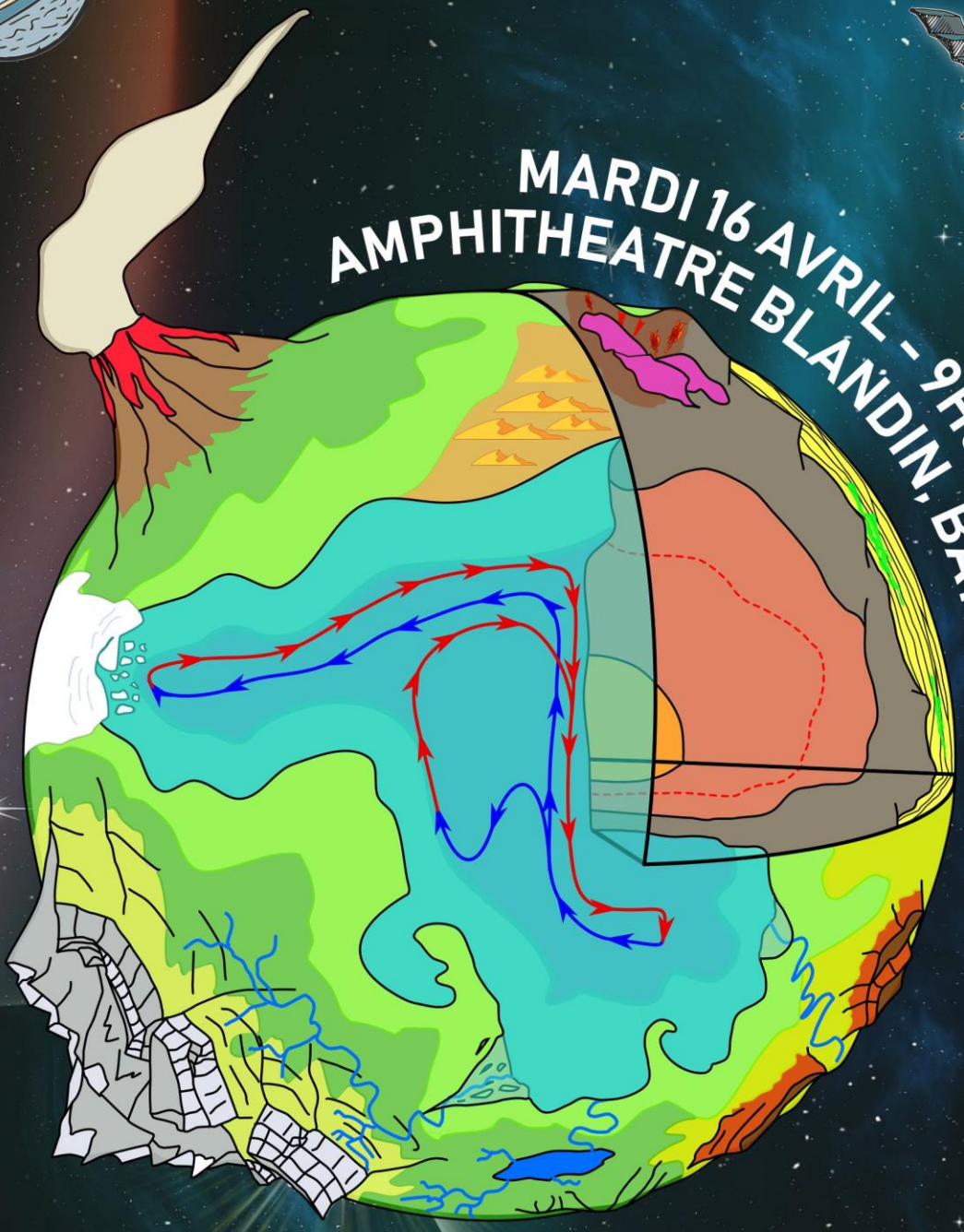
UNIVERSITÉ PARIS SUD | GEOPS GEOSCIENCES PARIS SUD

université PARIS-SACLAY

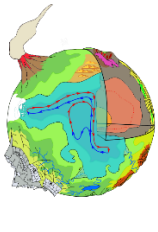
ÉCOLE DOCTORALE
Sciences mécaniques et énergétiques, matériaux et géosciences (SMEMAG)

# JOURNEE DES DOCTORANTS GEOPS 2019

MARDI 16 AVRIL - 9H00
AMPHITHEATRE BLANDIN, BAT 510



## LIVRE DES ABSTRACTS
## Abstract Book



16 avril 2019

# JOURNEE DES DOCTORANTS

PhD Students' Day

# LIVRE DES ABSTRACTS

Abstract Book

*Editors*

*Santiago SANTAMARIA, Louise LENOIR*

université PARIS-SACLAY | ÉCOLE DOCTORALE Sciences mécaniques et énergétiques, matériaux et géosciences (SMEMAG)

UNIVERSITÉ PARIS SUD

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# SESSION 1

Evolution of the planets' external sub-surfaces

# A new look at Europa's photometry

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**Thematics**: Europa, remote sensing
**Keywords**: photometry, image processing, inverse model, bayesian inversion

## Introduction

Europa is a prime candidate for habitability in our Solar System. The surface of the moon is the youngest of the Jovian icy satellites and shows signs of current activity [1,2,3]. The JUICE (JUpiter ICy moons Explorer) mission from the European Space Agency (ESA) is to be launched in 2022 and arrive at the Jovian system in 2030 to study Jupiter and its icy moons for three and a half years [4]. The spacecraft is being designed by Airbus Defence & Space in Toulouse, France, with a very innovative navigation system. An accurate photometric of the moons' surface will help the vision-based navigation algorithm implemented on JUICE [5].

## Data and Methods

A photometric study necessitates two pieces of information: reflectance and geometry (incidence, emission, phase). The first can be obtained after radiometric calibration. The second necessitates accurate projections of each pixel.

*Dataset*: This study uses images taken with the Imaging Science Subsystem (ISS) of the Voyager spacecrafts and includes more recent images taken of Europa with the LOng Range Reconnaissance Imager (LORRI) of the New Horizons probe. Both datasets were retrieved on NASA's PDS archive.

*Direct model:* For this study we are considering Hapke's direct model [6]. Six parameters are to be estimated: $b$, $c$, $\omega$, $\bar{\theta}$, $h$ and $B_0$.

*Bayesian inversion:* We have developed an inversion tool using a Bayesian approach based on previous work done on Mars [7] and recent improvements [8]. In this framework, we estimate the density probability function of each parameter which gives us not only information about the most probable value but also tells us how well the parameters are constrained on the different ROIs.

## Results

We arbitrarily selected 20 regions of interest across Europa's surface and estimated Hapke parameters on each of them. What we find is mostly consistent with past studies[9,10,11,12] but shows higher roughness parameter on some ROIs and no significant difference from one hemisphere to the other (fig. 1).If we look at parameters b and c describing the diffusion lobe, we can say that on most pf the ROIs have a large diffusion lobe (0.25<b<0.6) and backscattering (c>0.5). Some areas show a forward scattering behavior (c<0.5) adding to the one identified by Domingue and Hapke (1992) [12].

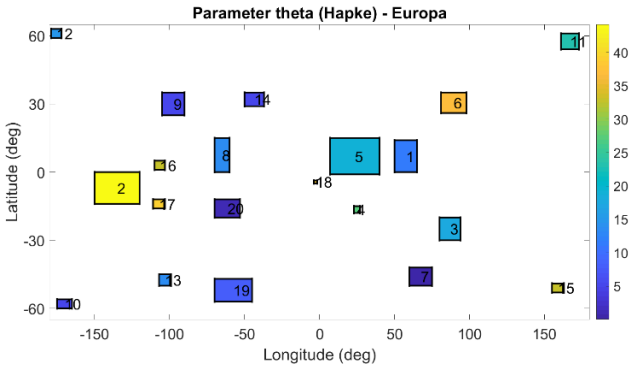


*Figure 1: Map of roughness parameter*

Based on the work of McGuire and Hapke (1995) [13], we can infer that the surface of Europa is mostly composed of complex aggregated particles with some internal scatters resulting in a rather large lobe of diffusion.

## Conclusion

We arbitrarily selected 20 ROIs across Europa's surface for which we estimated Hapke parameters. What we find is mostly consistent with past studies [9,10,11,12] but shows higher roughness, multiple forward scattering areas and a lot of variability across the surface.

## References

[1] Pappalardo et al. (1999), *J. of Geophysical Research* [2] Kattenhorn and Prockter (2014) *Nature Geoscience*. [3] Sparks et al. (2016), *Astrophysical Journal*. [4] Grasset et al. (2013) *Planetary and Space Sci.* [5] Brochard et al. (2018), *69th IAC*. [6] Hapke (1993), *Cambridge University Press*. [7] Fernando et al. (2016), *Planetary and Space Sci*. [8] Schmidt and Bourguignon (2019), *Icarus*. [9] Domingue et al. (1991), *Icarus*. [10] Domingue and Verbiscer (1997), *Icarus*. [11] Domingue, D. and Hapke, B. (1992), *Icarus*. [12] Buratti et al. (1985), *Icarus*. [13] McGuire and Hapke (1995), *Icarus*. [14] Hapke (2012), *Icarus*.

# Morphometric evidence of martian antique glacial landscape in Terra Sabaea

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**Thematics** : Planetary science, geomorphology
**Keywords** : Glacial landscape, Late Noachian/Early Hesperian, Morphometry, Early Mars

## Introduction

The climate of early Mars remains unclear and the debate is topical. Recently, climatic models have suggested a cold climate during the Noachian/ Early Hesperian on Mars, which goes against the wet and warm climate often put forward [1]. The purpose of this study is to seek geomorphologic evidence of this early cold climate.

## Data and Methods

To achieve this, a step-by-step study of the geometry and morphology of several martian valleys has been done in the southern highlands, using high resolution imagery (CTX, 6m/pixel) and topographic data. The analysis highlights the morphometric properties which enable the identification of martian glacial landscapes.

## Results

We identified 100 cirques, 83 glacial valleys in two craters and on one mountain and an ancient plateau ice cap in the southern part of Terra Sabaea. The studied morphologies have the same morphometric characteristics and trends as terrestrial and martian glacial valleys and glacial cirques. In contrary, these trends are very different from those observed in fluvial valleys on Earth and on Mars. The martian glacial valleys are U-shaped with a large flat floor and a V-index > 0.20. While martian and terrestrial fluvial valleys are V-shaped with a V-index < 0.1. Finally, the cross-sectional area and the elevation are higher for the glacial valleys compared to the fluvial ones. These glacial valleys often originate with a topographic hollow which have the same properties than terrestrial glacial cirque (Fig. 1). The glacial landscapes identified in southern Terra Sabaea are restricted to elevations > 1000 m and are dated by crater counting to be 3.6 Ga [2].

## Conclusion

This study strongly supports glacial processes as the origin of these valleys and cirques, and is the first morphometric evidence of glacial valleys associated with glacial cirques in the southern highlands in agreement with the climatic models. We propose that the martian climate during the late Noachian/early Hesperian was characterized by glaciated highlands at elevations greater than 1500 m and at lower elevations where fluvial valley network has been identified (<1500 m) the climate was more temperate allowing liquid water to be stable and creating fluvial valley networks.

## References

[1] Ramirez, R. M., Craddock, R. A., 2018. The geological and climatological case for a warmer and wetter early mars. Nature Geoscience

[2] Bouquety, A. Sejourné, F. Costard, et al., Morphometric evidence of 3.6Ga glacial valleys and glacial cirques in martian highlands: South of Terra Sabaea, Geomorphology. 2019

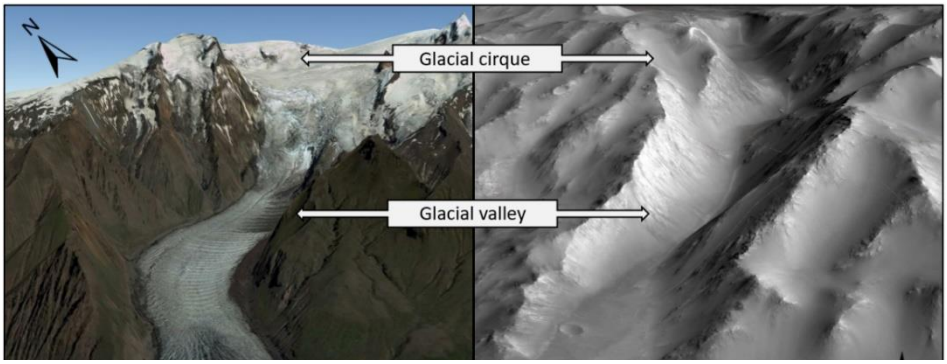


*Figure 1: Morphometric comparison between a terrestrial glacial landscape (left) and a martian glacial landscape (right)*

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# Cryovolcanism on Europa

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**Thematics**: physical modeling, numerical simulation
**Keywords**: cryovolcanism, icy satellite, reservoir, freezing, salts.

## Introduction

Europa, a Jupiter's icy moon, is entirely covered with water ice. Its surface exhibits smooth lobate plains that cover older terrains (see Fig. 1), and their morphologies and relationship with the surrounding features suggest that they could result from liquid extrusions [1]. Furthermore, recent literature suggests that the emplacement of common features, such as double ridges, lenticulae and chaos [2] could result from the presence of liquid reservoirs beneath the surface.

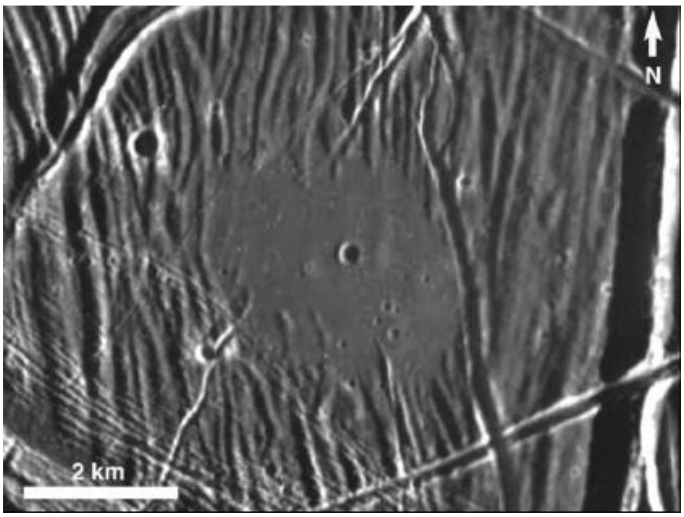


*Fig. 1: Smooth feature at Europa's surface.*

## Model

We model the eruption of liquid-filled reservoirs contained in Eropa's icy crust. After Fagents [3], we consider the following mechanism: at the first stage, a liquid water reservoir is present in the subsurface. Second, the cryomagma in the reservoir freezes and pressurizes over time. When the stress applied on the chamber's walls reaches a critical value, the walls break, and the fracture may propagate to the surface. Third, the remining fluid (that did not crystallize) flows out at the surface through a fracture or a pipe-like conduit.

We estimate the freezing time of the sub-surface reservoir necessary to begin an eruption. Considering available data for density and eutectic temperature of salt impurities recently proposed for Europa, we discuss their effect on the cryomagma freezing time and ascent. We also model the ascent of liquid water through a fracture from a reservoir toward Europa's surface and derive the eruption time-scale and total extruded volume at the end of the eruption as a function of the chamber volume and depth.

## Results and conclusion

A freezing liquid-filled reservoir contained in Europa's icy crust can pressurize enough to fracture the ice and generate an eruption at the surface. The freezing time-scale of a cryomagma reservoir depends on the cryomagma composition: it varies between a few days to 103 years for a pure water cryomagma and from few months to 104 years for a briny cryomagma. During an eruption, only 0.1 to 1% of the reservoir's volume is erupted at the surface, and the time-scale of the eruptions varies from few minutes to few tens of hours. [4]

We plan to use these results in order to define the conditions and plausible location of the cryovolcanic active areas on Europa. This could be useful for the two missions JUICE (ESA) and Europa Clipper (NASA) that will be launched in 2020.

## References

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[2] Schmidt, B. E., Blankenship, D. D., Patterson, G. W., Schenk, P. M., nov 2011. Active formation of 'chaos terrain' over shallow subsurface water on europa. Nature 479

[3] Fagents, S. A., dec 2003. Considerations for effusive cryovolcanism on europa: The post-galileo perspective. J.-Geophys.-Res. 108 (E12)

[4] Lesage et al., Cryomagma ascent on Europa, under revision, Icaru

# Tectono-thermal evolution of the southern Patagonian foreland (~ 44 - 48 ° S): origin and evolution of the Deseado Massif

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**Thematics**: thermochronology, geodynamic, geochemistry, tectonic
**Keywords**: Patagonian foreland, Deseado massif, exhumation, (U-Th)/He

## Introduction

The correlation between plate geodynamics (mantle, dip of the subduction plan) and surface evolution (change of topography, deformation propagation, …) is an important question in Earth Science. The Andean range is a natural laboratory to investigating those problematic due to it latitudinal extension, specifically for the coupling between climate and tectonics.

In the Andean southern part, the range construction has been well studied, but the understanding of foreland evolution in terms of time and deformation remain incomplete, and there are numerous mountain massifs with significant extension and topography. Constrain the development of massifs which are remote from the subduction position (> 1000 km) is a key to develop our understanding of the large-scale stress and deformation propagation. In this study, we investigate the southern Patagonian foreland evolution, and more specifically the Deseado massif formation by using multiple scale approach.

The Deseado massif is a 350 per 200 km area, considers as a geological block, with a mean elevation around 800 m and plateaus above 1000 m. It is mainly composed by a massive Jurassic formation (Chon Aik frm.), describe as a 1–3 km homogenous acid ignimbrite deposit, with local rhyolite domes; partially cover by Cretaceous and Cenozoic proximal sediment. The Deseado massif is bordered (North and South) by Cretaceous and Cenozoic basins, thus it is regionally interpreted as topographical high plateau since the early Cretaceous.

## Data and Methods

The study is focus on a low temperature thermochronological approach, based on the (U-Th)/He method (applied on apatite, zircon and hematite) and on the apatite fission tracks method (AFT). Those methods allow us to determine the rock cooling history, from 220 ° to 40 °C, which corresponds to the exhumation history from ~10 km to the surface. This information will allow us to reconstruct the massif building period, therewith to determine the event that conducted to the uplift.

During the last field trip (January 2019) in the Deseado massif, we sampled plutonic and metamorphic basement rock (under the Chon Aik frm.), Chon Aik rhyolite, and some deformed iron mineralization host in the Chon Aik frm.

## Preliminary results

Three samples from a previous field-trip has already been dated by AFT, preliminary results give one cooling age at 120 Ma and two at 50 Ma. In the bibliography the Deseado massif exhumation is classically described during the Upper Jurassic (180-150 Ma) and until now there is neither data nor indication that give this young exhumation period.

## Conclusion

In the bibliography there is no strong constraint about the mechanism of the Deseado Massif formation, and more generally about the foreland evolution in regard to the Andean range building. This preliminary result shows a gap between the forelands knowledge and its evolution, this study will allow us to better understand the Deseado Massif evolution, and the link between exhumation and geodynamic parameters (Andean built, slab dip, mantle dynamics, …)

This PhD is included in a larger project in collaboration with Padova University, Lille-1 University and geological survey of Argentina, which the aim is to understand the evolution of the whole Patagonian foreland (basin and mass).

# Numerical reconstruction of paleo-volcanoes of the East Carpathian volcanic range: volume calculations and implication of magma output rates and erosion rates

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**Thematics**: Volcanology- Geomorphology
**Keywords:** Carpathian, CGH, Volume, Magma output rates, Erosion rates

Carpathian Range forms an arc roughly 1500 km-long across Central and Eastern Europe where volcanism experienced a migration through time from West to East. Neogene to Quaternary volcanism in the Carpatho-pannonian region was related to the youngest evolutionary stage of the Carpathian arc in a context of subduction, extension and asthenospheric upwellings. Here, we focused on the 160 km-long zone of Călimani Gurghiu Harghita volcanic range (CGH), the easternmost and youngest volcanic segments of Carpathian. This range is formed by about 16 composite volcanoes, characterized by their medium size (1500-1000 m relative height) with highly to moderately eroded shape in the north and better preserved in the south. CGH zone show a migration of its volcanic activity from the north to the south between the Miocene (~11 Ma) and the Late Quaternary (~0.03 Ma). Therefore, it provides a unique opportunity to quantify long term erosion rates and magma output rates of volcanoes under ~11 Ma-long continuously moderate continental climate condition.

In order to assess magmatic output and eroded volumes and the rate of such dynamisms that characterized each identified volcano, we proceed with numerical reconstruction of the paleo shape of each single volcanic edifice of the CGH volcanic range. To achieve this goal, the topography of the entire CGH volcanic range was analysed from the SRTM Digital Elevation Model (DEM) with a 30 m resolution. Zones interpreted as representative to pre-erosional volcanic surfaces were extracted and used to constrain the reconstruction of paleo-volcanoes, by adequate interpolation method such as ShapeVolc algorithm especially dedicated to volcanic surface modelling.

Based on preserved volcanic surfaces and ShapeVolc algorithm, sixteen (16) majors' volcanic edifices were then reconstructed along the entire CGH volcanic range. Reconstructed volcanic edifice are characterized by small to superimposed volcanoes which display two types of radial profile according to their main concave or convex shape, and a base mostly defined with an elliptic surface with an eccentricity values ranging between 0.16 (almost circular) to 0.80 (very elongated).

Total reconstructed volume of the output volcanic rocks of the CGH range is about 2200±200 $km^3$ representing a huge amount of material during 11 Ma. Combining volume calculation and available ages allow us to estimate for the oldest Călimani area (10.6–6.7 Ma) a total reconstructed volume of 910±140 $km^3$ corresponding to a magma output rates of 234 $km^3$/Ma; On the intermediate Gurghiu area (9.2 – 5.8 Ma), we observed comparable values with a volume of 883±117 $km^3$ and a magma output rate of 260 $km^3$/Ma. The next area, North Harghita (6.3–4.6 Ma) is smaller (279±41 $km^3$ for its four majors' volcanic edifices) and experienced a less intense volcanism (116 $km^3$/Ma). Finally, in South Harghita area (5.4–0.03 Ma) we obtain an eruptive volume of 140±40 $km^3$ corresponding to a magma output rates of 32 $km^3$/Ma. These results clearly indicate two pulses of activity at 9 Ma and 6 Ma and next a drastically decrease of magmatic activity through time. For the point of view of erosion, a total erosional volume of 520±130 $km^3$ has been computed for the sixteen volcanic edifices along the CGH. In Călimani area we computed a dismantle rate (i.e. eroded volume of a volcano divided by its initial volume) of 30% corresponding to an average erosion rate of 16 m/Ma, in Gurghiu, we obtain 25% with an erosion rate of 11 m/Ma, 20% for north Harghita with an average erosion rates of 9 m/Ma and an erosional volume of 15% for south Harghita area with an average erosion rate 15 m/Ma. We can conclude that, erosion rates in a continental climate decrease gradually during the initial intense degradation until they reach an "equilibrium state". The two pulses of activity fits with the plate tectonic interpretation of the CGH where in the northern part (Călimani and Gurghiu area), the volcanism was subduction-related with a huge amount of magma productivity whereas the moderate edifice volumes (Harghita area) may support the hypothesis that, instead of continental-arc type subduction, a complex pattern of island arcs generated the calc-alkaline volcanism.

# Sediment routing in the syn-orogenic series of the Aquitaine basin - France

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**Thematics**: Source to sink
**Keywords**: Zircon crystals, U/Pb, detrital sediments, granite boulders, syn-orogenic conglomerates

Understanding the evolution of a syn-orogenic sediment routing system can improve our understanding of the development of the mountain belt. The North Pyrenean foreland basin evolved from underfilled to overfilled during Eocene time, contemporaneously with the development of the Pyrenean orogeny. The resulted syn-orogenic conglomerate series, known as "Poudingue de Palassou", recorded the exhumation and the denudation of the mountain belt. Three tectono-sedimentary units with different facies characteristics, lateral extension and petrographic content have been identified in the Palassou series in the Corbière zone (East of the Aquitaine basin): The first unit clasts are meso-cenozoic sediments deposited in the basin during late Ypresian – Lutetian time. The second unit clasts are Paleozoic sediments, mainly magmatic basement rocks (including granite) deposited during Bartonian. The third unit sediments are meso-cenozoic sediments as those of the first unit and are deposited during Priabonian time. However, clasts origins, transport modalities and the evolution of the source to sink system are poorly constrained. Identify the source(s) of deposited material, characterize the evolution the transfer zone i.e. the fluvial systems and the understanding of sediment dynamic production are the main goals of this study. Zircon U/Pb method is applied on granite boulders and detrital series from the Corbières zone in order to identify the source of deposited materials. Variscan ages ranging between 324±1 and 335±1 Ma are acquired for granite boulders from the unit 2 (5 samples). The results on one sample of granite boulders from the unit 3 give a Variscan (290-360 Ma), a Caledonian (440-490 Ma) and a Cadomian (530-600 Ma) sources. For detrital samples, a strong Variscan source signal is acquired on a sample from the top of the unit 1 (330-340 Ma) and the middle of the unit 2 (310 Ma) while the base of the unit 2 have a strong Cadomian source (520-650 Ma).

# Characterization and age of intraplate deformation in front of an orogen: from the North Pyrenean Fault to the southern limit of the Massif Central, France

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**Thematics**: understanding intraplate deformation related to the formation of an orogen
**Keywords**: intraplate deformation, Pyrenees, fault related calcite, microtectonic, LA-ICP-MS

## Introduction

In geodynamics, most of the deformation is accommodated on tectonic plate boundaries. Nevertheless, far field propagation of stresses induces so called intraplate strain. These phenomena have been characterized from a "geological" point of view (see examples in (Cloetingh et al., 1999) for lithospheric folding, (Navabpour et al., 2017) for small scale fracturing), but the question of their age and the time relationships with the building of the orogen itself remain puzzling : do they form during, before or after orogen building? Are they mono or polyphased? How long do they last? In this study, we aim at answering these questions in the case of the intraplate area located north of the Pyrenean mountain belt (Corbières, Grands Causses…).

## Data and Methods

From a structural point of view, the field missions carried out during this thesis allow to acquire structural data useful for understanding the geodynamic calendar (Fig.1). Field observations make it possible to determine the relative age of the different deformation episodes. Geological section surveys are also essential to understand the structures we are working on.

Regarding the geochemical and geochronological aspects, syn-kinematical fault related calcite sampling allow to characterize in the laboratory the geochemistry of the fluid at the origin of calcite precipitation based on the analysis of stable isotopes δ13C and δ18O as well as on the analysis of the composition of major elements, traces and REE (LA-ICP-MS, GEOPS laboratory). The dating of these calcites using U-Pb method with LA-ICP-MS allows to determine the absolute age of the deformations. The signals are processed using Iolite software (Paton et al., 2011) to obtain ages in Tera-Wasserburg diagrams (Fig.2).

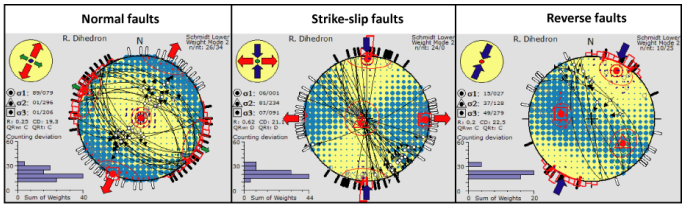


***Figure 1*** *– Stress tensors examples from fault plane data processed from the Wintensor software (Delvaux ans Sperner,*

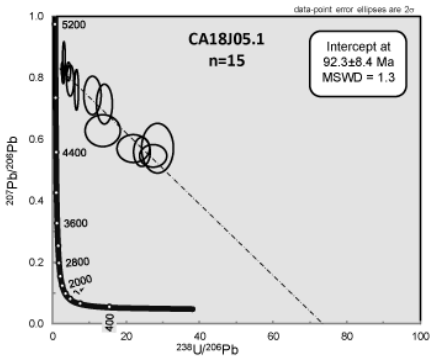


***Figure 2*** *– Tera-Wasserburg diagram*

## Results/Conclusion

Ages of intraplate deformation related to the formation of pyrenean orogen in Causses area range between 90 to 40 m.a. These results suggest an early and contemporary deformation to the building of the Pyrenean belt; whose paroxysm is of eocene age. The future study areas (Corbières, Causses du Quercy) will allow to better constrain this geodynamic calendar and thus to better understand the relationship between intraplate deformations and plate boundary deformations.

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# Reconstruction of the eruptive history of central Ecuador volcanoes: constraints on the spatiotemporal evolution of the Andean volcanism and assessment of associated hazards

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**Thematics**: Evolution of magmatism and volcanism in the North Andean arc.
**Keywords**: Geochronology, Volcanology, Geomorphology, Ecuador

## Introduction

The Ecuadorian arc is composed by seventy-seven volcanic centers located in a narrow strip of approximately 300 kilometers long, which makes it one of the areas with the highest volcanic density in South America. Santamaria & Bernard (2018) have shown that the period of formation and evolution of these volcanoes remains poorly defined. Therefore, this study aims to constrain in time the activity of volcanoes present in the center of the Ecuadorian arc, and to further investigate the relationship with the regional geodynamic context.

## Data and Methods

The central active zone of the arc is characterized by a remarkably high number of volcanoes emplaced in a densely populated area (Figure 1). However, most of them lack throughout studies of their past activity, which limits assessment of vulnerability to possible future eruptive activity.

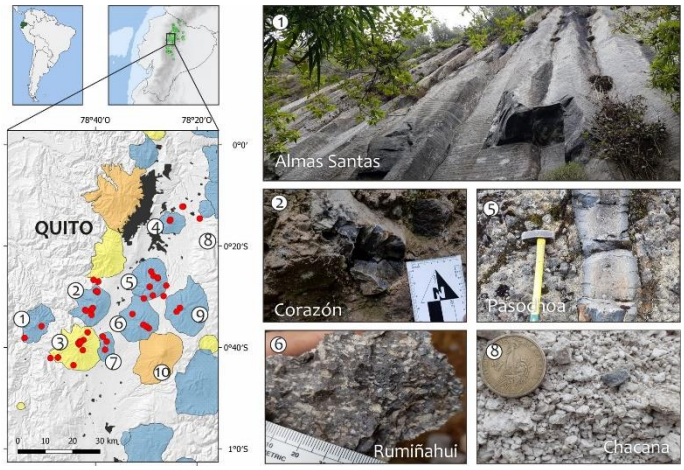


*Figure 2. Examples of rock samples taken from the volcanoes of the center of the Ecuadorian arc. 1=Almas Santas; 2=Corazón; 3= Ilinizas; 4=Ilaló; 5=Pasochoa; 6=Rumiñahui; 7=Santa Cruz; 8=Chacana (Pifo plinian fallout deposits); 9=Sincholagua; 10=Cotopaxi (distal lava flows).*

We have collected about 40 new volcanic rock samples from 9 volcanoes. They will be petrologically studied and dated at GEOPS using the K-Ar Cassignol-Gillot technique. The $^{40}Ar/^{39}Ar$ technique applied with the new instrument and extraction line acquired between GEOPS and the LSCE will also be used to date pyroclastic flows and other volcanic products of interest.

## Results and conclusion

The construction ages of the central volcanoes will be compared with those from the southern and northern volcanoes of the arc, which were previously studied (Bablon et al., 2019). This correlation will help to better understand the process of densification of the magmatism and its relationship with the subduction of the Carnegie crest occurring in front of the central arc. The ages obtained will also allow us to accurately calculate the emission rates of the volcanic products, to compare them at the arc scale, and, therefore, specify the potential links with the geodynamics and magma genesis (e. g., Ancellin et al. 2017). Finally, the erosion rates will also be calculated and compared with those from other Ecuadorian volcanoes in order to quantify the impact of Quaternary climate changes and its geographic variation in Ecuador.

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# Changes in clay minerals of early-middle Miocene Red Beds in the northern South China Sea

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**Thematics** : Paleoclimatology
**Keywords** : Sedimentology, Red Beds, Miocene, South China Sea

## Introduction

The oceanic red beds are considered as pelagic sediments, with red-reddish-brown color, formed under oxidation condition (Wang & Hu, 2005). It is generally believed that the redness of sediments is mainly due to the presence of hematite, goethite and manganese-containing ions in the mineralogical composition of sediments (Hu et al., 2012).

International Ocean Discovery Program (IODP) Expedition 367 Site U1499 is located on basement Ridge A within the South China Sea continent-ocean transition zone. The sediment at Hole U1499B (water depth 3758.1 m) recovered early-middle Miocene dark reddish claystone, calcareous-rich claystone and clay-rich chalk.. The 167.32 m thick (depth interval of 761.70-929.02 m, 23-10 Ma at Hole U1499B) red beds are very distinguished comparing to other part of the sedimentary sequence at this site and to similar age interval deposits recovered previously in the South China Sea.

## Data and Method

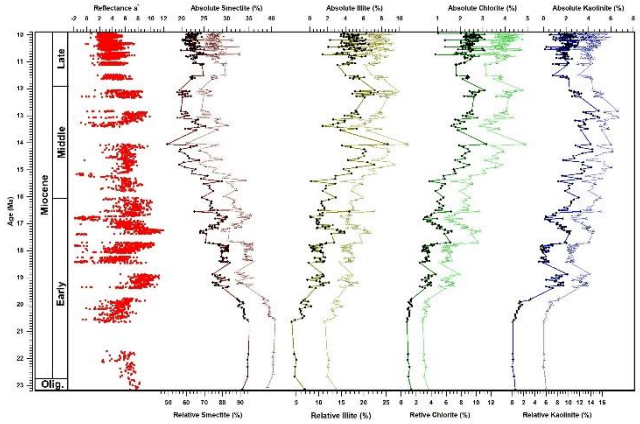


Figure 3 Variation of clay minerals assemblage at IODP Site U1499B in the South China Sea during early-middle Miocene.

Clay minerals was conducted on clay fraction (<2 μm) of 283 samples. The raw sediments were firstly leached with 0.1 N hydrochloride acids (HCl) to remove carbonate fractions. The measurements were performed using PANalytical X' Pert Pro Diffractometer at State Key Laboratory of Marine Geology, Tongji University. Proportions of different clay groups were semi-quantitatively calculated by MacDiff program (Petschick, 2001).

## Results

Clay minerals identified consist mainly of smectite (49-95%, average 70%), with associated illite (4-25%, 14%), chlorite (1-11%, 7%) and kaolinite(0-16%, 9%). Illite, chlorite and kaolinite increased since 20 Ma, while smectite decreased. Strikingly smectite first became more abundant at 23-21 Ma, up to 95%.

## Conclusion

We define the overall changes of clay minerals for the early-middle Miocene red beds with very stable tectonic setting in the South China Sea. This study provides insight to the deep-water sedimentologic properties of pelagic red beds developed to relate paleoclimate evolution.

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# SESSION 2

Superficial processes

# Influence of sequence stratigraphy and diagenesis on the quality of hydro-dynamic and thermal models of carbonate and clastic reservoirs: implication for geothermal development in the Paris Basin

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**Thematics** : Geothermal, modeling sedimentology
**Keywords** : Geothermal modeling, sedimentology, carbonates, sandstones, Petrel, Tough2

## Introduction

The quality of geological reservoirs is one of the risk factors for the future of development of subsurface energy and gas storage and geothermal exploitation in siliciclastic hydrological system [1]. Porosity and permeability are important factors for the characterization of reservoir quality. It is therefore important to better integrate diagenetic processes and the fine stratigraphic architecture into 3D geological models at reservoir scale to characterize the dynamics and thermal behavior of fluids. During this PhD, we aim to have a better understanding of the facies, porosity and permeability variability at different scales, and determine the influence of the heterogeneity on the water flow in reservoirs. A better understanding of those variables will limit the geological risk during exploitation.

## Data and Methods

Data that will be used in this PhD come from cuttings and cores from geothermal wells and outcrop samples. Two geological rock types are studied: Cretaceous siliciclastic rocks on the one hand, represented by sandstones and deposited in estuarine environments, and Dogger (Bathonian [2]) carbonate rocks on the other hand, deposited in marine environment, sampled in geothermal wells. They are studied using thin sections, SEM, laser granulometry, XRD analysis and soon in a net-to-gross ratio (siliciclastic) and CT scan. Static models of the porosity will be created in Petrel and Tough2 using geostatistical controls on stochastic models based on the observations made on the samples [3] [4]. Based on these models, flow simulations will be performed on the grid extracted from Petrel.

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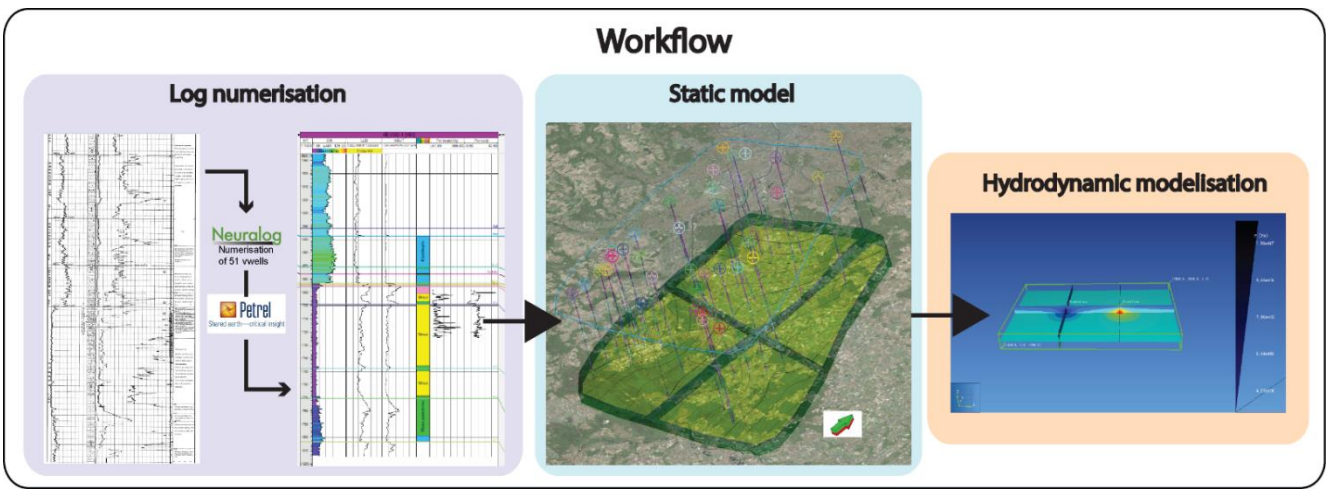

# Variations of the eastern Mediterranean hydrology during the last climatic cycle inferred from neodymium isotopes in foraminifera

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**Thematics**: Paleoclimate, Paleocirculation, geochemistry
**Keywords**: neodymium isotopic composition, Mediterranean Sea, sapropel events

## Introduction

The thermohaline circulation of the semi-enclosed Mediterranean Sea is highly sensitive to climatic change such as African monsoon. More sluggish thermohaline circulation combined with an increase of surface productivity have been responsible of the deposition of organic-rich sapropel layers in the Eastern Mediterranean Sea (EMS). However, paleoceanographic processes and associated ventilation dynamics associated to sapropel deposits are still debated because classical oceanographic proxies cannot be used due to anoxic conditions in the bottom water and the lack of benthic foraminifera in sediments of the EMS. Recent results have indicated that the Nd isotopic composition (εNd) of Mediterranean Sea water masses range from -4 for the Eastern Mediterranean deep-water (EMDW) to -9 for the Atlantic Water (AW) inflowing to the Mediterranean Sea[1-2]. εNd could be then used to track water masses exchange from the North Atlantic and the EMS and from the EMS and the western Mediterranean Sea (WMS). In this study, we have analyzed εNd of mixed planktonic foraminifera of two cores collected in the EMS close to the Nile river mouth to complete existing εNd records available on the EMS and reconstruct variations of the relative contributions of the Nile discharge and AW to the EMW during the last climatic cycle.

## Results

The two seawater εNd records display similar long-term variations with a decrease of the εNd up to 2 epsilon units during warm substages of the interglacial marine isotopic stages (MIS1 and MIS5) compared to glacial ones (MIS6, 4, 3 and 2). Time intervals corresponding to sapropel deposits are associated to an increase of the εNd.

## Interpretation / Conclusion

We have demonstrated that long-term glacial / interglacial variations of the εNd of the EMDW cannot be induced by variations of the Nile river discharge and Saharan dust inputs. Decrease of the εNd during interglacial MIS have been attributed by an increase of the contribution of AW in link with high sea-level state permitting an increase of the AW inflow to the Mediterranean Sea. Radiogenic seawater εNd observed during sapropel events are associated to an intensification of the Nile discharge and a decrease in the EMS–WMS exchange.

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# Late Quaternary biochronological events and faunal evolution in the Mediterranean Sea

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**Thematics** : palaeoceanography, paleoclimatology
**Keywords** : (planktic foraminifera, Biochronological events, Mediterranean Sea)

## Introduction

The Mediterranean Sea is a semi-enclosed marginal sea located at latitude between 30° and 45°N and 6°W and 3°E. it is subsivided into two basins eastern and western separated by the Siculo-Tunisian strait.

Despite this limited area, the Mediterranean Sea represent a complex marine environment and constitutes a vast sedimentary reservoir, a geological and climatic archive during the Upper Quaternary.

## Data and Methods

Three deep sediments cores are selected for this study. These cores are collected in the Mediterranean Sea: REC13-53 (12°08' E, 36°45'N, 1113 m) from the Siculo- Tunisian Strait (central basin), KET80-19 ( 13°21'E, 40°33'N, 1920m) from the Tyrrhenian Sea (western basin), and MD84-641 (32°38'E, 33°02'N, 1375m) from the Levantine Basin (eastern basin). All the specimens present in the sub-samples (fraction >150 µm) were then counted and identified according to the taxonomic concept adopted by Hemleben et al. (1989) and Pujol and Vergnaud-Grazzini (1995).

## Results

SST records were generated along all these cores using the MAT applied to the obtained foraminiferal counts. The faunal assemblage variations permitted to define many biozones since the Last Glacial Maximum. 7 biozones have been identified in the western and central basins whereas only 6 biozones were obtained in the eastern basin.

In the western and central basins, biozone 7, between 24 and 18.3 ka, corresponds to the last glacial period. It presents a mixture of cold and warm species with SST values around 11°C. The total disappearance of the subtropical species *G.ruber* since 18 ka permit to identify the biozone 6. During this interval (18.3-15.3 ka), SSTs are around 9 °C. From 15.3 ka, SSTs increase abruptly and reach a value of 15°C. This interval (bio-5) corresponds to the interstadial Bolling/Allerod and is characterized by the dominance of the warm species. Between 13.2 and 11.7 ka (bio- 4), the microfaunal composition is similar to that observed during the glacial time with similar low SSTs (9°C). This biozone corresponds to the Younger Dryas cold interval. From 11.7 ka, the reappearance of *G.ruber,* together with the marked decrease of the subpolar species *N.pachyderma r.c* stipulate the beginning of biozone 3. High SST values of about 14 to 15°C are recorded during this time-interval. The reoccurrence of *N.pachyderma r.c* at 9.5 ka permits to identity the biozone 2 which extends over the entire time interval of the deposition of S1 in the eastern Mediterranean. The onset of biozone 1 is highlighted by the abrupt decrease of *N.pachyderma r.c*. This biozone, which extends to the present day, displays the highest SSTs of the record. In addition, our results permitted to outline many biochronological events that can be used for the establishment of the chronology of the western and central Mediterranean cores. We report for example a prominent peak of *T.quinqueloba* at 18.2 ka BP recorded in all the cores. The first postglacial occurrence of *G.inflata* detected at 15 ka whereas the postglacial disappearance of the cold species *G. scitula* is dated at around 12.5 ka. At the middle of the Holocene, *G. truncatulinoides* disappeared at the same moment than the deposition of S1. Its reappearance is recorded at 5.6 ka and 4.5 ka in the western and central Mediterranean, respectively. However, the Tyrrhenian Sea and the Siculo-Tunisisian strait indicate a similar variability while the Levantine basin show different features.

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# Carbonate ion effects on elemental ratios in benthic foraminifera *Hoeglundina elegans*: application to intermediate water circulation in the north Indian Ocean during the last deglaciation

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The Indian Ocean is an important area to understand the circulation of intermediate water (IW) masses. We combined benthic foraminiferal stable isotope records ($\delta^{13}C$ and $\delta^{18}O$) and benthic elemental ratios (Mg/Ca, Sr/Ca, U/Ca and Li/Ca ratios), which have been analyzed on cores located at intermediate depth of the from the south tip of India (core MD77-191) and the northern Bay of Bengal (BoB) (MD77-176) to reconstruct the evolution of intermediate circulation in the northern Indian Ocean since the last deglaciation that still not well constrained.

Benthic $\delta^{13}C$ and $\delta^{18}O$ analysis were performed on *Cibicidoides pachyderma*, *C. wuellerstorfi* and *Uvigerina peregrina*. Mg/Ca, Sr/Ca, U/Ca and Li/Ca ratios were measured in shells of the epi-faunal benthic foraminifera *H. elegans* from cores MD77-191 and MD77-176, as an epi-faunal specie with a habitat above the sediment-seawater interface could minimizes the influence of pore water in the elemental ratios.

Seawater carbonate ion concentration ($[CO_3^{2-}]$) and benthic $\delta^{13}C$ can be used to trace intermediate-deep water masses in the past and then to constrain ocean -atmosphere exchange during the two-stage increase in the atmospheric $CO_2$ during the last deglaciation. Intermediate water carbonate ion is mainly affected by the oceanic alkalinity inventory changes which could be linked to the modulating atmospheric $CO_2$ on glacial-interglacial time scales. Higher values for benthic foraminifera $\delta^{13}C$, depleted $[CO_3^{2-}]$ and B-P age $^{14}C$ offsets at the intermediate water depth suggest a release of deep-sea $CO_2$ to the atmosphere through the Antarctic Intermediate Water (AAIW) in the Southern Ocean during the 17-15.2 and 12.6-10.5 cal kyr BP time intervals. During the late Holocene, a decrease in the intermediate-water $[CO_3^{2-}]$ indicates the contribution to atmospheric $CO_2$ rise since 8 cal kyr BP, as reduced $CO_2$ solubility due to the depleted global ocean alkalinity in the seawater.

# Dynamics of primary productivity in the NW Indian Ocean since the Last Glacial Maximum: an evaluation of Indian Monsoon evolution

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**Thematics**: Paleoceanography and Paleoclimatology
**Keywords**: Indian Monsoon, NW Indian Ocean, primary productivity, last deglaciation, coccoliths

## Introduction

The Asian Monsoon (AM), including the East Asian and the Indian (or South Asian) sub-systems (EAM and IM), is the most typical monsoon climate zone on our planet. Due to opposite summer and winter temperature gradients between continent and ocean, it is characterized by a seasonal shift of prevailing winds and precipitations. The monsoon climate is crucial for human societies and it directly affects over a billion people's livelihood. Understanding this type of climate as a whole requires the reconstruction of its evolutions in the past as well as the study of the mechanisms behind them. For the IM, most of the studies focus on summer precipitation patterns. However, very a few consider the winter monsoon strength mainly quantified by wind intensity.

Here, we aim to reconstruct changes in IM winter monsoon dynamic since the Last Glacial Maximum (LGM, 25 ka BP) based on a model-data comparison approach. We've investigated coccolithophore assemblages from two well-dated marine sedimentary cores from northeastern Indian Ocean within the IM area: core MD77-176 in the northeastern part of the Bay of Bengal (NEBoB, 14°31'N, 93°08'E); and core BAR94-24 from the northwest of Sumatra (NWoS, 6°44'N, 94°50 E) and compared the results to the transient simulation outputs (TraCE-21) of the climate model NCAR-CCSM3.

## Methods

Both sites have PP peaks during winter controlled by wind. Empirical evidences mainly focuse on the relative abundances of a lower euphotic phytoplankton *Florisphaera profunda* (Fp %), which have the availability to document changes in primary productivity and monitor the relative depth of nutricline related to wind stress. We use the outputs of TraCE-21 downloaded from the Climate Data Gateway at NCAR (www.earthsystemgrid.org).

## Interpretations/Conclusions

Empirical records obtained from both cores differ significantly, especially at orbital scale. In the NEBoB record, no large difference between the LGM and late Holocene is found but primary productivity peaks are observed at 17-15 ka BP, 12-9 ka BP and 6-5 ka BP. In the NWoS record, PP was ~15% higher during LGM than late Holocene, the deglaciation being characterized by a gradual decreasing trend (especially from 15 to 10 ka BP). The NEBoB record coincides very well with published empirical records of EA winter monsoon dynamic, which suggests similar evolution pattern in these two sub-systems probably driven by the variation of Northern Hemisphere insolation and Atlantic meridional overturning circulation, while the wind dynamics of TraCE-21 outputs show diversities. We also compare our results to other Fp % records within the Asian Monsoon and Indo-Pacific Warm Pool areas. It appears that all the records can be divided into two pattern groups: those showing trends that coincide with earth insolation (similar to NEBoB), and those associated to global sea level changes (similar to NWoS). However further numerical investigations are needed in order to test several hypotheses, such as the contribution of the Walker Circulation in the PP variation in the NWoS record.

# Dating iron duricrusts in the Guyana shield: relations with paleoclimate change

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**Thematics** : Weathering geochronology
**Keywords** : (U-Th)/He, Electron paramagnetic resonance spectroscopy, iron oxides, weathering geochronology geomorphology

## Introduction

Laterites are deep weathering soils which form in tropical climate conditions and currently cover about 1/3 of the Earths continental surface, making up 80% of the global soil-mantle volume. Through weathering and erosion and related greenhouse gas consumption lateritic soils play a significant role in the global geochemical budget. Despite their widespread occurrence and their importance for the Earth's surface, little is known about the timing of their formation and their evolution as response of paleoclimatic cycles.

This study focusses on the tectonically stable Amazon craton where laterites formed during the entire Cenozoic. Different models exist for the landscape evolution in this area, however, age data of paleosurfaces are very rare. Most lateritic profiles contain a duricrust at their top which is made up mainly by iron oxides and hydroxides. By direct dating of these mineral phases, namely hematite and goethite, this project aims to better understand the timing of duricrust formation. Dating of clay minerals which occurs as secondary minerals in all parts of the profiles allows a second, independent approach of age determination.

## Samples and Methods

The samples of this study derive from the Kaw mountain ridge in Northeastern French Guiana. The ridge is approx. 300m high and comprises a lateritic profile formed on Paleoproterozoic ultramafic rocks. The sample set consists of several duricrust samples from the top and the side of the ridge as well as material from a 75 m deep drill core provided by the BRGM.

This project uses two methods for age determination of lateritic profiles: i) (U-Th)/He thermochronology of hematite and goethite and ii) Electron Paramagnetic Resonance Spectroscopy (EPR) of kaolinite.

For (U-Th)/He dating samples were sawed into slices and individual generations of iron (hydr-)oxides were separated by micro-drilling. The material was slightly crushed in a steal mortar and cleaned in ultrasonic bath.

(U-Th)/He analysis is done in a two step procedure: i) degassing of the crystal under high vacuum and measurement of the noble gas content followed by ii) complete digestion of the crystal and measurement of the U, Th and Sm contents by ICP-MS.

X-ray diffraction is used to identify the mineral phases and diffractograms a evaluated by the Riedvelt method to determine the hematite-goethite ratio.

For ERP analysis kaolinite is purified by removing iron oxides. The age is calculated from the paleodose and the dose rate of the sample.

## Results

The duricrust samples show a big variety of structures and textures. In some samples up to 5 different generations of iron (hydr-)oxides could be separated.

The drill core reveals a rather incomplete lateritic profile presenting approx. 6 m of clay-rich, rather soft iron crust overlain by a thin soil cover and underlain nearly directly by about 70 m of saprolithic material. The mother rock was not reached by the drilling.

## Outlook

First age results are expected for late July 2019.

# Improving our understanding of the African Humid Periods recurrence through the last two climatic cycles based on the characterization of saharan dust deposits recorded in the Western Mediterranean basin and the Northeastern Atlantic Tropical Ocean

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**Thematics** : Mineral dust deposits, Spatio-temporal variations of West African monsoon
**Keywords** : Saharan dust, Western Mediterranean basin, Northeastern Atlantic Tropical Ocean, African monsoon, Late Quaternary

## Scientific context

Through the Quaternary, cyclic variations of insolation received over the African continent have driven the monsoon dynamic, triggering the recurrence of periods of intense precipitation called "African Humid Periods" (AHPs). These periods are characterized by major transformations in the Saharan hydrological cycle such as the development of rivers, lakes or tropical vegetation in an area that is currently hyperarid. Through the last two climatic cycles covering the last 240ka, eight AHPs have been identified.

Numerous studies are focused on the onset and the end of the last AHP that occurred around 9-5ka [1]. This AHP corresponding to a period when the obliquity and the local insolation reached their maxima in a quasi-synchronous time, the identification of the orbital forcings associated with the development of this AHP remains highly debated [1-4]. In this work, in order to bring new elements of discussion concerning the initiation, termination as well as the intensity of these recurrent AHPs we proposed to study the seven oldest AHPs that correspond to different orbital configurations.

To answer this objective, two sedimentary cores have been strategically selected. The first archive corresponds to a lacustrine core taken in the Western Mediterranean basin (Corsica, Bastani lake, core BAS15). This high sedimentation rate archive records Saharan dust supplied mainly from the North Sahara and nearly covers the last 12ka [5]. The second archive is a marine record that was taken on a seamount off Mauritania (West Africa, core MD03-2705) and that continuously records the Saharan dust supplied essentially from North and West Sahara during the last 240 ka [6].

## Methodology

A multi-proxy characterization is carried on the dust fraction recorded in these two sedimentary cores including the grain size distribution, the clay mineralogy and the geochemical (major elements, Sr and Nd isotopic ratios) compositions. In fact, these sedimentological, mineralogical and geochemical characteristics are partly linked to the environmental conditions prevailing over the source areas (vegetation cover, chemical weathering, aridity) allowing to retrace, indirectly but unprecedented, the variability of the Saharan hydrological cycle over the time.

## Preliminary results

The first results obtained for the Corsican lacustrine core indicate a drastic reduction of Saharan dust supplies (diminution of the palygorskite) during the late Holocene AHP, associated with a rise to the north of the ITCZ over the North African continent as indicated by the Illite/Kaolinite ratio changes. These mineralogical results are consistent with hydrological changes developed over the North African continent during this green period in the Sahara desert [1-3].

## Work in progress

The mineralogical characterization of the two sedimentary records is in progress. In parallel to this analytical work, first numerical simulations of the eight orbitally different AHPs have been started using a coupled ocean-atmosphere climate model in order to better constrain global and regional climatic contexts as well as environmental responses of the Sahara during these periods.

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# Late Quaternary climate and environment reconstruction of Lake Urmia basin (Iran)

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**Thematic**: Hydrogeochemistry
**Keywords**: Lake Urmia basin; Environment reconstruction; Late Quaternary

## Introduction

The ongoing changes affecting Lake Urmia are revealed by the lake water level decrease by more than 7 m in the last 15 years, desertification and formation of dust storms. This drop has been attributed to rainfall declining by ~10% and to anthropogenic causes mainly the construction of numerous dams on rivers feeding the lake and abusive groundwater pumping. Nevertheless, the exact roles of natural and anthropogenic factors that influence the state of the lake are still not identified. Indeed, the lack of the detailed record of environmental evolution in the past limits the understanding of actual and future processes and as a consequence, the capability to develop integrated management of this water resource.

## Data and Methods

Samples were collected including 1) sediment cores from recently dried out part of the lake; 2) gas and water rising up from drilling wells; 3) water from the lake, wells between Urmia city and the lake, Shahr Chai river. Six sediment cores were obtained from recently dried out part of the lake close to Urmia city. Ongoing analyses of mineralogy, radiometric chronology and stable isotope contents on plant remains will allow the establishment of the environmental changes and their accurate chronology.

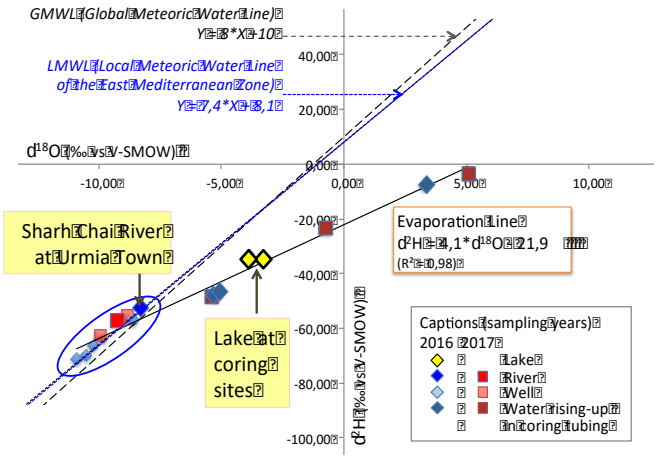


*Figure 4 $\delta^{18}O$ vs $\delta^{2}H$ plots for lake, river and well waters derived from Lake Urmia basin*

## Results

Sediments are composed by an alternation of sands and finer-silty and clayish fractions. Analyses for total mineralogy, clays, carbonates, magnetic properties, organic carbon, either contents and isotopes $^{13}$Corg and microscopic observations show important changes of the biological activity, sources of detrital material and transport energy, conditions of lake water evaporation and during early diagenesis. All these parameters are in relation with both lake water level fluctuations and precipitation variations over the lake watershed at local to regional scales through time.

## Conclusion

The establishment of a preliminary lake basin balance through sampling of feeding rivers and lake water (both surface and in-deep during the coring of the sedimentary sequence). Preliminary results highlight that: 1) the rivers upstream the lake are fed by the regional surficial aquifer, and downstream Urmia Town, the lake experienced a high evaporation process; 2)the brines embedded between salt layers and sampled while coring may be interpreted as residual lake water trapped during low lake stages (residual markers); 3) a change in air masses trajectories (mainly in summer) could explain the decreasing amount in precipitation.

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# SESSION 3

Geochemical processes

# Interface of Trarza aquifer and Atlantic Ocean between Nouakchott and the Senegal River (SW Mauritania)

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**Thematics**: Geochemistry and hydrogeology
**Keywords**: groundwater, geochemistry, seawater intrusion; Trarza.

## Introduction

Few data exist about the coastal aquifers of western Africa where a large part of the African population lives. Located in an arid area, the unconfined Trarza aquifer (Senegal-Mauritanian basin, SW Mauritania) contains a vulnerable groundwater resource. The study aims at investigating the hydrogeological functioning of the coastal Trarza aquifer. Two areas were considered: (a) the Tiguend area with a simple interface groundwater/ocean and (2) the Diawling national park at South where surface waters (Senegal river, artificial basins, streams) complicate the hydrosystem.

## Data and Methods

To study the relationship between the ocean, the Trarza aquifer and surface waters, a hydrodynamic approach has been combined to geochemical methods. A set of 102 samples (91 groundwaters & 11 surface water) have been collected in 2018 and 2019. Water level, temperature, pH and electrical conductivity were measured on field. Geochemical contents of water were determined at GEOPS.

## Results

The main groundwater flowlines are from SW to NO i.e. from the ocean and the Senegal River toward a depression at NE (Fig. 1). This result is uncommon as usually groundwater discharges into the ocean. This implies a very low annual renewal rate of groundwater and possible high rates of evaporation. A possible continental divide beneath the coastal sand dune (Fig. 1) has to be investigated. Concerning the geochemistry, the results shows a wide range of mineralisation (freshwaters to brines) with a dominant Na-Cl type.

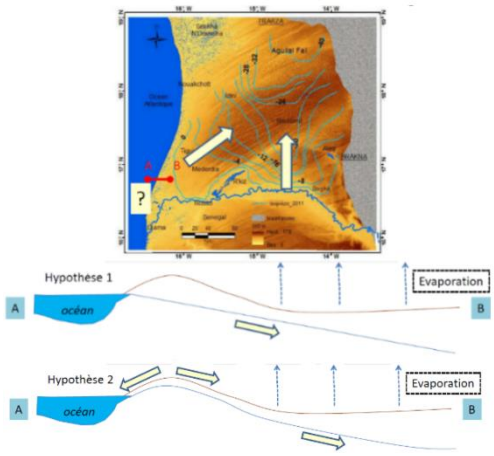


*Figure 1: Potentiometric map of the Trarza aquifer. The two A-B profiles are possible water-table positions below the coastal sand dune.*

In a Cl-Na plot, all the datapoints are not aligned along a dilution/evaporation line of ocean water, due to the interactions with Na-minerals. The Br/Cl ratio confirms that the salinity origin is ocean water (not halite dissolution) The isotopic contents confirm that groundwater is evaporated and most of them result from a mixing between fresh water (surface or groundwater) and ocean water.

## Conclusion

Crossing hydrodynamical and geochemical approaches has shown that, in a semi-arid area, the salted water wedge is not homogeneous along the coast. The dynamics of groundwater may be influenced by the multiple parameters: input of surface water, evaporation, sea-water intrusion, recharge rate and time.

# Hydrochemistry of the thermo-mineral waters from Western Algeria: origin and involvement of halogenides

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**Thematic**: Hydrogeology, geochemistry
**Keywords:** Thermal water, Salinity, Hydrochemistry, Water stable isotopes, Western Algeria

## Introduction

In northwestern Algeria, numerous geothermal reservoirs are located in carbonate rocks (Jurassic limestones and dolomites).

The region, which belongs to the Alpine-Magrebide belt, is bordered by the Mediterranean Sea and characterized by a complex geology, with tectonic and volcanic activities, which generate a significant geothermal potential.

Several studies conducted in this northwestern part of Algeria have shown that the location of thermal springs and the hydrogeochemistry of thermal waters are strongly controlled by the regional geology [1-5].

## Data and Methods

An environmental isotope and hydrochemical study were carried out to better understand the parameters that control the functioning of the hydrothermal systems: water-feeding conditions, possible mixings, acquisition processes and origin of mineralization, and deep reservoir temperature using geothermometry. For that purpose, 25 thermal-water samples and 12 cold-water samples were collected from springs and boreholes, in 2018, for chemical (major ions, Br, Li, Si) and isotopic ($\delta^{18}O$ and $\delta^{2}H$ of water, $A^{14}C$ and $\delta^{13}C$ in inorganic dissolved compounds of carbon, $\delta^{18}O$ and $\delta^{34}S$ in dissolved sulphate) analyses.

Electrical conductivity (EC), pH and temperature were measured in the field.

## Results

The thermal and cold water temperatures range from 24 to 68 °C and 16 to 22°C, respectively.

Cold spring waters are of Ca.Mg-Cl.$HCO_3$ type, and thermal waters are mainly of Na-$SO_4$.Cl and Ca.Mg-.$HCO_3$ types. While salinity of the cold spring waters is less than 1g/l, the highest measured salinity in the thermal waters is 68g/l.

Stable isotope contents of thermal waters range from -9.4 to -4.8 ‰ for $^{18}O$ and from -65.5 to -36.1 ‰ for $^{2}H$, *versus* V-SMOW. They range from -8.4 to -4.5 ‰ for $^{18}O$ and from -60.7 to -36.2 ‰ for $^{2}H$, *versus* V-SMOW, for cold spring waters.

## Conclusion

The thermal and cold waters from the northwestern Algeria are characterized by significant heterogeneities in their chemical and isotopic features. Most of the high-salinity spring waters probably acquired their characteristics by leaching evaporate minerals from Triassic or Messinian formations. For some coastal springs, contamination by seawater could contribute to this salinity. However, the water stable isotope contents indicate that both thermal and cold groundwaters are essentially of meteoric origin, with limited effects of evaporation.

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# Measurement of exceptionally high biospheric productivity at the beginning of MIS11 based on $\Delta^{17}O$ of $O_2$ in ice cores

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**Thematics**: Paleoclimatology, biogeochemistry, glacial-interglacial cycles, biospheric productivity
**Keywords**: Biospheric productivity, MIS 11, Termination V, $\Delta^{17}O$ of $O_2$, ice core

During the Quaternary, the deglaciations are associated with large changes of atmospheric $CO_2$ concentration with a difference of up to 100 ppm between the glacial and the interglacial periods. A complete and quantitative explanation for these $CO_2$ increases in atmospheric $CO_2$ concentration is still an open question since several fluxes contribute to the variations of atmospheric $CO_2$. Biological productivity is often invoked as one of the processes involved in the changes of atmospheric $CO_2$, and understanding its impact over deglaciations is key. While marine and continental proxies have been used to reconstruct the past variations of productivity at a regional scale, measurements of $\Delta^{17}O$ of $O_2$ ($\ln(\delta^{17}O+1) - 0{,}516 \ln(\delta^{18}O+1)$) in ice core has revealed to be a good indicator for inferring the past variation of global biospheric oxygen fluxes. We focus here on the special case of Termination V and the influence of the flux associated with biospheric productivity.

Of the last 9 deglaciations, Termination V displays a unique feature. This deglaciation occurs during a minimum in eccentricity and follows a strong glacial period (MIS 12) preceding the long and warm MIS 11 interglacial period. It is the first termination clearly associated with the 100 ka glacial – interglacial periodicity after the MPT.

Here we present the first record of the variation of the global biospheric productivity reconstructed from the triple isotopic composition of atmospheric oxygen ($\Delta^{17}O$ of $O_2$) measured in the bubbles of 50 samples of EDC ice core (Antarctica) over Termination V, i.e. from 444,1 to 405,7 ka. Compared to the previous records of $\Delta^{17}O$ of $O_2$ on the last 400 ka (Blunier et al., 2012), results show that Termination V is the only termination on which we can observe a different trend between $CO_2$ and $\Delta^{17}O$ of $O_2$, the decrease of $\Delta^{17}O$ of $O_2$ during the Termination and the beginning of MIS 11 being twice longer than the increase in $CO_2$. This shift reflects an increase in global oxygen biospheric productivity up to 20 % higher compared the other interglacial periods hence confirming the specificity of Termination V and MIS 11.

We then confront this result to other long series linked to terrestrial and marine productivities for a perspective on the link between $CO_2$ concentration and productivity over Termination V compared to the 4 younger Terminations.

# Transport of particulate organic carbon in the largest Chinese rivers: A global perspective

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**Thematics**: Biogeochemistry
**Keywords:** Carbon cycle; Particulate organic carbon; Isotopic carbon; Rivers

## Introduction

Particulate organic carbon (POC) transported by rivers can be considered as a mixture of two components: radiocarbon-dead $POC_{petro}$ eroded from the lithosphere and radiocarbon-enriched $POC_{bio}$ produced "recently" (<50,000 yr) by the biosphere[1]. Identifying the source, the transport mode and the fate (mineralization, disaggregation, sedimentation) of riverine POC is critical in determining the role of organic carbon in the global carbon cycle. Indeed, the imbalance between oxidation of rock-derived POC and burial of $POC_{bio}$ governs the potential sink of atmospheric $CO_2$ associated with the "organic cycle" over geological timescales (>$10^5$ years)[1,2]. Anthropogenic activities can alter this long-term balance of the organic carbon cycle in mobilizing previously stored OC (e.g., permafrost melting due to global warming, erosion linked to agricultural practices) or in reducing the total export of POC to the ocean (e.g., damming). Any environmental variation can impact the "organic carbon cycle" on short time scale and eventually the global carbon cycle. Here we study time series of POC transported by the four largest river systems in China (Pearl, Yangtze, Yellow and Heilongjiang rivers) which are characterized by different climatic conditions and anthropogenic pressure. These new data are compared to a global compilation of riverine POC to give some clues on the controls of POC transport and fate and hopefully to get a quantitative idea of the perturbation of the OC cycle associated with human activities.

## Data and Methods

An extensive riverine POC data collection from literature and original data were combined for the analysis. Literature data on suspended particulate matter (SPM) concentration, carbon content (OC%), carbon isotope composition ($\delta^{13}C$ and $\triangle^{14}C$), organic were used. Original data was mainly obtained from measuring $\delta^{13}C$ and OC% in bulk SPM in the four largest Chinese rivers.

## Results

Regarding transport of POC in global rivers, it shows a general trend that OC% decrease as SPM concentration increases. The Yellow River has the lowest %OC while that of the Songhua River (main tributary of the Heilongjiang River in China) is the highest. $\delta^{13}C$ and $\triangle^{14}C$ of POC were also river-depend.

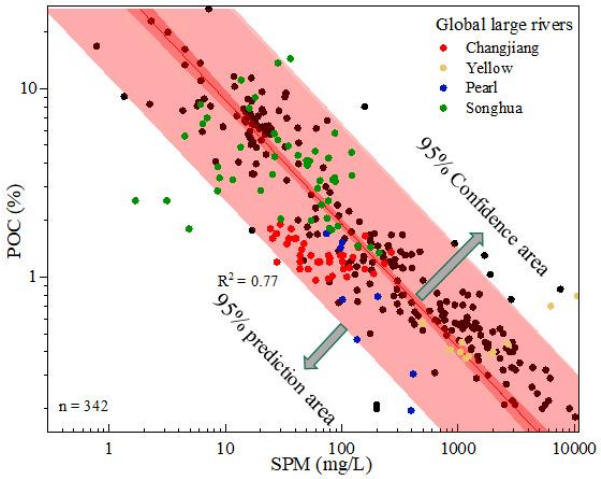


*Figure 1 %POC of the SPM in global large rivers.*

## Conclusion

Based on this comparison of global riverine POC, we found that POC in four largest Chinese rivers varies with each other in %OC, $\delta^{13}C$ and $\triangle^{14}C$ revealing the different source, age and transport mode. Comprehensive isotopic carbon measurement would be performed.

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# Experimental study on Mn oxides agglomeration key factors

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**Thematics** : Material science
**Keywords** : Agglomeration, dusts, manganese, binderless, uniaxial press

## Introduction

Dusts and sludges are the most important wastes in the mining and pyrometallurgical industry. In order to recycle those materials, they have to be agglomerated first to prevent furnace process instability. Agglomeration outputs are not well controlled, due to a lack of fundamental comprehension of the mechanisms. This study aims at constraining the impact of some parameters regarding the agglomeration: Mineralogy, moisture and pressure.

## Data and Methods

Agglomeration tests were performed on uniaxial press, where the material is compacted in a die between two pistons, producing flat, cylindrical tablets. This method does not require heat nor binder. The agglomeration cycle is composed of a pre-compaction phase, followed by a compression phase where the pressure was maintained for 5 seconds.

The agglomerated materials were as pure as possible: Montmorillonnite (smectite, main component of bentonite, commercial binder), kaolinite (non-swelling clay), MOR dusts (composed mostly of hausmannite, a Mn spinel) and a pyrolusite-enriched Comilog ore (hereafter called pyrolusite. Each material was agglomerated separately. Some mixed tests were also performed.

The moisture was modified from 0 wt.% (dry samples) up to 8 wt.% for each material. The effort applied varied between the lower limit of unsuccessful agglomeration to the upper one, or up to the limits of the machine (180kN).

Successful agglomeration was measured by the diametric resistance of the produced tablets following a simple rule: the higher, the better. The diametric hardness was first measured by applying an effort to the edges of the tablet, until it broke. The obtained value, in Newton, was transformed into pressure (Pa) by taking into consideration the tablet dimensions.

## Results

The different materials gave very different results depending on the conditions. Overall, the best results were, in this order: Montmorillonite, kaolinite, pyrolusite, MOR dusts. The MOR dusts produced very weak tablets in the best conditions.

The moisture has a non-linear behavior: the results improve up to 2-4 wt.%, depending on the material, and decrease from that point on. Around 7-9 wt.%, the material turns into a sludge and cannot be agglomerated.

The clays have an optimal effort applied at ~75kN, while the enriched Comilog ore does not reach an optimum value before the upper limit of the machine.

The mix performed (Pyrolusite-MOR, pyrolusite-kaolinite) show a roughly linear behavior between the end-member of each material.

## Conclusion

During high pressure agglomeration using a uniaxial press, the mineralogy of the material is the key component. It will define its behavior under pressure (plastic/fragile deformation, elastic rebound), but also the way it will interact with other parameters (moisture, other materials). The other parameters have to be optimized around the material in presence.

It appears that the relationship with pressure is not as linear as one might think, with optimal values that are not necessarily the highest ones. The moisture also have a local optimal around 2-3 wt.%, with the precise value depending on the material.

More parameters are to be considered, such as Particle Size Distribution, shape factor, moisture pH…

A correlation with adhesive forces (Capillary bridges, van der Waals and electrostatic forces) will be necessary to better understand the impact of the different parameters.

# Marine reservoir $^{14}C$ age estimation in the South East Pacific and circulation changes since the last glacial period

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**Thematics**: Last deglaciation mechanisms
**Keywords**: Radiocarbon, Paleoceanography, Tephrochronology

## Introduction

The last deglaciation was characterized by important changes in atmospheric $CO_2$ and $^{14}C$ contents that implicate the deep ocean as a major actor in the glacial–interglacial transition. Broadly, carbon would accumulate in the deep ocean during the Last Glacial Maximum (LGM) being released into the atmosphere during the deglaciation through oceanic circulation changes [1, 2], increasing the atmospheric $CO_2$ by ~75 ppm [3] and stating the interglacial state we now live in. In particular, the Southern Ocean (SO) has been indicated as a key area regulating the exchange of $CO_2$ between the deep ocean and the atmosphere.

## Data and Methods

The aim of this work is to study the variations in the distribution and characteristics of deep waters in the SO during the last deglaciation. In order to do this, we will obtain $^{14}C$ dates in benthic foraminifera, along with an oxygenation proxy ($\Delta\delta^{13}C_{C.\ wuellerstorfi\ -\ G.\ affinis/spp}$) in three cores in the southeast Pacific sector of the SO: MD07-3098 (40°56'S, 3055m), MD07-3119 (46°05'S; 2500 m) and MD07-3081 (49°26'S, 3273m).

Equally important is to obtain good chronologies for the cores to improve the possibilities of correct interpretations and correlation of the data. The active volcanism and explosiveness in the Andes makes it a potentially good way to improve chronologies in the area by obtaining marine reservoir ages using tephrochronology [4]. We aim to obtain marine reservoir ages in sediment cores MD07-3098 (40°56'S, 3055m) and MD07-3081 (49°26'S, 3273m) by identifying criptotephra layers as glass shard peaks. We will obtain major elements using the Electron Probe Microanalysis CAMPARIS (Univ Paris VI) and trace elements using the LA-ICP-HR technique in individual glass shards to, ideally, geochemically identify the corresponding tephras in land.

The difference of the $^{14}C$ age on land and of the foraminifera in the core results in marine reservoir ages in the area. The $^{14}C$ dating will be done depending on the available dating material with ARTEMIS or MICADAS instruments in individual benthic and planktic species. In order to correctly identify the eruptions corresponding to the criptotephra layers, a tephra database has to be made

## Results

So far, we have identified ten glass shards peaks in core MD07-3098, where major elements have been measured in six to fourteen individual glass shards per peak. Additionally, in the depths immediately below the peak (when possible) planktic and benthic foraminifera have been dated. With this information, together with prior information from nearby core MD07-3100 three Rs have been tentatively been obtained so far.

Additionally, work is being done to create an open source Tepchrochronology Database to share with the scientific community, along with scripts to treat the data and an interface for users to download the data according to different critera. So far over 10,000 measurements from ~100 eruptions of ~25 volcanoes have been added and a prototype is being tested in the ESPRI server from ISPL. This work is being done in collaboration with the chilean geological service in order for it to live in time and with the support of Chiara Marmo.

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# Siliceous phytoplankton as a marker of paleoceanographic conditions in the Southeast Pacific since the last glacial period

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**Thematics**: Paleoceanography.
**Keywords:** Paleoproductivity, Diatoms, Forams, Upwelling, Paleoclimatology, Chilean Patagonia.

## Introduction

Chilean Patagonia stretches from 41° S (Reloncavi Fjord) to the Drake Passage at 55° S. This region is characterized by the presence to the east of the Andes mountain range and represents the only continental landmass of mid-latitudes of the Southern Hemisphere, along with the Argentinian Patagonia.

The hydrology of this area is influenced by the ocean water masses and continental sourced fresh water such as, river inflow, glacier melt water, and precipitation. The precipitation in the west side of the Andes in modulated by the Southerly Westerly Winds (SWW) which advect water from the Pacific Ocean, precipitating when encountering the Andes. The position of the SWW is controlled by the subpolar belt, both of which are directly related to the global climate.

The main aim of this thesis is to study the impact of melting glaciers on the diatom and foraminiferal communities present in the Southeast Pacific over the past 20.000 years.

To address these objectives, we will analyze a marine series through a transect along the Chilean continental margin between 41° S and 49° S, with high temporal resolution. In this transect, we will analyze the assemblages of siliceous microorganisms since the Last Glacial Maximum.

## Data and Methods

The sediments analyzed in this study come from three sites in Chilean Patagonia (MD 07-3082: 49°10.07 S; 76° 34.03 W, MD 07-3088: 46°04.30 S; 75°41.23 W, MD 07-3100: 41°36.13S; 74°57.40W) and were collected in February 2007 during the IMAGE PACHIDERME cruise.

For the identification of siliceous microfossils (diatoms, sponge spicules and silicoflagellates), organic matter was removed using H2O2 and HCl [1].

Diatoms were identified at the lowest possible level [2,3,4,5].

## Preliminary Results

Preliminary results of the diatom analysis of core MD 07-3088 shows a dominance of marine diatoms with an average of 1 x 106 valves g-1, within this group we find high abundance of resistance spores, Thalassiosira eccentrica, Paralia sulcata and Fragilariopsis kerguelensis. The abundance of continental diatoms (mainly Discostella stelligera and Cyclotella litoralis) were two orders of magnitude lower averaging 2 x104 valves g-1. The silicoflagellates were represented by two species Distephanus speculum and Dictyocha fibula and averaged 9 x 103 skeletons g-1.

Greater abundances of diatoms began to be observed from the 12.000 years BP (after deglaciation) to the present, which would be related to the increase in temperature and the entry of nutrients from upwelling.

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# Fluorite as a marker of fluid-rock interactions in unconformity-related F-Ba ore deposits in the South of the Paris Basin

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**Thematic**: metallogeny, basin, geochemistry
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## Introduction

Fluorite is a raw material classified since 2017 as a very important economic resource with high supply risks in the European Union. In France, the Morvan massif located in the south-east of the Paris Basin hosts 5,5Mt of fluorite, in stratabound ore deposits related to the basement/sediment unconformity.

The Pierre-Perthuis fluorite deposit is one of the most important of the Morvan Massif and is located at the north-western border. Fluorite is predominantly associated with barite and has been dated by Sm-Nd on bulk fluorite minerals at 130My ± 15 [1]. At Chitry-les-Mines (25 km away in a south-westward direction), fluorite and barite are associated with higher concentrations of lead and zinc, as galena and sphalerite and their alteration products [2].

My PhD research project intends to better understand these heterogeneities in terms of fluid origin and ages of crystallization events, using fluorite crystals as physical, chemical and geochronological markers of these mineralizations.

## Data and Methods

A detailed petrographic work (light microscopy, cathodoluminescence, SEM) will attempt to determine precisely the paragenetic sequence of these two case studies (Pierre-Perthuis and Chitry-les-Mines). The physicochemical conditions of mineral precipitations and the chemical characteristics and potential evolution of the initial fluid (temperature, salinity) are determined by fluid inclusion microthermometry.

An extraction line coupled to a cavity ring-down spectrometer [3] has be used to quantify the stable isotope ratios of oxygen and hydrogen of the fluid inclusions in fluorite crystal.

The U-Pb dating method on fluorite will be developed by LA-ICP-MS at GEOPS laboratory to radiometrically date very small (ca. 100 µm) fluorite growth bands.

## Results

Preliminary results were acquired on Pierre-Perthuis fluorite samples. Fluid inclusions minimum trapping temperatures range between 90°C and 120°C, with salinities around 15-20 wt.%. Fluid inclusion water stable isotope ratios in Pierre-Perthuis fluorite samples range from -2,6 to -3,2 ‰V-SMOW for δ18O and from -13,2 to -26,9‰ V-SMOW for δD. Some U-Pb ages have been obtained on the most external overgrowth of fluorite crystal. This last generation is dated at 33,4My ±1,6 but this first age estimate needs to be confirmed.

## Conclusion

These results indicate the contribution of a meteoric fluid in accordance with isotopic compositions and validate the use of a new extraction line coupled to a cavity ring-down spectrometer for fluid inclusion stable isotope analyses in fluorite. This new method provides for the first-time isotopic compositions performed directly on fluorite fluid inclusions and are better constrained compared to previous studies [4]. The age obtained is also very different from the previous studies [1] and concerns only an external overgrowth of fluorite crystal but which is a petrographic marker in the paragenetic sequence in Pierre-Perthuis. This age corresponds to a vertical fracturing and calcite veining in the Gondrecourt graben (eastern Paris Basin) induced by major late Eocene extension [5]. It also corresponds to a major subsidence period in the southern Upper Rhinegraben along with flank uplift led to mineralization event along a major rift and related faults [6]. So, would fluorite mineralizations be a marker of tectonic events at largest scale? More detailed investigations will be carried out to compare petrographic and isotopic data at the growth bands scale to understand heterogeneities of metal mineralizations.

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# Characterization and geochemical functioning of laterites of the Amazonian Basin

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**Keywords**: Laterite, weathering, environmental geochemistry, Amazonian shield

## Introduction

Laterites are hydrolytic weathering profiles that are derived from silica rocks and that form, nowadays, in the intertropical zone relating to the very warm and humid climate. They occupy 1/3 of the Earth's land surface, and, because of their thickness represent 80% to 85% of the pedologic cover [1]. Their importance regarding carbon cycle by the alteration of silica minerals, and because of their mineralogical components give them a double role toward the climate: actor of climate change by the $CO_2$ consumption during the silica mineral weathering and witness of climate change by the presence of specific minerals (e.g. kaolinite, hematite, goethite …) [2] or isotopic variations (e.g. $\delta^{18}O$ and $\delta D$) [3] as example.

The current research investigated an entire weathering profile from Brownsberg Natural Park (Suriname) on the Guiana Shield. This geological unit is located on an area which remained geodynamically stable since 100 My, staying close to the equator and enduring warm and humid climatic conditions, but still, with contrasted periods. Such weathering profiles are, in consequence, constantly evolving.

Mineralogical and geochemical studies enable to identify intense alteration, typical of lateritic profiles, which imply a strong leaching of alkali and earth alkali, and a clear iron enrichment firstly and a clear aluminium enrichment secondly in the uppermost part of the profile. Moreover (U-Th-Sm)/He dating results on (hydr)oxides from duricrusts show younger ages than previous studies in the Guyana Shield. This distinctness regarding scientific theories, implies complex processes of formation and evolution of weathering profiles which are still, nowadays, unclear. Indeed, heterogeneities observed in distribution of Th/U ratio vs. age indicate the existence of multiple iron oxides and hydroxides generations that could imply successive processes of dissolution/re-precipitation of these minerals and a constant renewall of duricrusts.

## Data and Methods

The first step consists on sampling different profiles from the Amazonian craton located in specific areas, such as Suriname for the first target area. Then, mineralogical and geochemical analyses will be performed to understand the evolution from the unaltered rock to the duricrust and so, understand weathering processes that lead to the studied lateritic profile.

Various characteristics will be considered such as the nature of the basement or the different location and different actual and past climate (temperature, intensity of rainfall), but also biological activities. The use of isotopic methods ($^{18}O$, D, Li, Fe or Si) will be considered to study those characteristics.

## Results

A better understanding of weathering processes and their intensity is the major issue of this study. Geochemical budget and profile age will be used to determined weathering rate in order to estimate the timing of laterites formation and its consistency regarding important climatic events.

## Conclusion

Deep weathering profiles such as laterites are an important component of the critical zone as they participate to $CO_2$ cycle and as they record past climate. However, only few recent studies have aimed to a better characterization of weathering processes in relatively stable tropical context.

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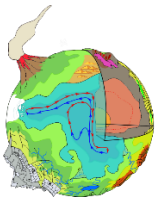

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