6ème CONGRÈS DES DOCTORANTS

de l'Observatoire de Lyon

Conference guide & Abstract booklet

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Abstracts session 1:

Bio-Geochemistry

Molecular and isotopic study of a contemporaneous analog for the Proterozoic Oceans: lake Dziani Dzaha (Mayotte)

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For over the first half of the history of Earth, oceans remained anoxic and dominated by communities of procaryotes. Lake Dziani Dzaha (Mayotte) has recently been identified, on the basis of its biogeochemical characteristics (anoxia under 1.5m, permanent euxinia, 13C-enriched carbonates precipitation, prokaryotic preponderance), as one of the best contemporary analogues of Proterozoic oceans. In this study, we have realized the molecular and isotopic characterization of the organic matter present in the water column of the lake for two periods of the year (stratified period / mixed period) for two consecutive years, and in two sediment cores. The results show that the presence of a chemocline plays a prime role in structuring microbial communities in the water column, along with the recycling and preservation of the organic matter. Indeed, if productivity in the cyanobacterial mixolimnion remains intense and similar from one season to another, remineralization of this biomass appears much more intense in the stratified period. The systematic production of specific biomarkers at the chemocline suggests the existence of mesophilic and halophilic bacterial populations involved (directly or indirectly) in the sulfur cycle. The study of the sediment biomarkers composition demonstrated that in a stratified and euxinic context, part of cyanobacterial biomass generated in the surface waters (carotenoid pigments) may escape selectively from remineralization and be exported in sediments via abiotic sulfurization/reductive desulfurization reactions. In addition, strong levels of archaea biomarkers (probably methanogens) and bacteria indicate the pervasiveness of an important active microbial community in the subsurface sediments. Finally, the assembly of biomarkers in deep sediment brings up changes in the lake's functionning at the start of its history, suggesting an initially evaporitic, hypersaline environment and the presence of different procaryotic communities comparing to the current ones.

Comparison of ocean chemistry before and after the Great Oxidation Event with implications for the origin of life

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The present-day high atmospheric oxygen level allows for the current life-sustaning oxidizing conditions on Earth's surface. However, atmospheric oxygen contents were not always this high, nor were they stable, at the beginning of Earth's history 4.54 billion years ago. Two independent abrupt steps that each led to increases in atmospheric oxygen concentration were needed to reach the current level: one took place at about 2.4 Ga, known as the Great Oxidation Event (GOE), and is at the core of this project. The other, the Neoproterozoic Oxidation Event (NOE), occurred about two billion years later. The GOE likely resulted from the emergence of continents, the erosion of which brought phosphate to the ocean, which in turn boosted oxygenated photosynthesis. The two incremental increases observed in atmospheric oxygen levels match two major events in the evolution of life: shortly after the GOE, eukaryotes appear, while the Metazoan outbreak during the Cambrian explosion is related to the NOE. Better documentation of especially the GOE hence may significantly improve our understanding of the origin and evolution of life, which was primarily marine at that time. The only archives of the Proterozoic era in the oceans are sedimentary rocks. To understand how atmospheric oxygenation is related to marine life, we first need to establish how the ocean interacted with the atmosphere during the Proterozoic. The central goal of the present project is to determine how the GOE influenced the biogeochemical cycles in the ocean on which life depended. Banded iron formations (BIF) may shed light on this question as the chemistry of these sedimentary marine rocks mirrors that of the contemporary ocean. Quantitative derivation of the composition of the ocean from that of coeval sediments is a challenge almost impossible to meet, even with today's analytical means. This is why we propose to instead obtain the residence times of the redox-sensitive elements sulphur, iron, and copper in the Proterozoic ocean. The principal aim is to determine the spectra of the temporal isotopic fluctuations of these elements as recorded in BIF cores. The inferior temporal limit should lead to the respective residence times of these elements in sea water and thereby provide robust information about their concentrations in the concurrent ocean. The samples to be targeted come from the Archean-Proterozoic boundary in the Transvaal group, South Africa, the Archean of Hamersley, Australia, and the Eoarchean of the Nuvvuagittuq belt, Canada.

Neurodegenerative diseases: New constraints from Cu and Zn cerebrospinal fluids compositions

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Neurodegenerative diseases affect more than 45 million of people worldwide and represent the third leading cause of death in the most developed countries. These irreversible chronic diseases are characterized by progressive deterioration of nerve cells but their causes remain unknown. In addition, visible symptoms are difficult to detect at the early stages of the disease due to their similarity with "normal" ageing symptoms and currently, there is no robust and reliable clinical and/or biological markers. All these issues make it difficult to find efficient curative treatments for neurodegenerative diseases.
To address these problems, we analyzed trace element concentrations and copper and zinc isotopic compositions, referred as $\delta^{65}Cu$ and $\delta^{66}Zn$ respectively, in cerebrospinal fluids of patients with amyotrophic lateral sclerosis (ALS) and Alzheimer's diseases (AD) as well as of control patients (CTRL) (i.e. people without neurological disorders). Using principal component analyses and boxplot diagrams, we demonstrate that δ65Cu and [Zn] are significantly distinct between SLA and CTRL as well as SLA and AD (pvalue <0.05). We show that cerebrospinal fluid of SLA patients tend to have higher $\delta^{65}Cu$ and lower [Zn] than both controls and Alzheimer's people. We observe a large range of Zn concentrations and isotopic ratios in CSF Alzheimer's patients ranging from 0.011 to 0.035 ppm and from -0.19 to +0.30‰ respectively. This Zn variability reflect a dysregulation of Zn homeostasis in the brain and seems to be linked to the breaking of the blood-CSF barrier that could be one of the main cause accounting for Alzheimer's disease onset.
Our results have important consequences and imply that Cu and Zn compositions of cerebrospinal fluids could potentially be used as (1) potential non-invasive biomarkers to diagnostic and discriminate different neurodegenerative diseases at early stages, (2) robust chemical tools to identify the biological process(es) responsible for Alzheimer and amyotrophic lateral sclerosis and evaluate the disease progression.

Understanding copper fluxes in cancerous cells using natural copper isotopic compositions in a model organism

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Copper (Cu) is an essential cofactor in several proteins and is transported from blood to organs by Cu-proteins. In cancer, Cu concentration increases in tumor cells (Engelken et al., 2014). Balter et al. (2015) have shown that liver cancer tumors are enriched in heavy Cu isotopes compared to healthy patients liver tissue. However, the reason for this difference remains unknown. We proposed that this differential isotopic composition could be due to differences in Cu transport between tumors and healthy cells.

To test this hypothesis, we have used the model yeast *Saccharomyces cerevisiae* in which Cu enters cells through both high-(CTR1, CTR3) and low-affinity importers after its enzymatic reduction by FRE proteins. These three activities are the three potential sources for isotopic fractionation in the system. To understand the impact of Cu import on Cu isotopic composition, we have monitored the evolution of both Cu concentration and isotopic composition as a function of time in two strains with different uptake systems: a wild type strain (WT) with both high- and low-affinity transporters and a strain lacking high-affinity importers (MPY17). Both WT and MPY17 show a preferential uptake of the lighter Cu isotope compared to the culture media with similar fractionation: Δ^{65}Cu=-1 and -0.8‰, respectively. Hence, the observed fractionation is not due to the activity of high-affinity importers. The impact of the reductase activity was tested using strain SKY34 which has a low reductase activity. In this strain, the Δ^{65}Cu remains stable *ca.* 0‰. This absence of fractionation may be due to the low availability of Cu(I) as a consequence of SKY34 low reductase activity. In fact, if Cu is exclusively provided to the cell as Cu(I), the Δ^{65}Cu=-1‰. These results clearly demonstrate that the origin of the fractionation in yeast is linked to the activity of low-affinity transporters.

References
Balter al al., PNAS, 2015, **4**, 982
Engelken et al., *bioRivix,* 2014

Abstracts session 2:

Extra-Galactic

Supersymmetry in the quest for dark matter particles

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Various astrophysical and cosmological studies have suggested the existence of a particular kind of matter, called “dark matter” which can be observed so far only through its gravitational interactions with ordinary matter. Even though dark matter is invisible, its existence is fundamental as it represents almost 85% of the total mass of the Universe and is believed to be crucial in the process of galaxy formation. Beyond that,understanding its nature in terms of particle content could be key to test the validity of models aiming to describe the Universe at an infinitesimal scale. In particular, some of these models assume “supersymmetry”, the hypothesis that for each elementary particle that is known so far, one or two undiscovered ”superparticles” exist. One of these “superparticles”, the lightest one, could be a very good candidate for a dark matter particle. The aim of my Ph.D. project is to test the validity of a few of these models by confronting them to the results of several particle physics experiments, such as the Large Hadron Collider (LHC). So far, even though no supersymmetric dark matter particle has been found, I have been able to put constraints on its properties, particularly its mass and rate of interaction with matter.

Strong gravitational lensing + VLT/MUSE: a new hope for understanding Pandora's cluster

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Probing the central mass distribution of massive galaxy clusters is an important step towards mapping the overall distribution of their dark matter content. Thanks to gravitational lensing and the appearance of multiple images, we can constrain the inner region of galaxy clusters with a high precision. The Frontier Fields program conducted with HST telescope (FF) provide us the deepest data ever in such clusters.

The MUSE instruments measure the spectra over an entire field of view thanks to his integral field spectroscopy technics. With ~500 measured redshifts in the entire multiply-imaged region for the cluster of galaxies Abel 2744, MUSE offer a gold mine to constraints the mass in the vicinity of the cluster. 64 of those redshifts represent the strong lensing constraints and this such amount of constraints make the mass modelling able to reach a level of unprecedented precision.

Study of distant faint galaxies in galaxy clusters

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I will present a way to study low-mass galaxies even lower than the actual limit, by using the gravitational lensing. But to make use of the gravitational lensing effect, we need to observe objects through galaxy clusters. And for low spatial resolution images it can happen that interesting objects are blended with cluster galaxy. The aim of my work is to use the informations of cluster galaxy on high spatial resolution images, to deblend the low spatial resolution image and study the interesting object.
Firstly, I will introduce the general method I worked on during my first year as PhD student, why is it needed and in which cases. I will briefly present the different software I used and illustrate the method by focusing on one object in the galaxy cluster MACS0416. This allowed us to build its Spectral Energy Distribution (SED) and derive its physical properties such as its mass. The limits of the method will be discussed.
Secondly I will present my PhD project, what I did until now, what are the next steps and what are the objectives. I will present the several improvements done until now and their results, specially for a galaxy-galaxy lensing system study where the multiple images and the cluster galaxy are very blended. You will see how the method handle that and how I helped it, and the improvement of the result.
Finally I will conclude briefly by presenting the advantage of a such method, and how I will use it to study low mass galaxies.

Exploring the Outskirts of Distant Galaxies

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Understanding galaxy evolution is a long-standing problem. Current assumptions are mainly based on numerical modelisations suggesting that a galaxy interacts with its environment through gas inflows and outflows. These gas exchanges, by modifying the quantity of gas within the galaxy, may impact the star formation rate and thus influence the evolution of the galaxy. Considering that gas is extended beyond galaxies, we assume that they could be all linked together in a larger scale structure called the cosmic web.
I will show you the first results of the study of the extended gas, called 'halos', around galaxies observed with the Multi-Unit Spectroscopic Explorer (MUSE).

Abstracts session 3:

Planetary Sciences

Growing porous grains: a solution to planetary formation problem?

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About 2000 exoplanets have been discovered for the past 20 years and those planets are thought to form in protoplanetary discs which are made of gas and dust spinning around young stars. Initially submicronic, dust grains can grow by coagulation during collisions till they reach pebble, then planetesimal and planet sizes. Grains in protoplanetary discs are subject to an aerodynamical drag force. Growth and dynamics are understood for very small and very big grains which are respectively strongly-coupled with and decoupled from the gas phase. However, when they reach intermediate sizes (from millimetre to meter), compact grains are subject to several theoretical or experimental formation problems called « barriers ». Several hypotheses on how grains overcome these barriers have been proposed but they rarely focused on intrinsic solutions. In my Ph.D. project I focus on one of them: grain porosity. With a model of porosity evolution during growth, I investigate the effects of porous grains on dust dynamics and evolution through analytical and numerical studies using our 3D bi-fluid SPH code. The results of these studies will help to understand how grains grow enough to reach a state where they keep growing thanks to their gravity and would also contribute to understanding the nature of porous objects in the Solar System.

Metal/silicate differentiation and volatile elements depletion in the Solar System: isotopic study of Zn and Sn

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Planets formation resulted from gravitational collapse of the solar nebula and accretion of objects in the early Solar System. Meteorites allow us to access to the global initial chemical composition of planets. However, several processes such as core formation or impacts can significantly modify their composition. It is known that the bulk composition of the Earth, Mars and the Moon are characterized by a depletion in volatile elements compared with the primary material of the Solar System, i.e. CI carbonaceous chondrites. In order to identify the processes responsible for the origin of the planet composition (i.e., partial evaporation and partial condensation), we compare meteoritic isotope compositions to the effective composition of planets. We focus on Zn and Sn which have similar 50% condensation temperature, meaning that they are both volatile elements. Therefore, during partial evaporation/condensation processes, one can expect to observe isotopic fractionation for both elements. On the contrary, as Sn is a moderately siderophile element whereas Zn is both litophile and chalcophile, metal/silicate equilibrium might affect the Sn isotope composition but not Zn. In order to compare the composition of the Earth with other materials, we need to know the bulk composition of the Earth. However, we do not have access to Earth's core and inherent processes, such as magmatic processes can also affect sample's isotopic compositions. In the case of Sn, no isotopic study had been conducted on this topic until now. Therefore, it is still unknown whether this isotope system is affected by magmatic processes or not. We propose to determine how tin isotopes are affected by igneous processes using two independent methods. On one hand, we determine the equilibrium fractionation factor of Sn between several speciation and phases using NRIXS spectroscopy; on another hand, we measure the isotope composition of terrestrial samples such as basalts and peridotites using MC-ICPMS.

Estimation of Mars erosion rates from crater size distribution

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Datation using crater size frequency is a widely used tool in planetology. This method assumes that the number of craters on a planetary surface is a function of its age. It has been calibrated using datations of moon samples and then extrapolated to other objects of the solar system. Unfortunately this method doesn't take into account resurfacing events such as erosion or lava flows that are featured on a lot of objects such as Mars or ice satellites. Those events can obliter craters and thus alter the crater size distribution. Small craters are more likely to be eroded than bigger ones creating an inflexion on the distribution. This inflexion is widely observed on Mars surface.

Our purpose is to take into account resurfacing events providing a more constrained age and an estimation of the resurfacing intensity. We model the evolution of a surface undergoing both craterisation and erosion. Those models are compared to observed data on Mars with an inversion method that finds the more probable age and obliteration rate. We are introducing the crater depth distribution as a new constrain to our models. Our preliminary results show that a very low obliteration rate can alter the slope of the crater size distribution thus biasing the datation of numerous surfaces on Mars. We compared our model to crater size distribution on Gusev Crater (Mars) and found an obliteration rate around 0.1 mm/Myr. This result falls within the estimated values found with in situ observations. Our model is still very simple and better formulation of the obliteration rate should be implemented.

First-principles calculations of Gibbs free energy of mixing of NaCl in body-centered cubic water ice

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Understanding the behaviour of materials under planetary interior thermodynamic conditions is a long-term challenge. The calculation of mixing models between two phases implies a knowledge of the free energy of the system. However, although the internal energy and the pressure can be calculated from first-principles calculations, the entropy remains an issue. Here, we use first-principles molecular dynamics to simulate high-pressure and high-temperature water ices, and we calculate the vibrational entropy from the recently developed two-phase thermodynamic – memory function (2PT-MF) model (Lin et al. (2003) and Desjarlais et al. (2013)). This method allows to compute the free energy and the vibrational entropy of a system at a given condition from a single simulation through a decomposition of the partial vibrational density of states into a gas-like and a solid-like subsystems. We will present the application of the multicomponent 2PT-MF model to the high-pressure mixing of NaCl in H2O ice along the 1600 K isotherm and in the Mbar pressure range.

Abstracts session 4:

Internal and External Geodynamics

Thermal convection in a spherical shell with phase change boundary conditions

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It has been proposed that the crystallization of the Earth mantle started in the middle of the primitive magma ocean, leading to a situation with a solid shell surrounded by two magma oceans. With such a configuration, the internal and external boundaries of the solid mantle are melting/freezing interfaces. Plumes or plates reaching these interfaces are then able to pass through the boundaries by melting, the flow being balanced by freezing of a magma where plumes move away from the boundaries. The phase change interfaces are then semi-permable boundaries. The effects of such interfaces has already been studied in the context of the inner core dynamics, with a melting/freezing condition at the inner core boundary. We propose here to use a similar condition to study the effects of the presence of magma oceans on the convection in the solid mantle. We performed the linear stability analysis of the problem, as well as fully non-linear numerical simulations using the convection code StagYY. Two main effects are observed: the horizontal wavelength of convection and the radial heat transfer are increased, potentially leading to a translation regime of the solid shell similar to the already suspected translation of the inner core.

Quantifying extrinsic anisotropy due to small scale isotropic heterogeneities

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Observations of seismic anisotropy are used as a proxy for lattice-preferred orientation (LPO) of anisotropic minerals in the Earth's mantle. LPO means that under finite strain accumulation, plastic deformation of minerals can result in a preferential orientation of their crystalline lattices. Therefore, the anisotropy observed in seismic tomographic models provides important constraints on the geometry of mantle deformation associated with thermal convection and plate tectonics. However, in addition to LPO, small-scale heterogeneities that cannot be resolved by long-period seismic waves also produce anisotropy. The observed, i.e. apparent anisotropy, is then a combination of an intrinsic and an extrinsic component. Assuming the Earth's mantle exhibits petrological inhomogeneities at all scales, tomographic models built from long-period seismic waves may thus display extrinsic anisotropy. Our project aims to investigate with simple synthetic models the relation between the amplitude of heterogeneities in terms of variations of shear-wave velocity and the level of induced radial anisotropy as seen by long-period waves. Our 1D and 2D models are isotropic and exhibit a power spectrum of heterogeneities as expected for the Earth's mantle i.e. varying as 1/k with k the wavenumber of these heterogeneities. The 1D toy models correspond to simple horizontally layered media whereas the 2D models are 'marble-cake' patterns in which an anomaly in shear-wave velocity has been advected within 2 convective cells. The long-wavelength equivalents to these models are computed using upscaling relations that link properties of a rapidly varying elastic medium to properties of the effective, i.e. apparent medium as seen by long-period waves. The resulting homogenized media represent what would be observed in tomography and exhibit extrinsic anisotropy. Numerically, we find that the level of extrinsic radial anisotropy increases with the square of the heterogeneities in both 1D and 2D media. This relation has been proven analytically in the 1D case. Moreover we predict that a non negligible part of the observed anisotropy in tomographic models may be extrinsic and the result of unmapped fine layering in the mantle.

Developping new methods to study the scattered seismic wavefield

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Our comprehension of the interior of the Earth has benefitted a lot from direct wavefield studies such as first arrival time tomography. These study however usually lack of fine structure detail and resolution. The study of the scattered seismic wavefield can help gather information about small scattering structures inside the Earth such as low velocity regions, density anomalies and interfaces within the mantle. One common way to study the scattered wavefield is to look at P-to-S and S-to-P conversion using Receiver Functions (RF) Upon crossing an interface with a sharp velocity variation, waves are scattered and converted, which leads to larger (P-to-S) or smaller (S-to-P) arrival times than the direct wave. These waves contain the information about the fine structure they encounter and can be studied to enhance our comprehension of regions like the upper mantle. Most studies about Receiver Functions use the computationnaly efficient CCP (Common Conversion Point) stacking method that bins source-receiver pairs with near vertical incidence. Therefore the 3D information about the scatterers is lost during the migration or inversion processes. This is usually a good assumption under stable cratons and continent, but falls short when we want to study tectonically active regions such as orogens or subduction zones. Subduction zones are amongst the most hazardous regions on Earth. Gaining a better understanding of the subduction zones may help us better predict and prevent the dramatic effects that megathrust earthquakes, such as the 2004 Sumatra or 2011 Tohoku earthquakes, can generate. In order to image correctly regions with dipping features methods have to be developped to engage a full 3D analysis. Great steps have be made forward using a full 3D Pre-stack migration method that relies on Kirchhoff principles, primarly developped at UC Berkeley (USA) by C. Cheng, R. Allen and T. Bodin that we will be developping during this thesis. The new 3D Kirchhoff approach is designed to treat large ensembles of teleseismic Receiver Functions recorded at arrays of stations. The energy observed on the records is migrated back to potential scattering points not only along the assumed close to 1D direct path of the incoming wave but across the whole 3D investigated volume according to a reference velocity model. Proceeding this way allows the energy to focus along the actual scattering interfaces and to fade into noise when there is no real feature. Because this method requires only travel times, it is at conceptually simpler and computationally more efficient than most sophisticated Receiver Function techniques. Moreover, synthetic tests have shown that the use of free-surface reflections may eliminate almost completely the artifact of multiples of reflectors. This method therefore offers at the same time a more precise imaging of lithospheric and upper mantle discontinuities as well as the possibility to work on bigger arrays and datasets.

A new paleothermometer for evaporitic halite: Brillouin spectroscopy

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The reconstruction of changes in Sea and Lake Surface Temperatures (SST and LST, respectively) is critical for our knowledge of past climatic changes. Most of these reconstructions are based on bio and or geochemical proxies. In ancient evaporitic basins, however, where fossil life is unable to provide any temperature proxy as it is virtually absent, microthermometry on fluid inclusions appears to be the most adequate paleothermometer alternative. Fluid inclusions (FIs) are present in virtually all rock minerals, including halite, and are commonly used to constrain formation temperature of crystals, via the microthermometry technique. This approach assumes that the vapour bubbles contained in FIs disappear, during heating, at a given homogenization temperature Th corresponding to the FI formation temperature. Samples are cooled in a freezer to nucleate a vapour bubble in the FIs, prior to gradually heating them to reach the Th. Although this technique is widely used, it also faces several limitations, namely:

- The unpredictability and scarcity of bubble nucleation. Indeed, only a small fraction of FIs show bubble nucleation upon cooling.
- The samples can be damaged by thermal treatment, as shown by the change in Th for the same FI after several cooling-heating cycles.
- The observed values of Th in a single sample form a broad distribution, covering a wide temperature range.

The latter is the main limitation of the microthermometry approach. Conflicting views about the true formation temperature are found in the literature: some authors recommend to use the mean of the Th distribution, others its maximum.
We have used FIs in synthetic halites to demonstrate the potential of a novel technique, Brillouin spectroscopy, in determining the formation temperature of fluid inclusions in evaporites. The main asset of this new method is that it is free from the above limitations because it does not depend on the formation of vapour bubbles. The application of these two techniques to the same samples of synthetic halites has confirmed the advantage of Brillouin spectroscopy and its usage on natural evaporites. Indeed, in contrast to microthermometry, the Brillouin technique gives a narrow distribution of Th values, consistent with the known precipitation temperatures of the synthetic samples. Brillouin spectroscopy thus provides a unique tool for SST and LST reconstructions in evaporitic sequences.

Climate effects on the sediment dynamics on coastal areas: the Goulven bay (Brittany)

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At present, recurrent storm events cause the landward retreat of coasts and increase the risk of flooding in the northwest of France. Increase of damages related to coastal flooding is expected in the next decades because of sediment starvation, global mean sea level rise and climate change.
This study aims (1) to quantify the spatial shoreline mobility, (2) to identify the storm events responsible of the coastal evolution, (3) to evaluate the impact of climate change on a sandy beach of kilometric extent situated in the *Goulven bay* in French Brittany over the past 45 years. This is a large beach affected by a high tidal range (2 to 9 m). The shoreline mobility is estimated from a set of aerial images of the French National Geographic Institute (IGN) at different time steps according to their availability. These images, acquired during 12 campaigns between 1971 and 2012, are orthorectified, georeferenced and included in a GIS to be compared. The shorelines are digitalized for each campaign. The net shoreline mobility between two timelines is quantified with a 50 m step using the DSAS (Digital Shoreline Analysis System) software. In addition, the temporal distribution of the storm events is reconstructed from the Brignogan weather station measurements (*Météo-France*), climate reanalysis (ERA-20C and ERA-Interim model from ECMWF) and the DREAL storm inventory for Brittany. Speed and wind direction, significant wave height, surface air pressure and coastal sea level changes from tide gauge are used to characterize the intensity of each storm event and define the major storms responsible of the shoreline evolution.
Significant displacements of the shoreline are evidenced over the past 45 years. Average displacement rates, ranging between -20 my-1 and +15 my-1, display a strong interannual variability and are associated with high spatial variability within the same shore. The duration and frequency of storm events vary as well. The strong storm period in the 1989-1990 winter is linked to a significant shoreline variation: -10 my-1 between 1987 and 1990 in the center of the bay against + 15 my-1 at the west (Penn ar C'hleuz spit) in average. At some periods, the beach exhibits a certain stability linked to minor average storm recurrence (2000-2012).
The comparison between shoreline mobility and storm events suggests that the recurrence and duration of storms strongly influence the spatio-temporal shoreline mobility for the *Goulven bay*. We can assume that this evolution is a marker of the climate impact and possibly of the current climate change. This study also shows the importance of local environmental factors like coast currents related to the longshore drift to the west in this case.

Abstracts session 4 : Poster Session

Abstracts Poster session:

Understanding copper fluxes in cancerous cells using natural copper isotopic compositions in a model organism

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Copper (Cu) is an essential cofactor in several proteins and is transported from blood to organs by Cu-proteins. In cancer it has been demonstrated that Cu concentration is increased in tumor cells [review by Engelken et al., 2014]. The natural Cu isotopic compositions, expressed as $\delta^{65}Cu = 1000\times[(^{65}Cu/^{63}Cu)sample/(^{65}Cu/^{63}Cu)standard -1]$, have been shown to vary between organs and can be used to trace exchanges and fluxes within one organism (Balter et al., 2013). In 2015, Balter et al. have shown that liver cancer tumors are enriched in heavy Cu isotopes compared to healthy patients liver tissue. However, the reason for this difference is yet unknown. One possible reason for that is a difference in Cu transport in tumors cells.

To test this hypothesis, we have used the model organism *Saccharomyces cerevisiae* in which Cu enters cells through both high-affinity (CTR1, CTR3) and low-affinity importers (review by Peña et al., 1999) after it enzymatic reduction by FRE proteins (Hasset & Kosman, 1995and Georgatsou et al., 1997). To understand the impact of Cu import on the Cu-isotopic composition, Cu was monitored in two strains with different uptake systems: a wild type and a CTR1;CTR3 knock-out. The three strains have been cultivated with 0.25 µM of Cu, and then transferred in a medium with 80 µM of Cu. We have monitored the evolution of both Cu concentration and isotopic composition as a function of time.

The $\delta^{65}Cu$ in the double mutant strain cells is not significantly different than in the wild type strain (-0.8‰ versus -1‰). This fractionation can come from the Cu reduction by Cu reductase and the import through Cu importers. Therefore, we have used a third strain (SKY34) where Cu reductase activity is lower. In this strain, the isotopic composition stay around 0‰. When a chemical reducing agent which reduced all the available Cu was added, the observed Cu isotopic composition difference was anhilated and that Cu was entering massively in cells. Cu reduction is the limitating process in Cu uptake and does not induce Cu fractionation. Thus, Cu importers are the reason for Cu isotopic fractionation.

Liver cancer tumors have a high $\delta^{65}Cu$ (0 to 0.5‰) in comparison to healthy liver tissues (-0.1 to -0.5‰) which are very close to the values observed in wild type yeasts (-0.6‰). Since transporters activity does not seem to increase intracellular $\delta^{65}Cu$, we postulate that the values observed in tumor cells may result from modifications of Cu fluxes between the different organs and the tumor. Reduced Cu fluxes have been observed in connection with the apparition of resistance to cisplatin, an anti-tumoral agent, in tumoral cells [Du et al, 2012]. Therefore, our results clearly show that we could use $\delta^{65}Cu$ monitoring as a proxy for cisplatin resistance in cancer cells.

References
Balter et al., *Metallomics*, 2013, **5**, 1470, Balter al al., PNAS, 2015, **4**, 982, Du et al., *Metallomics*, 2012, **4**, 679, Engelken et al., *bioRivix,* 2014, Hasset & Kosman, *J.Bio.Chem.,* 1995, **272**, 13786, Peña et al., *J.Nutr.*, 1999, **129**, 1251

Si-, O-, S-stable isotopes-study as a tool to understand early Earth

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Supracrustal rocks with Eoarchean ages (from 4.1 to 3.6 Ga) are key samples for pushing back in time our knowledge of magmatic/geodynamic processes, primitive environmental conditions and early life. However, this original imprint is convoluted with the signature of younger events and has to be investigated carefully. The stable isotope signatures of some specific supracrustal environments being both pronounced and well-persistent through time and geologic events, they represent first-class candidates for the study of early Earth.

The Nulliak supracrustal assemblage represents the oldest suite of volcano-sedimentary rocks preserved in the Saglek-Hebron segment of the North Atlantic craton [1]. The different lithologies and their field relationships have been studied in detail in the werstern limb of the Nulliak Island (58°18'30.1"N, 62°35'48.4"W). Based on chonological constraints on the intrusive Uviak I gneisses, a minimum age of 3.95 Ga has recently been proposed [2]. Besides mafic volcanics and ultramafic pods, the Nulliak supracrustal assemblage comprises meta-Iron Formations of uncertain origin. Silicon-, oxygen- and sulfur-isotopes were studied using an ultra high resolution isotope ratio mass sprectrometer (TF 253 HR-IRMS) to investigate the precursor of these Iron Formations. We report as preliminary results significant fractionations in the isotopic compositions (δ^{30}Si=-1.8±0.5‰, δ^{18}O=-11.0±0.5‰, δ^{34}S=-1.6±0.5‰) which would be consistent with an iron-rich sedimentary precursor for these meta-Iron Formations.

[1] Komiya, T., Yamamoto, S., Aoki, S., Sawaki, Y., Ishikawa, A., Tashiro, T., Koshida, K., Shimojo, M., Aoki, K., Collerson, K.D. (2015).*Tectonophysics*, 662 40-66.
[2] Ermanovics and Kranendonk (1998). *Bull. of the Geological Survey of Canada*, Vol. 497.

Anatomy and affinities of a new 535-million-year-old Medusozoan from the Kuanchuanpu Formation, South China

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Background: The early Cambrian Kuanchuanpu Formation from South China (Ningqiang, Shaanxi Province) yields abundant Small ShellyFossils (SSF) among them embryonic stages of medusozoans. Their exceptional phosphatic preservation allows very detailed reconstructions of their internal anatomy to be made by using X-ray microtomography. Although these fossils reveal unknown aspects of the early evolution ofcnidarians, important issues remain unresolved such as the development cycle of these early medusozoans, their taxonomy and their relation tomodern cnidarian groups.

Results: Here we describe *Sinasterpetalon* gen. et sp. nov., a new species of Medusozoa characterized by a pentamerous symmetry and a smooth periderm which contrasts with the stellate external ornament of co-occurring forms such as *Olivooides*. Xray microtomography reveals finedetails of its internal anatomy such as coronal muscles, perradial and adradial frenula, interradial septa, accessory septa, gonad-lamellae, tentaclebuds and perradial pockets.

Conclusions: Our results stress the key importance of internal features in the taxonomy of medusozoans from the early Cambrian Kuanchuanpubiota that still remains in a state of flux. The exceptionally well-preserved endodermic and ectodermic features of *Sinaster petalon* gen. et sp. nov.clearly differ from those of co-occurring embryo fossils. The position and overall shape of the reproductive organs of *S. petalon* gen. et sp. nov.can be reconstructed and compared with those of extant cnidarians and other Cambrian medusozoans. The gonad lamellae of *S. petalon* gen. et sp.nov. are inserted into the interradial septa in a similar way as in extant cnidarians and fossil embryos from the early Cambrian Kuanchuanpu biota.However, they are characterized by a smaller size and a lation closer to the embryo aperture. The accessory septa, although common in many Kuanchuanpu medusozoans, resemble that of extant coronates in shape and disposition.

Experimental Compressible Convection

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Compressible convection, in particular in Earth's outer core dynamics, is usually described with the anelastic approximation. A number of theoretical and numerical studies have been done about this approximation but there is no experimental work on it. We present here an experiment especially designed to study compressible convection in the lab.

For significant compressible convection effects, the parameters of the experiment have to be optimized. We use a centrifuge to artificially increase the apparent gravity. Moreover, compressibility is higher with a gas and in particular with xenon. With these choices, we can obtain an adiabatic gradient of 10 K/cm and the dissipation number $\alpha.g.L/c_p$ is equal to 0.2 which is close to the value of 0.5 in the outer core

A first version of the experiment allowed us to measure an adiabatic gradient and to study pressure fluctuations. A new version, with new sensors and with an higher rotating speed, should reach a larger adiabatic gradient, better temperature measurements and increase the time resolution.

Moreover, due to the high rotating speed, effects of the Coriolis force will be important. So, we will study how the stratification caused by compressible convection will change geostrophy and inertial waves in the special case where gravity and rotation vector are orthogonal.

A particle-in-cell method for studying double-diffusive convection in the liquid layers of planetary interiors.

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Numerous planetary bodies contain internal liquid layers in the form of either partially liquid iron core, buried water oceans or post-accretion primitive magma oceans. The presence of convective currents within such layers can generate magnetic fields by dynamo action in planetary cores like those of the Earth, Mercury and Ganymede, affect the geology of the surface ice of icy satellites such as Ganymede, Europa and Enceladus, and influence the dynamics of a crystallizing magma ocean in the young Earth. Convection in these layers is usually driven by the combination of two sources of buoyancy: a thermal source directly related to the planet's secular cooling, the release of latent heat and possibly the heat generated by radioactive decay, and a compositional source due to some process of cristallisation or fusion, for example the growth of a solid inner core which releases light elements into the liquid outer core, or the melting/freezing of an ice layer which locally enriches or depletes the adjacent water ocean in salts. Other potential compositional buoyancy sources may also include precipitation of magnesium at the Earth's core mantle boundary.
The molecular diffusivities of the thermal and compositional fields typically differ by several orders of magnitude: the Lewis number (ratio of the thermal to the compositional molecular diffusivity) is at least 100 in oceans and 1000 in the Earth's outer core which can potentially generate “double-diffusive” instabilities leading to significant differences in the convective dynamics compared to pure thermal or compositional convection, respectively. This “double-diffusivity” scenario has recently received much attention by a few authors but these studies were conducted only up to a moderate Lewis number of 10. The reason is purely technical and due to the fact that classical Eulerian descriptions of scalar fields generate numerical diffusion which can hide the appropriate transport phenomena when the diffusivity is weak. To allow for a correct description of composition, a solution is to opt for diffusion-free semi-Lagrangian representations such as “particle-in-cell” (PIC) methods.
During my first two years of PhD, I implemented a “particle-in-cell” (PIC) method into a pre-existing geodynamo code in 3D spherical geometry to describe the compositional field properly. I developed several numerical devices to solve various problems inherent to the implementation of a PIC method for convection in spherical geometry and coded a hybrid scheme suitable for massively parallel platforms. I tested this new code on two benchmark cases which validate its applicability to the study of double-diffusive convection in the internal liquid layers of planets. First simulations at infinite Lewis number (neglecting the compositional diffusivity) show that new convective regimes emerge that cannot be described by classical Eulerian methods. Applications of this new tool are numerous and I will show preliminary work on the dynamics of a crystallizing magma.

Ensemble Kalman Filter For Mantle Convection

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Recent advances in mantle convection modelling led to the release of a new generation of convection codes, able to generate self-consistently plate-like tectonics at their surface. Those models physically link mantle dynamics to surface tectonics. Combined with plate tectonic reconstructions, they have the potential to produce a new generation of mantle circulation models that use data assimilation methods and where uncertainties on plate tectonic reconstructions are taken into account. We recently provided a proof of this concept by applying a suboptimal Kalman Filter to the mantle circulation reconstruction (Bocher et al., 2016). Here, we propose to go one step further and apply the Ensemble Kalman Filter (EnKF) to this problem. The EnKF is a sequential Monte Carlo method particularly adapted to solve high dimensional data assimilation problems with nonlinear dynamics. We tested the EnKF using synthetic observations, on a 2D-spherical annulus model and compared it with the method developed previously. The EnKF performs on average better and is more stable than the former method. Less than 300 ensemble members are sufficient to reconstruct an evolution. We use covariance adaptive inflation and localization to correct for sampling errors. We show that the EnKF results are robust over a wide range of covariance localization parameters. The reconstruction is associated with an estimation of the error, and provides valuable information on where the reconstruction is 15 to be trusted or not.

Small-scale dynamic topography in whole-mantle convection models

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Surface topography is the result of both external (erosion and sedimentation) and internal processes (tectonics and mantle convection) that continuously shape the Earth with different rhythms and scales. Mantle convection is important to surface topography as it contributes to long-term global sea-level trends [1], the geometry of intra-continental sedimentary basins [2], and produces geoid anomalies [3].
Classically, geodynamicists decompose topography in an isostatic component, resulting from density variations within the lithosphere, and a dynamic component, often defined as the topography resulting from mantle flow.
Global models of residual topography, an observation-based proxy for the dynamic component of topography [1,4], suggest that the dynamic topography predicted by numerical models of mantle convection overestimate by one order of magnitude the role of deep and large-scale (degree 1 to 4) mantle thermochemical anomalies and underestimate the scales of mantle dynamics smaller than degree 15.
Here, we present mantle convection models with large lateral viscosity variations and a yield stress law for lithosphere that self-generate plate-like tectonics, and produce both large-scale and small-scale convection in the upper mantle. Contrary to previous models in which the rheology is simpler, these models predict small scales in the spatial and temporal distribution of isostatic and dynamic topography, as observed on Earth.
The effect of rheology parameters on surface topography is explored through 2D spherical annulus models [5] computed with StagYY [6]. Power spectra of dynamic topography are similar in 2D annulus and 3D spherical models. The temporal scales of dynamic topography evolution are also studied, with particular attention to continents.

References:
[1] Müller, R. D., Sdrolias, M., Gaina, C., & Roest, W. R. (2008). Age, spreading rates, and spreading asymmetry of the world's ocean crust.
[2] Mitrovica, J. X., Beaumont, C., & Jarvis, G. T. (1989). Tilting of continental interiors by the dynamical effects of subduction.
[3] Ricard, Y., Fleitout, L. & Froidevaux, C. (1984). Geoid heights and lithospheric stresses for a dynamic Earth.
[4] Hoggard, M. J., White, N., & Al-Attar, D. (2016). Global dynamic topography observations reveal limited influence of large-scale mantle flow.
[5] Hernlund, J.W. & Tackley, P.J. (2008), Modeling mantle convection in the spherical annulus

D-H inter-diffusion in serpentines

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Interactions between aqueous fluids and ultrabasic rocks are essential processes in a broad range of contexts including hydrothermal alteration on the parent body of carbonaceous chondrites, at mid-oceanic ridge, and in subduction zones. Tracking these processes and understanding reaction kinetics require knowledge of the diffusion of water in rocks, and of isotope fractionation in major minerals forming under hydrous conditions, such as serpentines. We present a study of D-H inter-diffusion in antigorite, a common variety of serpentine. High-temperature (HT) experiments were performed in a belt apparatus at 540°C and 3.0 GPa on natural antigorite powders saturated with interstitial D2O. A low-temperature (LT) experiment was performed in diamond anvil cell at 350°C and 2.5 GPa on an antigorite single-crystal loaded with pure D2O. D/(D+H) ratios were mapped using Raman spectroscopy for the HT experiment and NanoSIMS for the LT experiment. As antigorite is a phyllosilicate, diffusion coefficients were obtained for crystallographic directions parallel and perpendicular to the antigorite layers (perpendicular and parallel to the *c**-axis, respectively). The equations of D/H inter-diffusion coefficients were determined to be DH-D (m^2/s) = $5.04.10^{-5}$.exp(-170(±53) (kJ/mol)/RT) and DH-D (m^2/s) = $1.52.10^{-7}$.exp(-157(±32) (kJ/mol)/RT) perpendicular and along the *c**-axis, respectively, and DH-D (m^2/s) = $7.29.10^{-6}$.exp(-166(±14) (kJ/mol)/RT) for the bulk diffusivity. These results are similar to those obtained on chlorite, in agreement with the similar crystallographic structures and atomic bonds in the two minerals. Assuming D/H inter-diffusion coefficients for antigorite are the same for all serpentine species, closure temperature and diffusion durations are applied to hydrothermal fields and in CI, CM and CR chondrites. Closure temperatures lie below 300°C for terrestrial hydrothermal alteration and depend on serpentine variety because they have different typical grain sizes. They lie below 130°C for carbonaceous chondrites, indicating that D/H isotopic exchange may have persisted down to very low temperatures on their parent bodies. D/H isotopic composition may be associated with grain size heterogeneities in carbonaceous chondrites due to protracted alteration of fine-grained material with the lowest closure temperatures (*ca* 50°C).

Reconstitution du paysage de St-Restitut (Drôme) il y a 16 millions d'années

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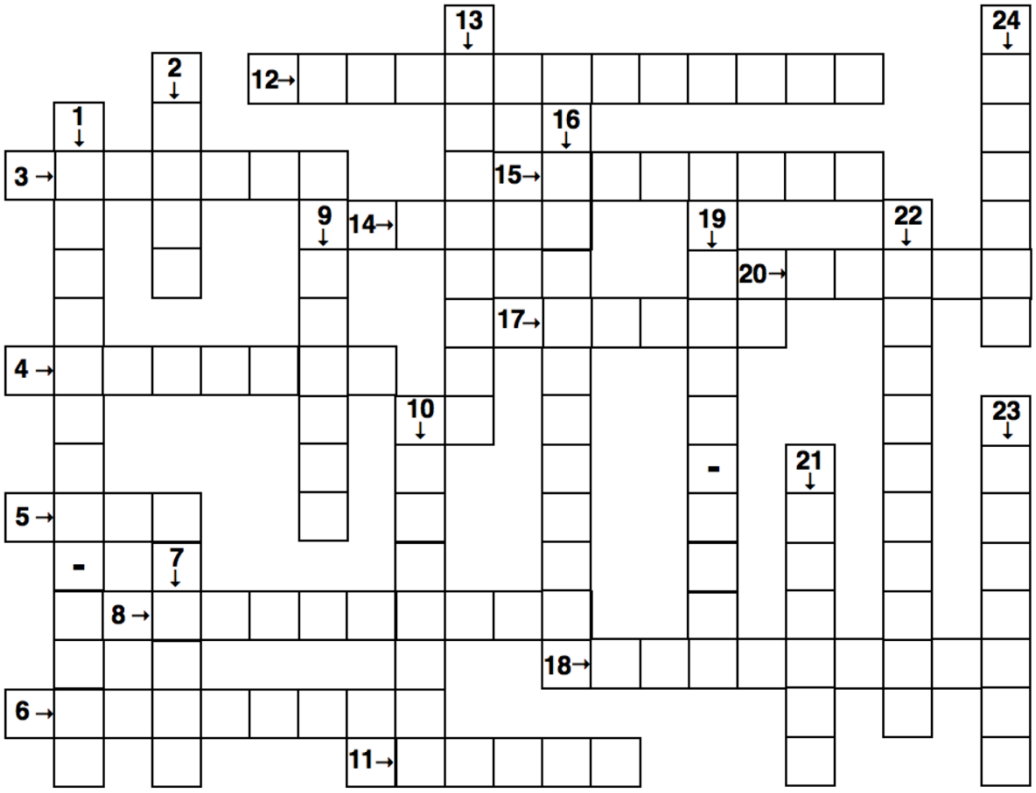
Depuis sa formation, la surface de la Terre n'a jamais cessé de se transformer. Les continents situés sur des plaques mobiles se sont assemblés puis séparés, le climat était plus ou moins chaud et même les êtres vivants ont évolué. Si bien qu'il y a des millions d'années, bien avant l'apparition de l'Homme, la surface de la Terre avait un visage bien différent de celui qu'on lui connaît aujourd'hui. Mais comment savoir à quoi ressemblait notre planète en ces temps reculés ? Etudier les archives de la Terre : les roches et les trésors fossiles qu'elles renferment, c'est la mission qu'ont acceptée les 23 élèves de la classe de CM1/CM2 de l'école primaire Montbrillant. Lors d'une première séance en classe, les élèves se sont d'abord familiarisés avec les fossiles et leur formation. Les élèves ont ensuite pu voir un panel d'outils utilisés par les paléontologues sur le terrain. Ils ont ensuite reporté dans leur carnet de terrain personnel les outils qui leur seront utiles pour aller chasser eux-mêmes les fossiles. Riches de ces connaissances, nos 23 paléontologues en herbe se sont rendus en bus sur le site de Saint-Restitut, où des roches vieilles de 16 millions d'années attendaient de livrer leurs secrets. Armés de leurs tamis, de leur patience et de leurs yeux affûtés les élèves ont récolté plus de 300 fossiles de dents de requins, daurades et raies mais également de nombreux restes de coquillages, d'oursins et de coraux. De retour en classe, les élèves ont d'abord identifié, compté, observé et comparé ces restes fossiles à des êtres vivants similaires que l'on rencontre dans la nature actuelle. Ils sont alors parvenus à la conclusion qu'un climat tropical régnait sur la région il y a 16 millions d'années et que Saint-Restitut se situait au niveau d'une mer chaude, peu profonde et proche de la côte. Troquant leurs loupes pour des crayons de couleurs, les élèves ont finalement valorisé leur travail scientifique en reproduisant le paysage de Saint-Restitut il y a 16 millions d'années.

BINGO

La vidéo que veut montrer le speaker ne marche pas	Un chercheur regarde son téléphone pendant les speechs	Le speaker skippe des slides à la fin	problèmes de microphone	j'ai tout compris ! :D	speaker ne parle pas assez fort
problèmes de projecteur	PPT sur fond bleu	quelqu'un s'endort dans l'amphi	un prof travaille sur son PC et n'écoute pas	speaker tient le micro trop près	mais, où est l'accent anglais ?
speaker ne dit que des "euhm...."	fautes d'orthographes dans le PPT	**BINGO FREE**		Une slide est remplie d'équations	j'ai rien compris... :(
pointeur qui tremble !	speaker avec un ton monotone		la présentation dépasse le temps imparti	Aucune question dans l'assemblée	La slide est une liste
"That's an interesting question!"	Le speaker n'arrête pas de sautiller en parlant	"The data *clearly* show..."	Un téléphone sonne dans la salle	Nourriture gratuite !!	Le speaker n'arrive pas à utiliser le pointeur laser du premier coup
Plus que 5 couleurs sur une même slide (sans les figures)	Une figure/un graphe sans légende	"Désolé, on n'arrive pas à voir ce qui est écrit là..."	Le speaker montre un tableau rempli de chiffres sans les expliciter	Trop de texte sur une slide	quelqu'un porte une cravate

CROSSWORD PUZZLE

Do you know your basics in Geology and Astrophysics?



1) L'ultime réponse à la grande question sur la vie , l'univers et le reste.
2) Endroit où Matt Damon aime passer ses vacances (et planter des patates).
3) Présent dans le sable et les montres.
4) Particules fines en suspension dans l'atmosphère (est-ce que j'ai une gueule d'atmosphère?).
5) Echelle de temps.
6) "Science" qui cherche à savoir si c'est un avion, un oiseau, Superman ou autre chose…
7) Une des disciplines de la journée en abrégé.
8) I have a rock, I have chemistry, hop…
9) Enveloppe externe sous pansement.
10) Patron du Système solaire entouré de ses maîtresses.
11) Rock without roll.
12) Rock'n'roll.
13) Détermination de l'âge (même si c'est malpoli de demander l'âge).
14) Sécrétion volcanique.
15) S'enflamme si elle est Note 7, peut avoir des bras spirales aussi.
16) (Terre + chaleur) x grec = …
17) Tu es dessus et on ne parle pas du siège.
18) Elément tout petit (ex : muon, électron).
19) Monstre du cosmos dévoreur de lumière.
20) La deuxième discipline de la journée abrégée.
21) Dans le guide Michelin ou à Hollywood.
22) Danse de la fin des années 2000 mal orthographiée.
23) Einstein : "Deux choses sont infinies : l'… et la bêtise humaine. Mais, en ce qui concerne l'…, je n'en ai pas encore la certitude absolue".
24) Animal trop mignon

Affiliations:

Observatoire de Lyon

Observatoire de Lyon

LGL TPE

Laboratoire de Géologie de Lyon - Terre, Planètes, Environnement

CRAL

Centre de Recherche Astrophysique de Lyon

ED 52 - PHAST

Ecole Doctorale 52 Physique et Astrophysique

ED 341 - E2M2

Ecole Doctorale 342 Evolution Ecosystèmes Microbiologie Modélisation

Labex LIO

Institut des Origines de Lyon

UCBL

Université Claude Bernard

ENS de Lyon

Ecole Normale Supérieure de Lyon

CNRS

Centre National de la Recherche Scientifique