 occurred in El Asnam region. The main shock occurred along the fault-related folding structure of
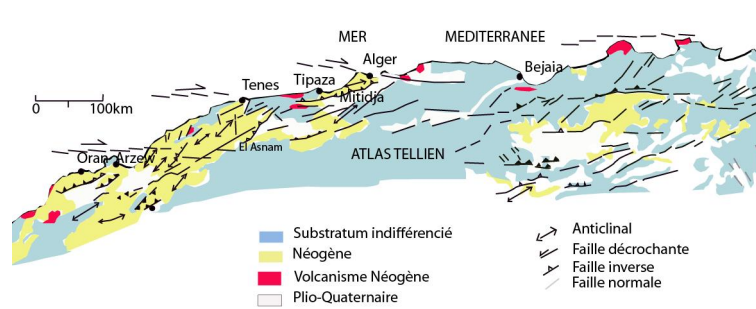
Figure: Neotectonic framework of the Tell Atlas (Meghraoui, 1988).

El Asnam. Through the Algerian Tell, many structures (Fig.1) show a similar geometry to the previous one, these include: Zemmouri area, Sahel d'Alger, Boukadir, the fault related faulding of Dahra, Tenes Abu Al Hassan, El Magtaa structure, Mourdjadjou and Tafna structure. In the Zemmouri region an earthquake of magnitude Mw 6.8 occurred in 2003. The fault was not known by seismologists until this event. Historical earthquakes of 1365, 1716 and 1825 attest to the existence of a recurring seismic activity near Algiers (Algiers Sahel). Thus, in this paleosismological study, we aim to get a better understanding of the relationship between the fault related faulding and earthquakes in the past. The evolution of these active quaternary structures will be determined based on geomorphological, geological and seismological approaches. The determined parameters can be used to improve our knowledge on seismic risk and hazard in these regions and cities built over or around them.

7 The role of transfer zones in the formation and reactivation of hyperextended rift systems: the example of the Mauléon-Basque-Cantabrian basins

Rodolphe Lescoutre[1], Emmanuel Masini[2], Gianreto Manatschal[1]

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Numerous studies have revealed the importance of rift-inheritance on the formation of orogens but little consideration was given to rift segmentation and the role of transfer zones on the architecture of mountain belts. Our study focuses on the Basque region (Pyrenees) and more particularly on the Pamplona transfer zone that delimits the Mauléon-Arzacq rift system to the east from the Basque-Cantabrian system to the west. The aim of this study is twofold: 1) describe the role of the Pamplona transfer fault and define its tectonic evolution associated to adjacent basins, and 2) understand its role during reactivation. The influence of the Pamplona fault system on the structuration of the Mauléon and the Basque-Cantabrian basins is substantial as expressed by their large offset and the occurrence of exhumed deep crustal and mantle rocks flooring the two basins. Fieldwork in the Labourd Massif enabled to describe faults and their relations to hyperextension and sedimentary sequences. Sparsely reactivated faults show a peculiar reorientation approaching the transfer zone. In the Basque-Cantabrian basin, preliminary field observations show a well-preserved ultra distal domain thrust northward along the Leiza fault. This distal domain is composed of high temperature - low pressure rocks that have not been recognized in the Mauléon basin. These observations show a different mode of deformation on either side of transfer faults during extension and compression with rather well preserved rift structuration. This suggests a key control of transfer systems at crustal and lithospheric scale during formation and reactivation of hyperextended systems.
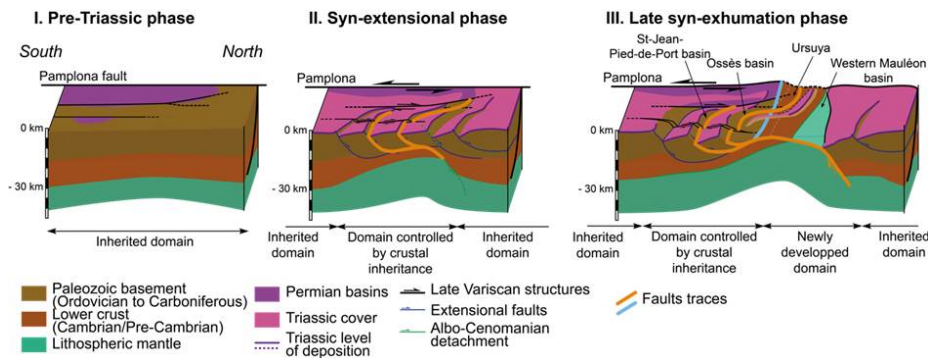
Figure: 3-Dimensional evolution of the Pamplona transfer
zone during Mesozoic rifting

8 Study of the petroleum system of the Ivorian Basin
Fofana Bakary, Luis Martínez, Ariana M. Vazquez Almaguer, Dobo Kalou Hervé, Koné K. Lamissa

Cote dÍvoire Basin is predominantly an offshore basin (97.5%) which is bounded to the east and west by major strike slip faults Romanche and St Paul Fracture Zones respectively. The rifting period seems to starts in the early Aptian. The end of the rifting stage is marked by an unconformity of the late Albian age. From early Cenomanian to Santonian has undergone uniform thermal subsistence. After Santonian, it has been subjected to a classic margin subsiding evolution. Cote dIvoire basin contains very rich source rocks. The richer are Albien, upper Senonian and Cenomanian. There are three types of source rocks in this basin (type I, II and III). The Albian sediments are generally mature for oil generation with fair to good organic content and good petroleum potential. Variations of heat flows are important and some wells present erosions based on basin tectonic. The best reservoirs rock are Albian and Cenomanian with values of porosity and permeability respectively of 20% average, 44 mD average and 14% , 186 mD average. The Ivorian basin contains mature and immature rich sources with good potential and reservoirs. We will establish the model in order to well understand the petroleum system.

9 The genesis of Iron oxide-Apatite deposits in The Tarom Zone, SE Zanjan, NW Iran
Shahin Ghahramani and Hubert Whitechurch

The Tarom volcano-plutonic zone in northwestern Iran is part of the Cenozoic AlborzAzarbaijan magmatic belt. This area is covered by Eocene marine volcanic rocks including pyroclastic and lava flows of trachyte, trachy-andesite, andesite, basaltic andesite, olivine-basalt, porphyritic and non-porphyritic rhyodacite with high-K calc-alkaline to alkaline affinity. The volcanic rocks are intruded by a NW-trending batholith of Upper Eocene quartzmonzonite to quartz monzodiorite. The plutons are I type granitoids of calc-alkaline affinity, The age is post-Eocene-Early Oligocene. The iron oxide-apatite deposits including Sorkhe-Dizaj, Morvarid, Aliabad, Zaker, Eskandar, Golestan Abad and Zarnan, are hosted by quartz monzonite and subordinately by andesitic tuff. The host rocks are extensively altered. The iron ore is composed of magnetite with apatite, pyroxene,and actinolite. Many veins include prismatic up to 20 cm long apatites. The main types of mineralization are: (1) dissemination of magnetite and apatite in the host rock, (2) massive vein-type ore, (3) stockwork, (4) banded magnetiteapatite, and (5) minor brecciated ores. First results in geochemistry of plutonic rocks show that the iron oxide apatite mineralization is formed by a quartz-monazonitic magma with calk-alkaline affinity, that occurred in a magmatic arc setting, First results on Oxygen isotope on magnetite only in Sorkhe-Dizajand Aliabad deposits show that the magnetite-apatite veins formed from a predominantly magmatic-derived fluid, The first hypothesis are the quartzmonzonitic pluton served as the most likely source for ore fluids and metals. We will use the following methods to test these hypothesis in all of deposits on the samples collected in November durin:

- Petrography and mineralogy of plutonic, volcanic, and altered rocks by thin sections;
- Mineralogy of Iron-Apatite ores including REE minerals by polished section and SEM;
- Mineralogy of different hydrothermal alteration facieses by XRD;
- Geochemistry of plutonic, volcanic, and altered rocks and Iron-Apatite ores by ICP-MS;

III GEOGRAPHY

Oral presentations

1 Active remote sensing data time series for floods detection and surface water mapping

Filsa Bioresita[*,1,2], *Anne Puissant*[1], *André Stumpf*[2]

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Surface waters are essential for human live, food crops, and ecosystems but can also pose hazards to human settlements and infrastructures (e.g. floodplain flooding). Reliable information about the spatial distribution of surface waters is critically important in various scientific disciplines, especially when floods occurs. Monitoring spatial distribution of floods will be very usefull for observe the effect of floods in their surrounding areas. Synthetic Aperture Radar (SAR) remote sensing is an effective way to monitor floods distribution over large areas. It provides excellent temporal coverage and, in certain situations, enables to determine the floods extent through emergent plants and forest canopies. Sentinel-1 satellite Images are a new available SAR data. Their spatial resolution and short temporal baselines have the potential to facilitate the monitoring of surface waters changes which are very dynamic in space and time. Existing methods for surface waters extraction from SAR image are often based on manual processing and need user intervention. These methods also commonly used direct threshold based on pixel values and ignoring the correlation with nearby pixels. Thus, in this research, the originality consists to use bilateral filtering as one of smooth labeling methods after per-pixel classification to increase accuracy of results. This research proposes an automatic chain processing for floods rapid mapping with smoothness method and suitable with Sentinel-1 SAR data. Results shows automatic chain processing were succesfully extracted surface waters areas and detected floods distribution in study case areas (Ireland and England) from Sentinel-1 images. Furthermore, the proposed smootness methods improve the overall accuracy.

2 Energy transition of Urban Territories
Sophie Buessler, Weber Christiane and Dominique Badariotti

The aim of my thesis is to study the potential of energy mix in urban territory. Thus, different results are to be proposed and applied to the Eurométropole de Strasbourg (EMS): (i) estimate the local technical potential of renewable energy (RE); (ii) estimate the potential reduction of consumption of the housing sector; (iii) studying the perception of renewable energy by households. The optimization and evaluation of the energy mix are based on two components. The first, which is a socio-technical one, focuses on actors (groups, skills, constraints to the energy transition, behavior). This component includes individual interviews, graphs method and survey. The second methodological and technical component is based on data collection among actors. All data were geolocated using a Geographic Information System (GIS). Different maps obtained thereby could be crossed in order to visualize information with different items (consumption, production).
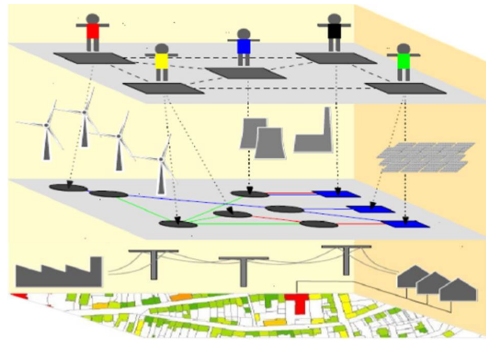

Image source: T.Wittmann and T.Bruckner (2007)

3 First large application of closed partially ordered patterns to data collected for the French national ecological assessment of rivers: toward a new approach to understand the state of aquatic ecosystems
Corinne Grac, Xavier Dolques, Florence Le Ber, Agnès Braud, Michèle Trémolières, Jean-Nicolas Beisel

In France, a National network has been created to assess the river ecological state according to the European Water Framework Directive (WFD, 2000). It produces big data, as chemical results and biological indices regularly collected along a set of 1800 locations. To explore the relationship between biological responses and potential chemical pressures, we implemented a specific data mining process to these data. The process generates frequent closed partially ordered patterns (CPO-patterns). A sequential pattern is a succession of chemical events that can be verified by the preceding samples of a biological state assessment for a station in one or several cases. We revealed the interest of this tool: (i) it is rapid and performing, (ii) CPO-patterns always gave coherent results between chemical and biological states, (iii) original results were detected. For example, chemical states were often better than biological state what suggest synergism between toxicants and/or an additive impact of other pressures related to hydromorphology or hydrology. Another original result is that depending on the biological index chosen, chemical parameters in the CPO-pattern varied. That suggested a differential sensitivity of the biological compartments to different chemical pressures. We discussed the perspectives to use CPO-patterns on water data analysis to improve our understanding of the state of aquatic ecosystems.

4 Sensitivity analysis of the air quality model INCA-Indoor to few input parameters using automatic differentiation
Fangfang Guo[*1], *Nadège Blond*[*1], *Isabelle Charpentier*[*2],*Maxence Mendez*[1], *Didier Hauglustaine*[1,3], *Jean-Luc Ponche*[1,4]

[1]Laboratoire Image Ville Environnement (LIVE), UMR 7362, CNRS/Université de Strasbourg, Strasbourg, France; [2]Laboratoire des sciences de l'ingénieur, de l'informatique et de l'imagerie (ICUBE), UMR7357, CNRS/Université de Strasbourg, Strasbourg, France; [3]Laboratoire des Sciences du Climat et de l'Environnement (LSCE), UMR8212, CEA/CNRS/UVSQ, Gif-sur-Yvette, France [4]Institut de chimie et procédés pour lénergie, lenvironnement et la santé (ICPEES), UMR7515, CNRS/Université de Strasbourg, Strasbourg, France

INCA-Indoor, a new indoor air quality (IAQ) model is developed to simulate the concentrations of the indoor major chemical species which may impact the health. A sensitivity analysis of the INCA-Indoor model is performed to identify the most sensitive parameters and processes. Our objective is to identify the main chemical reactions pathways and the physical parameters that affect indoor hydroxyl radical (OH) concentration which is the major oxidant that initiates the degradation of many primary volatile organic compounds (VOCs) to product secondary species, which may be harmful to peoples health. In this communication, a first sensitivity analysis is carried out using a differentiation algorithm, called hereafter TAPENADE. It is applied here to calculate the local sensitivities defined as partial derivatives of indoor species concentrations with respect to the model parameters. The sensitivity analysis shows that indoor OH is highly sensitive to changes in outdoor concentrations of O3 and NO, gas phase reaction rate constants of D-limonene/OH, D-limonene/O3, ethanol/OH, indoor ethanol emission rate, air exchange rate, and indoor O3 deposition velocity when the ventilation is activated, during which the peak OH concentration attains.

5   Global study of ecosystem dynamics in a context of ecological restoration by sediment recharges and bank erosion in the Upper Rhine River

Cybill Staentzel[1], Isabelle Combroux[1], Michèle Trémolières[1], Laurent Schmitt[1], Agnès Barillier[3], Jean-Nicolas Beisel[1,2]

[1]Université de Strasbourg, CNRS, LIVE UMR 7362, F-67000 Strasbourg; [2]Ecole Nationale du Génie de lEau et de lEnvironnement (ENGEES), F-67070 Strasbourg; [3]EDF CIH - Service Environnement - Savoie Technolac

Over the last two centuries, the Upper Rhine River was subjected to important hydraulic engineering works which have severely damaged its functioning. These changes (rectification, groyne construction, damming and lateral channel construction) have resulted in severe hydromorphological changes that have contributed, among others, to purge the river a part of its coarse sediment load and greatly alter the biodiversity of the entire floodplain. These effects concerned particularly the "Old Rhine", a 50km long by-passed single bed channel, which is located downstream the Kembs dam. Given these functional deficits, restoration actions were initiated via experimental sedimentary recharge and erosion works control. We explored how the modification of the physical environment should lead to a structural and functional diversification that is likely to restore typical biodiversity of alluvial environments. Three biological compartments closely related to the physical quality of the environment were studied: vegetation, macroinvertebrates and fish. The general objective of the study includes the assessment of ecological impacts of restoration actions and the identification of factors of sustainability and effectiveness, in a context of multiple pressures (climate change, water pollution, biological invasions and food web changes). The results of this research will yield concrete keys to the management of large rivers about biological responses to restoration, species interactions in biodiversity structuring, sensitivity of these river ecosystems restored to invasive species and relationship between geomorphology and ecology.

Poster presentations

6   Geomorphic responses of restoration actions: the case of the Old Rhine River downstream of Basel

Valentin Chardon

Over the last two centuries, the Upper Rhine has been strongly impacted by engineering works (e.g. straightening, construction of groyne fields, damming, by-passing and flow diversion), notably for flood protection, navigation, and hydro-electricity production. This 50 km reach is divided into two water ways regulated in the mid-20th century. Most of the flow (until 1400 m3/s) is permanently diverted by the Kembs dam into the Grand Canal d'Alsace equipped with four hydroelectric power plants: Kembs, Ottmarsheim, Fessenheim and Vogelgrn. A minimum flow is routed into a by-passed section named the Old Rhine. This reach exhibits poor ecological functionalities due to severe geomorphic alterations. In the frame of a relicensing of the Kembs power plant (2010), Électricité de France has undertaken three restoration actions in order to improve bedload supply and transport along the Old Rhine: two artificial gravel augmentations (18 000 and 30 000 m3) into the streambed and one bank protection removal to promote controlled erosion of the left bank. A geomorphic monitoring is performed to assess the effects of such actions, in terms of efficiency and sustainability. It is based on bedload tracking, grain size analyses and topo-bathymetric surveys. An ecological monitoring is also performed (PhD of Cybill STAENTZEL) and is complementary to our PhD. The main preliminary results can be summarized as follows: (i) the mobilization of gravel deposits occurs for a two year flood, (ii) gravels are mainly transported in the center of the channel, (iii) morphological and grain size diversification is still limited following gravel augmentation but more significant along the controlled bank erosion section . Morpho-sedimentary indicators are developed to assess efficiency and sustainability of restoration actions, as well as to provide recommendations for future restoration projects along the Old Rhine.

7 Point clouds time series analysis for monitoring landslide processes: displacement field analysis using image matching algorithms

Pierrick Bornemann[*1,2], *Anne Puissant*[1], *Jean-Philippe Malet*[2]

[1]MCF HDR Université de Strasbourg LIVE; [2]CR CNRS HDR IPG

Time series of dense 3D point clouds have proved useful for long-term monitoring of slope movements. However, such datasets are large and complex and therefore require accurate and efficient processing methods. Image-based feature tracking methods that rely on the use of interpolated 2D data are able to provide a robust and precise estimation of surface movements. We propose and compare two approaches to compute the displacements fields using image matching algorithms on interpolated intensity images: a hierarchical multi-scale image correlation algorithm and an optical flow algorithm based on the LucasKanade method. Both methods produce an estimation of 2D displacements in image plane, from which 3D displacements can be reconstructed through a back-projection procedure using high-resolution gridded DEMs. Both methods are applied on time series of Terrestrial Laser Scanning point clouds acquired in the French Alpes on the Sanières rockslide (2013-2015), the Super-Sauze earthflow (2007-2016) in the Ubaye Valley, and the Séchilienne rockslide in the Romanche Valley (2009-2015). Computed displacements are compared to GNSS and total station surveys on reference targets and to features tracking on the 3D point cloud for validation. The results indicate that both methods provide an accurate estimation of surface displacement fields and deformation patterns but show limitations such as the inability to track non-rigid deformations, the use of a perspective projection does not maintain angles and distances on the interpolated images, and uncertainty on the interpolation accuracy in case of occluded or insufficiently dense ground areas.
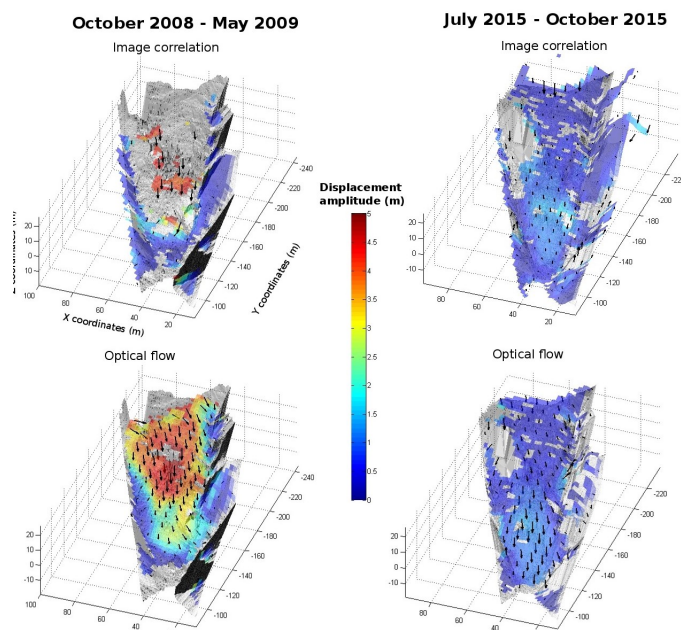
Figure: Example of results on the Super-Sauze dataset

8 How to establish the link between hydromorphological and ecological indicators in a context of river restoration?

Nadia Fernandez[1,2,3]*, Frédéric Labat*[1]*, Corinne Grac*[2,3]*, Bruno Fontan*[1]*, Jean-Nicolas Beisel*[2,3]

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The French national standard to describe hydromorphological measurements is called CarHyCE (Characterization of streams hydromorphology). This habitat survey method is applied on river stretch of 14 times the full bank river width. A large variety of parameters are taken into account, measured or evaluated on field: geometry of the bed and width, depth and flow, slope of the water line, description of channel geomorphic units, granulometry, organic substrates, type and thickness of river bank vegetation, longitudinal and lateral continuities. In the framework of restoration programs, we explore the relationships between hydromorphological features and bio/ecological traits of macroinvertebrates within the four dimensions of the river ecosystems. For example, considering the lateral distribution, the CarHyCE protocol provides the full bank height and width, what could potentially be used as a ratio correlated with several traits such as the transversal distribution describing the use by species of hydraulic annexes. We explore these potential relationships within the framework of a PhD devoted to the research of biological indicators of river restoration programs (mainly over at least 5 years in ranks 2 to 6 according the Strahler classification). The test of several hypotheses could help to integrate species traits in the evaluation methods of river restoration to transform descriptive community ecology into a predictive science.

9 The ergonomics of access to everyday facilities by urban public transportation (bus and tramway) and soft mobility: Creating a measuring tool and a decision support applied to the Eurométropole of Strasbourg

Wassim Hached, Eliane Propeck Zimmerman and Dominique Badarotti

My research forms part of the sustainable development research domain. The political commitment is partially reflected by local urban policies. In this case transport is a recursive question. The aim of the cities is to lessen the negative impact caused by the transport of goods and people. They try to reduce the domination of the city by cars; decrease distances travelled by polluting means of transportation and propose alternative solutions. These policies affect the morphology of urban space and change it. This can bring out new risks. The RED project (Risques Emergents de la mobilité Durable) analyses in detail these various risks. I am interested on the impact of the sustainable mobility system on citizens' daily life by focusing on urban public transport means and soft mobility infrastructure. My goal is to create a GIS measurement and cartography tool of ergonomics of access to everyday resources. Its aim is to take into account many factors which can encourage or discourage people to adopt sustainable mobility such as: accessibility, space ergonomics like defined by T.Saint-Gerard, the social factor and the quality of urban space. This tool will be applied to selected areas at first and then, after some investigations, to the whole Eurométropole of Strasbourg. This statistical and mapping tool could be used as a support to take decisions which help for the detection of socio-spatial disparity, the optimization of the supply of sustainable mobility infrastructure at lower cost, and the simulation of the impact of changes in infrastructure on the life of everyday citizens.

IV HYDROLOGY AND GEOCHEMISTRY

Oral presentations

1 Calcium isotopic fractionation during sorption (adsorption/desorption) phenomenon onto soil secondary minerals
Jean-Michel Brazier[1], Anne-Désirée Schmitt[1], Sophie Gangloff[1] and Emmanuel Tertre[2]

[1]Laboratoire d'Hydrologie et de Géochimie de Strasbourg (LHyGeS), Université de Strasbourg, CNRS : UMR7517, 1 rue Blessig, F-67084 Strasbourg Cedex - France; [2]Institut de Chimie des Milieux et Matériaux de Poitiers, Université de Poitiers/CNRS, UMR 7285 IC2MP, Bat. B8 rue Albert TURPAIN, TSA 51106 - 86073 Poitiers CEDEX 9. - France

A better knowledge of nutrients dynamic into the soil has to be attained to ensure a sustainable management of natural ecosystems. The calcium (Ca) is an essential macronutrients for vegetation growth and its reservoirs and bio-availability have to be understood particularly in case of low Ca content in soils. Organo-mineral soils phases play an important role in the storage/release of nutrients due to their ability of cation retention during adsorption/desorption phenomenon. Previous work highlighted the calcium isotopes as a proxy to identify secondary processes in the soils. Nevertheless, the study of calcium fractionation mechanisms (range, nature) associated with sorption process remains poorly understood. This is a fundamental step to increase our comprehension about calcium biogeochemical cycle at the water-soil-plants interface. Therefore, sorption processes of Ca have been experimentally grasped on soil model substratum (phyllosilicates) in order to identify and quantify mechanism behind isotopic fractionation. Abiotic experiments have been realized in water-mineral batch systems with a great control onto physico-chemical conditions: pH, solid/solution ratio, Ca concentration, granulotmetry. First results show no significant isotopic fractionation associated with adsorption of Ca onto Kaolinite (KGa-2) and Muscovite (Tuftane) regardless of used parameters (reaction kinetic, pH, Ca concentration, ionic strength, competition between cations). However, during sorption of Ca onto Montmorillonite (Swy-2), the light isotope ($40Ca$) shows an important selectivity and an isotopic fractionation of 0.25 is observed. It suggests an isotopic fractionation due to the presence of an interfoliar space onto clay mineral. So, the fractionation amplitude is function of the clay minerals types.

2 Implementation of Isotopes into coupled Hydrogeochemical modeling
Marianna Marinoni and Philippe Ackerer

Reactive Transport describes the variation of the chemical state of water moving within a porous media, being this porous media some concrete, the soil or a rock . Studies on pollutants migration, nuclear waste disposal and rock weathering are among the applications of reactive transport modeling. The physics that rules reactive transport is described, as it often happens, through equations. The solution of these equations, mostly differential, is nearly impossible to obtain analytically. This is why numerical solutions are needed. Depending on the problem, we might need hundreds of thousands of numerical solutions, therefore we need to obtain them in the fastest and the most reliable way. If governing equations of phenomena like flux, transport and kinetic reactions are differential, thermodynamic equilibrium is described through algebraic equations. Finding concentrations at the equilibrium is reduced to the solution of a nonlinear system of algebraic equations. One of the most applied techniques for solving nonlinear systems in numerical codes is Newton-Raphson algorithm. It consists in the iterative solution of linear systems until convergence. Newton-Raphson algorithm has its strengths and weaknesses: when it succeeds, it works fast; on the other hand, if the search of the solution begins far from the objective, the algorithm is likely to fail. Small gains on the robustness of the single numerical solution may result in significant improvement of the performance of the codes and therefore reduce the time of reactive transport simulations.

3 Assessing the elements mobility through the regolith and their potential as tracers for hydrological processes

Cristina Moragues-Quiroga[1,2], Christophe Hissler[1], François Chabaux[2], Arnaud Legout[3] and Peter Stille[2]

[1]Luxembourg Institute of Science and Technology (LIST), Luxembourg; [2]Université de Strasbourg, France; [3]INRA-Nancy, France

Investigations in catchment hydrology are typically focusing on questions related to water source, flow paths and transit times. Stable isotopes of water and certain major elements have become standard tools for determining spatial and temporal variability in rainfall-runoff transformation. Reportedly, the initial thrill that surrounded the use of these tracers has gradually faded away essentially, because some of the underlying fundamental assumptions related to their application are only rarely met (e.g. incomplete mixing, unstable end-members). Additionally, these studies often consider the regolith system as a 'black box' with hardly assessable impacts on the catchment waters. This study aims at improving the understanding of the catchment regolith evolution and its impact on the spatial distribution of water (i.e: water sources and flowpaths) at regolith and catchment scale, by completing the set of tracers commonly used in hydrology with tools that are able to link regolith and geochemical signatures of water. The additional tools that we propose consist in concentrations of major and trace elements and the Sr-Nd-Pb-U-Th isotope ratios, both combined with a profound knowledge of the mineralogical composition of the regolith. Eventually, this newly gained information is to shed light on the impact of a catchments regolith on water - and more specifically on its spatial distribution, storage and release.

Poster presentations

4 Compound Specific Isotope Analysis at the Catchment Scale: Developing innovative approaches to monitor micropollutants threatening water resources

Pablo Alvarez-Zaldívar, Gwenaël Imfeld and Sylvain Payraudeau

Even though pesticides undergo degradation tests prior to use, determining their fate under field conditions remains a challenging problem that precludes the adequate management of water resources [1]. The use of compound specific isotope analysis (CSIA) provides direct evidence on the extent of degradation as it is independent of non-destructive processes regulating contaminant concentrations. While this technique has been successfully implemented in subsurface environments [2, 3], its application to dynamic near-surface hydrological environments is lacking [4]. This study developed a unique data-set that demonstrates the applicability of CSIA to effectively quantify degradation and to evaluate occurrence of diffuse micropollutants such as pesticides in soils and runoff at the catchment scale. We find that, despite low environmental concentrations, the analytical methods [5] enable the CSIA-based monitoring approach to closely correlate S-metolachlor isotope signatures and concentrations to distinct applications across time and space. Furthermore, the methodology was effective until the degraded fraction estimated in soils reached 95% and 90% for soils and discharged water, respectively. Our results demonstrate the applicability of CSIAbased monitoring tools to evaluate in-situ degradation and transport of chloroactanilide herbicides such as S-metolachlor under highly dynamic and complex field conditions. The use of CSIA-methodologies in combination with new modeling techniques including stable isotope fractionation at the catchment scale may help delineate a more complete understanding of the key drivers regulating pesticide fate and transport in the hydrological environments. We anticipate that it will help to improve the reliability of risked-based studies and to facilitate the adoption of more effective regulatory and monitoring strategies in order to improve the water quality.

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Hydrology 2004, 75:215255; [3] Thullner M, Centler F, Richnow H-H, Fischer A: Quantification of organic pollutant degradation in contaminated aquifers using compound specific stable isotope analysis Review of recent developments. Organic Geochemistry 2012, 42:14401460; [4] Elsner M, Imfeld G: Compound-specific isotope analysis (CSIA) of micropollutants in the environment - current developments and future challenges. Current Opinion in Biotechnology 2016, 41(Table 1):6072; [5] Wiegert C, Imfeld G: Anilide Extraction Methods.

5 Solving the inverse problem for groundwater flow in dual porosity systems relying upon the continuous adjoint state
Hamid Badri

This work is geared towards model parameter estimation in a dual porosity approach to groundwater flow in fractured porous media. The dual porosity model conceptualizes the system as two overlapping continua (the fractures and the host matrix) characterized by contrasted hydraulic properties between continua and coupled via fluid flux exchanges. We rely upon an adaptive multiscale parameterization technique manipulating model parameters located at the nodes of a grid independent of the calculation grid. The parameter grid can eventually be refined at some locations. Inversion is performed by an optimization technique based on descent methods to seek optimal parameters. In this context, the descent directions are composed with entries as the gradient components of the objective function, the latter being calculated by employing the so-called adjoint state technique. We address the problem using either a discrete adjoint state directly derived from the discrete equations of the forward problem or a continuous adjoint state derived as the perturbation of the model equations in response to a variation of the parameters. The continuous adjoint state is in essence non-intrusive with the meaning that it does not need modifying the code of the forward problem to be calculated. Both discrete and continuous adjoint states are tested and compared over different test cases encompassing various degrees of heterogeneity of the system. It is shown that the continuous adjoint state can be employed with success under the condition that its calculation is performed over a grid refined enough to catch the spatial distribution of the model parameters.

6 Experimental and numerical study of water transfer in the plain of Sidi Bouzid (Tunisia)
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In the region of Sidi Bouzid (Tunisia), the problem of availability of water resources is particularly acute because of the spatial and temporal variability of rainfall. Therefore, the State of Tunisia has made use of artificial groundwater recharge by the development of work bypass on Oued El Fekka designed for spreading flood waters. The overall aim is to build-up a three-dimensional hydrogeological model using the finite element model Feflow in order to quantify water fluxes and to evaluate the role of floods on the recharge process. Quantifying the groundwater recharge was based on a one-dimensional numerical study on the most upstream located areas of Oued El Fekka. This study showed a positive impact of recharge. It allows to determine the water residence time from the ground surface to the groundwater and the time required to return to the initial state. The hydrodynamic properties of the individual soil profiles will then be used to implement the 3D model to the entire area of the plain of Sidi Bouzid in order to quantify at the regional scale the groundwater recharge. Particular attention will be paid, firstly, to evaluate the influence of the root water uptake on the moisture distribution, the water flux and the total water volume infiltrated. Secondly, we will study the level of the water head of the unconfined groundwater during the different flooding events. These simulations will be validated by field experiments. Indeed, an experimental site will be set up in January 2017 to study the temporal and spatial variation of water potential and water content of the vadose zone.

7 Dimensionally reduced model for solving surface and subsurface flow at the scale of watershed system
Benjamin Jeannot

Discrete modeling based on a mechanistic approach to various hydrological systems has revealed to be an efficient tool of decision making regarding sustainable water resource management. In addition, hydrologic models that couple surface and subsurface flow and named as integrated models, seem the most appropriate for studying water resource evolutions from short- to mid-time periods and over small- to mid-scale watershed systems. The reason for that is probably in the way these integrated models handle with a large fraction of the physical processes ruling transfers in the hydrosystem. In the present case, the topic is to deeply revisit and amend a pre-existing integrated hydrological model with the aim of rendering it suited and efficient for various simulations of complex systems.

Figure: Two-dimensional problem

The model (fig.1) reduces the three dimensionality of flow to a two-dimensional problem. This is done by assuming that the flow is mainly parallel to the substratum of the aquifer with the consequence of rendering hydraulic heads mainly uniform along a normal direction to the substratum. This assumption allows for a rigorous integration of the flow equation which results in a two-dimensional problem manipulating averaged parameters as integrals along the direction normal to the substratum. The main benefit of this operation is to drastically reduce the number of elements necessary to implement the discrete calculation, resulting in a substantial gain in simulation time, while still preserving accuracy of water fluxes and hydraulic heads.
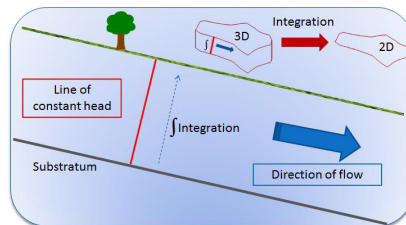
8 Behaviour of Radium and radioactive ascendants in soil and its transfer to terrestrial plants
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Radium (Ra) is a long-lived alpha emitting radionuclide and can be highly concentrated in mining areas, especially where uranium ores are extracted. Because Ra is of major concern in risk assessment, the objective of this study is to use the isotopic potential of U-Th-226Ra series nuclides and the (226Ra/228Ra) ratios to improve knowledge of the Ra biogeochemical cycle. This study was carried out at the experimental forest site of Montiers (Meuse, France). U-Th-226Ra disequilibria were measured in alocrisoil profile developed under the beech forest on the site, and in two soil solutions. (226Ra/228Ra) ratios were determined in the soil profile and in different vegetation compartments to identify the bioavailable Ra into soil and to identify the residence time of Ra within beeches. (226Ra/234U) activity ratios in soil solutions are higher than one and increase with depth, which indicate a Ra enrichment in soil solutions with respect to U. A higher leaching of Ra than U from soil to soil solutions and a Ra input by litter degradation process may explain these results. Analysis of U and Th concentrations as well as (234U/238U), (230Th/234U) and (226Ra/230Th) ratios in the bulk soil shows a distinct behaviour of U, Th and Ra nuclides in the shallowest (above 50 cm) soil layer, where activity ratios remain roughly constant, relative to deeper layer, where activity ratios evolve with depth. The potential link between this contrasted behaviour of the U-series nuclides and the vegetation remain to be elucidated, using sequential extractions of different soil fractions (clays, sesquioxides).

9 Origin and evolution of the isotopic signal of sediments in fluvial systems
Fatima Meite and Gwenaël Imfeld

Synthetic and inorganic (containing metals such as Cu or Zn) pesticides enter soils after their application and undergo sorption, precipitation or degradation that decrease their availability and mobility. So far, evaluations of: i) pesticides partitioning kinetic among the soil particle-size fractions, ii) temperature and soil moisture impacts on pesticides fate in soils, and iii) co-effects of both synthetic and inorganic pesticides on their respective partitioning and dissipation are needed. To assess impacts of pesticides pools evolution in soils on their runoff or leaching with hydrological conditions and agricultural practices, we conducted field and lab experiments. Following sampling of soil and waters in a vineyard catchment, 1 conventional and 1 organic farming plots, we quantified Cu, Zn and pesticides and found: i) higher metals exports in the conventional plot and ii) pesticides degradation dynamic in soils can be followed using CSIA. We also spiked crop and vineyard soils with i) a pesticides mix (alone), or ii) in addition to Cu and Zn. These soils were i) incubated up to 200 days at two soil moistures and temperatures, or ii) used to mimic pollutants runoff and leaching. We found: i) pesticides degradation is impacted by their structure, the temperature and soil moisture, ii) metals and pesticides leaching were mainly controlled by precipitation duration and intensity, respectively. We anticipate our work to improve predictive models for pesticide transport considering transformation reactions in soils.

10 Origin and evolution of the isotopic signal of sediments in fluvial systems
Justine Négrel, D. Lemarchand and F. Chabaux

In this study, we develop a new approach combining boron, lithium and uranium-thoriumradium isotopes that are intended to be used as markers of intensity of water-rock interactions and geochronometers, respectively. In order to relate the observed isotopic variations to the weathering reaction rates and to compare them to the geochemical signal exported from the watershed, we focused on two weathering profiles showing contrasted development and on outlet sediments from the Strengbach basin (Vosges). The erosion/alteration dynamic of the "top-slope" weathering profile has been previously characterized as close to steady-state (Ackerer et al. 2016) whereas the "inslope" weathering profile shows a more complex structure with the presence of a colluvion horizon. In the "top-slope" profile, preliminary boron data from bulk soil samples show a slight vertical variation indicating a weakly developed weathering profile in line with previous conclusions. In contrast, boron isotope data in the "in-slope" profile show an intriguing discontinued trend on both sides of the colluvion horizon. With respect to boron isotopes, our observations suggest that the base of the colluvion is less altered part of the profile, thus puzzling our understanding of the chemical and physical processes that have led to the present profile. So far, the outlet sediments have been only analyzed for boron isotopes in the bulk samples, which are mostly made of primary poor-weathered minerals. More information are expected from the analyses of the clay fraction and the combination with lithium and uranium-thorium-radium isotopes has also to be done.

Ackerer et al. (2016) Earth and Planetary Science Letters, 453, 33-43.

11 Study of hydrothermal alteration processes using a combined isotopic approach (Boron, Lithium and Uranium series)
Mylène Mombru, Damien Lemarchand and Sophie Rihs

The understanding of high temperature water/rock interactions is critical to determine the production potential of geothermal power plants and to develop new exploitation technics. The main issue is that modifying the circulation of water in the host rock at high temperature can dramatically change the physico-chemical properties of the reservoir. In this project, we develop a new approach based on the use of Li, B and U isotopes to determine the kinetics, intensity and temperature at which water/rock interactions occur. Experiments are conducted at different pH values (pH 2-8) and temperatures (50-200°C) to investigate the isotopic fractionation of each of these elements during reactions of dissolution (open flow, see figure below) and dissolution/precipitation (batch) and their relation to the experiment parameters. The minerals and rock samples are chosen to represent volcanic (Guadeloupe) and granitic (Soultz-sous-Fôrets) host rocks. Our first results, corresponding to the dissolution experiments (open flow reactors) conducted at 50 and 90°C, show a near stoichiometric release of all the major elements, in line with the large literature available so far. However, we observe a large release excess of most of the trace elements that is not documented in the literature yet. Careful examination of the parent minerals tends to rule out a significant contribution of accessory mineral phases to explain this opposed behavior. Our preliminary results suggest a transport of trace elements that should be considered as disconnected from the dissolution reaction (break of the mineral structure) and therefore challenge our present description of the mineral dissolution reactions.
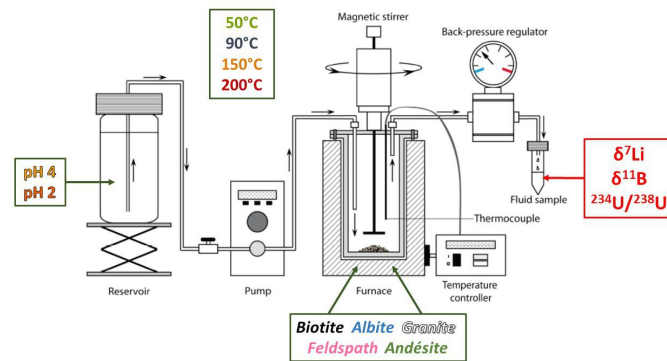

Figure: Open flow high temperature experiment

12 Global sensitivity analysis and estimation of unsaturated soil hydraulic parameters using streaming potential measurement
Jabran Zaouali

Water flows in vadose zone generate measurable electrical potential differences that are related to the flow direction and volumetric fluxes, additionally to the soil properties themselves. Many studies have used these data so-called streaming potential (SP) to estimate hydraulic properties of a saturated soil, but there have been fewer tries to estimate unsaturated hydraulic properties from SP. Until now they can find some hydraulic parameters, although we succeed to estimate all Mualem-van Genuchten hydraulic and geophysical parameters from synthetic data. We started by developing a numerical model based on coupled hydrogeophysical approach, then we used the global sensitivity analysis combined with sparse polynomial chaos expansion (SPCE) to help assess unsaturated soil hydraulic and geophysical parameters from synthetic SP data, finely we estimate models parameters using a Markov chain Monte Carlo sampler (MCMC) and a Marquardt Levenberg algorithm.