ABSTRACT BOOK

4EME CONGRES DES DOCTORANTS DE L'OBSERVATOIRE DES SCIENCES DE L'UNIVERS DE LYON

23 OCTOBRE 2014

AMPHI DESCARTES - ENS

Programme

08:30 - 09:00	Installation des posters
09:00 - 09:15	Accueil des intervenants
09:15 - 10:30	**Session "Jurassic Park" – Paléoenvironnement, Biologie**
09:15 - 09:30	› Palaeoecological insights from Toarcian and Lower Aalenian Calcareous Nannofossils of the Lusitanian Basin (Portugal) - *Jorge Ferreira, Laboratoire de Géologie de Lyon - Terre, Planètes, Environnement*
09:30 - 09:45	› Seasonal isotope oxygen analysis of apatite from theropod teeth - *Jean Goedert, Laboratoire de Géologie de Lyon - Terre, Planètes, Environnement*
09:45 - 10:00	› In-situ Raman study of an aqueous solution of glycine under hydrothermal conditions: implications for the origin of life - *Ulysse Pedreira-Segade, Laboratoire de Géologie de Lyon - Terre, Planètes, Environnement*
10:00 - 10:15	› Influence of Saccharomyces cerevisiae Cu importer on the Cu isotopic composition - *Jean-Loup Cadiou, Laboratoire de Géologie de Lyon - Terre, Planètes, Environnement*
10:15 - 10:30	› Structural diversity, ecophysiological role and possible utility for (paleo)environmental studies of alkylglycerols from mesophilic bacteria - *Arnauld Vinçon-Laugier, Laboratoire de géologie de Lyon*
10:30 - 11:00	Coffee break - Poster session
11:00 - 12:00	**Session "Voyage au centre de la Terre" – Terre interne**
11:00 - 11:15	› A sequential data assimilation approach for the joint reconstruction of mantle convection and surface tectonics - *Marie Bocher, Laboratoire de Géologie de Lyon - Terre, Planètes, Environnement*
11:15 - 11:30	› Tracers approach for studying double diffusive convection in Earth's outer core at high Lewis number - *Mathieu Bouffard, Laboratoire de Planétologie et Géodynamique de Nantes, Laboratoire de Géologie de Lyon - Terre, Planètes, Environnement*
11:30 - 11:45	› Properties of silicate melts under high pressure from first principles calculations - *Alexandra Seclaman, Laboratoire de Géologie de Lyon - Terre, Planètes, Environnement*
11:45 - 12:00	› Self-consistent thermodynamics in the MgO-FeO-SiO2 system: Application to a crystallizing magma ocean - *Charles-Edouard Boukaré, Laboratoire de Géologie de Lyon - Terre, Planètes, Environnement*

12:00 - 14:00	Buffet - Poster - Discussion
14:00 - 14:15	Surprise
14:15 - 15:30	**Session "Star Wars" – Astrophysique, Planétologie**
14:15 - 14:30	› First-principles modeling of the superionic phase of pure and salty ices under extreme conditions of pressure and temperature - *Jean-Alexis Hernandez, Laboratoire de Géologie de Lyon - Terre, Planètes, Environnement*
14:30 - 14:45	› Deep alteration of the Martian crust: insights from a cross section between Hellas and Isidis basins - *Benjamin Bultel, Laboratoire de Géologie de Lyon - Terre, Planètes, Environnement*
14:45 - 15:00	› High-precision chronometry of volatile element depletion in the early Solar System - *Elsa Yobregat, Laboratoire de Géologie de Lyon - Terre, Planètes, Environnement*
15:00 - 15:15	› Photophoresis effects in protoplanetary disks - *Nicolas Cuello, Centre de Recherche Astrophysique de Lyon*
15:15 - 15:30	› A detailed study of a young and distant galaxy - *Vera Patricio, Centre de Recherche Astrophysique de Lyon*
15:30 - 16:15	Happy Hour – Poster session
16:15 - 17:30	**Session "2012" – Tectonique des plaques**
16:15 - 16:30	› Plate tectonics of convection models - *Claire Mallard, Laboratoire de Géologie de Lyon - Terre, Planètes, Environnement*
16:30 - 16:45	› Concomitant melting of the crust and the mantle in the Variscan French Massif Central: a coupled U-Pb and Lu-Hf isotope study of late-collisional granites and high-K mafic intrusives - *Simon Couzinié, Université Jean-Monnet*
16:45 - 17:00	› Petro-geochemical study of a cratonic eclogite suite - Roberts Victor Mine (Kaapvaal, South Africa) - *Ioana-Bogdana Radu, Laboratoire Magmas et Volcans*
17:00 - 17:15	› MCT location and thermal structure of the Jaljala klippe : insights from RAMAN spectrometry - *Alexandre Aubray, Laboratoire de Géologie de Lyon : Terre, Planètes, Environnement*
17:15 - 17:30	› Permeability and transport properties of serpentine in subduction zones - *Hélène Pilorgé, Laboratoire de Géologie de Lyon - Terre, Planètes, Environnement*
17:30 - 18:00	**Mot de clôture**

Session “Jurassic Park” – Paléoenvironnement, Biologie

Session “Voyage au centre de la Terre” – Terre interne

Session “Star Wars” – Astrophysique, Planétologie

Session “2012” – Tectonique des plaques

Poster

Session

"Jurassic Park"

Paléoenvironnement

Biologie

Palaeoecological insights from Toarcian and Lower Aalenian Calcareous Nannofossils of the Lusitanian Basin (Portugal)

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Abstract

Though Lower Toarcian calcareous nannofossils have been extensively studied for palaeoenvironmental purposes (e.g. Fraguas et al., 2012; Mattioli and Pittet 2004; Mattioli et al., 2004; 2008, 2009; Mailliot et al., 2009; Reggiani et al., 2010; Pittet et al., 2014; Reolid et al., 2014; Suan et al., 2008a, b, 2010), with few exceptions (e.g. Mattioli, 1997; Mattioli and Erba, 1999; Sandoval et al., 2012) little attention has been given to Middle and Upper Toarcian substages. The Toarcian and Aalenian ages are of particular interest in the geological history of the planet. Palaeoenvironmental changes took place across this time interval, where important and drastic temperatures shifts and eustatic oscillations occurred (Hallam, A., 1981; Dera et al., 2009, 2011a; Pittet et al., 2014), including the probably most important thermal maximum recorded during the Mesozoic at the base of the Toarcian, also corresponding to the Toarcian Oceanic Anoxic Event (T-OAE), an interval of widespread organic matter burial (Jenkins, 1988; Suan et al., 2008b). Being a major component of the extant marine phytoplankton, coccolithophores are one of the main open ocean primary producers, and their skeleton elements, the coccoliths, represent the most important component of deep-sea sediments. Their importance in palaeoceanographic, palaeoecological and biostratigraphic studies are highly significant due to their rapid evolution and radiation, and above all, for their distribution, abundance and diversity being highly controlled by water temperature, nutrients and salinity (Winter et al., 1994). This work aims to understand the behaviour of calcareous nannoplankton associations during the Toarcian and Aalenian stages in the Lusitanian Basin, and infer of any relations linked to shifts in auto- and synecological parameters such as temperature shifts in sea water temperature, proximity from continental nutrient input sources, or even interspecific competition. For this purpose three sections representing the stratigraphic continuum of the totality of the Toarcian and Lower Aalenian stages outcropping in the Lusitanian Basin, Portugal, spanning across 10.74 Ma (Gradstein et al., 2012), were studied. A quantitative and qualitative study of coccolithophorids calcareous nannofossils is herein presented, as well the absolute and relative abundance of the dinoflagellate cyst Schizosphaerella. During the time interval which this work refers to, the Lusitanian Basin was a narrow corridor connecting a colder epicontinental water mass at

*Intervenant

north (Euro-Boreal realm) and a warmer one at south (Mediterranean Tethys realm) making it the perfect place to study changes occurring in the western Tethys boundary between these two domains and their influence on calcareous nannoplankton associations. Age calibration was defined according to the ammonite content described in the literature and to nannofossil bioevents. In order to assess bottom water temperatures and carbon signature in this sector during this period, geochemical data was collected after brachiopod shells were analyzed for carbon and oxygen isotope composition. This work aims to address the long-term evolution of calcareous nannofossils in the Lusitanian Basin, quantify and infer on palaeoecological affinities for different calcareous nannofossil taxa and their response to en- vironmental stressed conditions forced by palaeoceanography changes that occurred during the Toarcian and Lower Aalenian.

Mots-Clés: Calcareous nannofossils, Carbon and oxygen stable isotopes, Torcian, Aalenian, Lusitanian Basin

Seasonal isotope oxygen analysis of apatite from theropod teeth

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Abstract

Phosphate oxygen isotope analysis (18Op) of apatite from tooth enamel of terrestrial vertebrates constitutes a valuable method to reconstruct past climates of continental environments. This method is based on interdependent relationships between the 18Op, the isotopic composition of environmental water (18Ow) and the air temperatures. Here, we present a method to reconstruct the seasonal variations of cretaceous climates. Six teeth of large carnivorous dinosaurs (Theropoda: Dinosauria) coming from different Cretaceous periods and latitudes have been analyzed for their oxygen isotope ratios (18Op) through an incremental sampling performed along the major growth axis in order to investigate climate seasonality. Slow and continuous tooth growth in the absence of enamel remodeling ensures an intra-annual record of climatic variations. Results show that Cretaceous climates were diverse and far from being equable as previously regarded, and expressed strong seasonal variations. These results partly help us to better understand the evolutionary success of the dinosaurs, which were endothermic organisms, and as such, were particularly well adapted to these fluctuating climates. In the framework of forthcoming studies, it will be necessary to take into account such strong seasonality when studying the dynamics of populations and the ecological adaptations they may have developed consequently.

Mots-Clés: Cretaceous, climate, seasonality, theropods, apatite, oxygen isotope

*Intervenant

In-situ Raman study of an aqueous solution of glycine under hydrothermal conditions: implications for the origin of life

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Abstract

The abiotic synthesis of biopolymers in prebiotic chemistry is a major obstacle to our understanding of the emergence of the first cells. Among the unresolved debates in the origin of life community is the question about whether the building blocks of biopolymers where made to react at the mineral-water interface. It has long been supposed that the prebiotic chemistry was mostly carried out in the adsorbed state in hydrothermal conditions, i.e. in an aqueous solution undergoing a pressure of several megapascals (MPa) and a temperature up to 400°C. In those conditions, the fate of building blocks such as amino acids is not a trivial one. Some experiments in the solid state have shown that amino acids can polymerize under high pressure and temperature, but water has only rarely been added to the studied systems. Moreover, these have always been ex situ analysis. The products of the reaction are analysed after quenching, when the experiment is stopped. Fairly recently, using numerical models, it has been shown that small building blocks can be abiotically formed in hydrothermal conditions. Most of the 20 amino acids used by life are then supposed to be produced and stable under such conditions. We are presenting a preliminary study of the fate of glycine ($C_2H_5NO_2$), the simplest amino acid, under hydrothermal conditions (250 MPa, 200°C). Experiments have been carried out in a diamond anvil cell and in situ analyses were made by Raman spectroscopy. Results showed that a detectable part of the glycine polymerized to form at least the linear dimer form, diglycine.

Mots-Clés: origin of life, glycine, amino acids, hydrothermal conditions, Raman spectroscopy, diamond anvil cell

*Intervenant

Influence of Saccharomyces cerevisiae Cu importer on the Cu isotopic composition

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Abstract

Metal ions such as Cu are essential for life and toxic in the free form in organisms. Therefore, the intracellular Cu concentration is finely regulated. Cu is always transported by proteins in organism. Cu enters cells via Cu-importer such as Ctr1 and Ctr3 and exits cells through Cu-exporter such as Cu-ATPase 7A and 7B. Over the last few years, transition metals stable isotopes have been used to understand metal dynamism in biological systems. Recent results have shown that during the development of cancer the patient serum is enriched in lighter Cu isotopes While tumors are enriched in heavy Cu. These results show a link between Cu uptake/export and the action of the various transporters. The aim of our study was to better understand the role of the various transporters on the isotopic fraction- ation in eucaryota cells. Here, we have used mutants of the yeast Saccharomyces cerevisiae (S.c), a classical simple biological model, because its Cu importers are the same high affinity proteins (Ctr1 and Ctr3) as in human cells. In S.c., the Cu can also enter cells by low affinity transporter (e.g. Fet4). When Ctr1 and Ctr3 are functional, 65Cu = - 2.5, when Ctr3 is functional 65Cu = - 1.5, and when only the low affinity transporter are functional 65Cu = - 1. So, the Cu isotopic fractionation is higher when the high affinity transporters are functional. In order to remove the effect of cell division, we have studied the evolution of the 65Cu in yeast during a "pure" uptake phase. The same tendency has been observed. Moreover, the maximum of fractionation occurs during this "pure" uptake phase. These results show a strong relation between the proteom, i.e. all the protein that are expressed in a cell, and the Cu isotopic composition. More experiences coupled with simple modeling will allow us to link the Cu flux via each transporter to an isotope fractionation. The main goal of my PhD is to use the isotope fractionation of metals, such as Cu, to better understand the resistance to chemotherapy. In effect, it has been shown that Platinium compounds, e.g. cisplatin, which are used in chemotherapy enter cells via Cu importers. Therefore the resistance to chemotherapy which appears and increase with time can be linked to an unusual fonctionning of Cu importers which might be traced with the 65Cu. I will combine the study of human samples and in vitro cultures of cancer cell lines.

Mots-Clés: Saccharomyces cerevisiae, Ctr1, Ctr3, low affinity transporter, Cu isotopic composition, cancer, chemotherapy

*Intervenant

Structural diversity, ecophysiological role and possible utility for (paleo)environmental studies of alkylglycerols from mesophilic bacteria

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Abstract

A major distinction between the domain of Bacteria and Archaea resides in the membrane lipid structure. Generally, bacterial phospholipids are constituted of fatty acids with linear carbon chains esterified to glycerol, whereas the lipids of Archaea are formed of isoprenoidal chains bound to one or two molecules of glycerol by ether linkages. These differences in chemical structures have implications for ecology and evolution between Bacteria and Archaea, and allow the use of these molecules as environmental and paleoenvironmental biomarkers. Bacterial alkylglycerols are an exception because they have a chemical structure at the inter- section between bacterial and archaeal lipids (i.e. linear carbon chains linked to glycerol via ether bonds). Detected in different (hyper)thermophilic bacteria, non-isoprenoidal diethers lipids are usually considered as a characteristic of extremophilic bacteria. However, a wide variety of these biomolecules has been observed in various non-extreme ecosystems, including environments associated with the anaerobic oxidation of methane, where the origin and mode of biosynthesis of these lipids are unknown. Recently, the analysis of the lipid composition of pure strains of sulfate-reducing bacteria demonstrated for the first time the presence of non-isoprenoidal diethers in marine anaerobic mesophilic bacteria. The main goals of the present study have been to better characterize the structure and diversity of these peculiar lipids, and to characterize their (eco)physiological role (i.e., possible role in membrane adaptation) in mesophilic bacteria. Cultures grown under different controlled laboratory conditions (varying growth substrate, temperature, pH, salinity) allowed 1) explaining part of the structural diversity of alkylglycerols observed in situ and, 2) demonstrating the implication of these lipids in cell adaptation to varying environmental conditions, suggesting the utility of these biomarkers as (paleo)environmental proxies.

Mots-Clés: Mesophilic sulfate, reducing bacteria, Non, isoprenoidal ether lipids, physiological adaptation, paleoenvironmental proxy

*Intervenant

Session

"Voyage au centre de la Terre"

Terre interne

A sequential data assimilation approach for the joint reconstruction of mantle convection and surface tectonics

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Abstract

Mantle circulation models (MCM) are estimates of the evolution of the Earth's mantle flow. So far, they are obtained from a convection code where surface velocities from plate reconstructions are imposed at the surface. Thus, these models do not take into account the dynamic feedback between mantle convection and surface tectonics. Including this dynamic feedback could improve both estimates of mantle flow and surface tectonics for past times. As a proof of concept, we consider a simplified 2D mantle model and develop a sequential data assimilation method to estimate the temperature field evolution of the system. This method is based on a modified version of the Kalman filter. The observations used here are maps of surface heat fluxes and velocities. The sequential data assimilation procedure is divided into two parts: a forecast, followed by an analysis whenever observations are available. During analysis, the whole temperature field of the model is corrected considering a prior guess (the forecast) and the new observations at hand. The two stages are repeated sequentially until all the observations have been taken into account. The efficiency of the methodology is evaluated by conducting synthetic tests. Noised observations is built from a reference computed evolution and assimilated through our scheme. We compare the reference evolution to the estimation obtained by data assimilation. We report on the influence of two parameters on the behavior of the scheme: the time between two analyses (1 to 50 Myrs), and the amplitude of noise in the synthetic observations (1% to 30%). Our technique proves to be efficient in retrieving the temperature field evolution, provided the time between two analyses is 10 Myrs here: the misfit between the true temperature field evolution and the estimated one decreases dramatically within the first 50 My of the assimilation. However, if the time between two analyses is too large (20 to 50 Myrs), the estimated temperature field eventually diverges from the true field after a few hundreds of Myrs. These results are a proof of concept, before the developpement of such methodology for 3D convection models and observations of the Earth.

Mots-Clés: Mantle convection, Data Assimilation, Mantle Circulation Model

*Intervenant

Tracers approach for studying double diffusive convection in Earth's outer core at high Lewis number

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Abstract

Numerous planetary bodies of the Solar system contain internal liquid layers in which convective flows may occur. Convection in these envelopes generally involves two main sources of buoyancy: a thermal source, which is a direct consequence of the planet's secular cooling and a compositional source, which classically results from the local release of light or heavy elements due to a process a cristallisation (of a cooling metallic inner core in the case of the Earth). This compositional source of buoyancy is thought to represent up to 80% of the total buoyancy in Earth's outer core at present [Lister and Buffett, 1995]. Moreover, it is essential to take composition into account to assess the existence of hypothetical stratifications in this layer. So far, temperature and composition have been either combined into one single variable (called codensity) under the debatable assumption that they obey similar turbulent diffusivities, or treated separately by solving distinct transport equations in a Eulerian scheme. However, this latter approach only allows a limited exploration of the parameters space: the compositional diffusivity, which is very low, cannot be given a realistic value because of numerical diffusion. The Lewis number (ratio of compositional and thermal diffusivities) was thus limited to 10 in the studies using a Eulerian approach, which is far from realistic values (higher than 1000). We propose to overcome this obstacle by treating composition with a method of tracers which has already been used successfully for mantle convection [Tackley and King, 2003]. The Lagrangian point of view of this method theoretically guarantees the total absence of numerical diffusion and is thus particularly well adapted for the treatment of weakly diffusive fields. We implemented a MPI parallel version of this method in the dynamo code Parody (E. Dormy, J. Aubert) and tested it on different benchmarks [Christensen et al., 2001, Breuer et al., 2010]. We discuss the advantages of such a method and give examples of its first applications to geodynamo simulations.

Mots-Clés: Geodynamo, numerical methods

*Intervenant

Properties of silicate melts under high pressure from first principles calculations

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Abstract

Silicate melts play an important part in the formation and evolution of planetary bodies. In the history of the Earth, silicate melts shaped its evolution since the magma ocean phase and continue to do so even today. I use first principles calculations, Molecular Dynamics in the Density Functional Theory and under the Planar Augmented Wave formalism in order to study the behavior and properties of silicate melts doped with different amounts of transitional metals under high pressures and temperatures. Supercells of clinoenstatite and forsterite were created and melted at 5000K. Both compositions were then cooled at 3000K and 4000K. After thermalization (1 ps) production runs of 4ps or more were com- puted. In both melts (MgSiO3 and Mg2SiO4) different amounts of iron, nickel, tungsten and cobalt were added and production runs with these new compositions were run. All compu- tations are NVT computations, meaning that all the productions runs were isothermal and are done on two isotherms: 3000 and 4000K. The pressure range covers the entire Earth's mantle. Changes in silicate melts structure might affect the partitioning of elements between themselves and a solid or more interestingly between themselves and a metallic melt. The composition of the silicate melts might also affect the pressure dependence of the coordina- tion change. Here we investigate the effects of composition and pressure on the structural changes that occur in the silicate melts at pressures that span the Earth's mantle.

Mots-Clés: silicate melts, first principles, molecular dynamics, melt structure

*Intervenant

Self-consistent thermodynamics in the MgO-FeO-SiO_2 system: Application to a crystallizing magma ocean

Charles-Edouard Boukaré*[1]

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Abstract

The nature of mantle phases at both solidus and liquidus represents a key part in the under-standing of the dynamics of the deep mantle. Seismic observations such as ultralow-velocity zones (ULVZs) raise the question of the origin of probably partially molten regions and large low-shear velocity provinces (LLSVPs) might be related to the crystallization of a basal magma ocean The modelling of the basal magma ocean hypothesis [Labrosse, 2007] relies on our knowledge of physical properties of materials at relevant pressure and tempera-ture. We have build a thermodynamic database for silicates in the MgO-FeO-SiO_2 system by ensuring self-consistency between various types of observations such as rst principles calculations, diamond anvil cell (DAC) experiments or shocks measurments. Our database agrees well with the experimental melting curves of peridotite [Fiquet et al., 2010], basalt [Andrault et al., 2014] and iron partition coecient between melt and perovskite [Nomura et al., 2011][Tateno et al., 2014]. Our model have also revealed that more extensive observations are required to explain self-consistently melts as dense as the ones of [Thomas et al. , 2012] and [Sanloup et al., 2013]. We have etablished the ternary phase diagram in the system MgO-FeO-SiO_2 up to 140 GPa and we have computed crystallization sequences of simplied mantle composition. We show here that a gravitationally stable melt layer at the CMB is consistent with the thermodynamics of the MgO-FeO-SiO_2 system.

*Intervenant

Session

"Star Wars"

Astrophysique

Planétologie

First-principles modeling of the superionic phase of pure and salty ices under extreme conditions of pressure and temperature

Jean-Alexis Hernandez*[1] and Razvan Caracas[1]

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Abstract

With more than sixteen stable phases, H2O is a textbook system to understand hydrogen bonded solids. Between 3 and 400 GPa, high-pressure ices are characterized by a body-centered cubic lattice of oxygen atoms, and present a transition from molecular solids (ice VII and ice VIII) to an ionic solid (ice X) depending of the dynamics of the hydrogen bond (Hemley and Dera, 2000). This transition is continuous with the formation of translational disordered phases (ice VII' and ice X') and well-characterized in the low-temperature and high-pressure domain (Benoit et al., 2002 ; Pruzan et al., 2003). At high-temperature, theoretical studies have shown a large increase of the protonic diffusion, characteristic of the superionic phase, but no structural study has been carried out (Cavazzoni et al., 1999 ; Schwegler et al., 2008). Such phases of H2O are believed to compose the mantles of ice giants whose thermodynamic conditions correspond to the high-temperature and high-pressure regime (Cavazzoni et al., 1999). High-pressure ices could include non-negligible amounts of ions in the structure by erosion of the underlying rocky core. Moreover, it has recently shown that the inclusions of LiCl and NaCl in ice VII structure have shown disordering effect of the salt over the ice VII structure (Klotz et al., 2007 ; Journaux et al., 2013). Here, we investigated the high-temperature and high-pressure regime of H2O ice in the presence of NaCl using first-principles molecular dynamics. We discuss in detail the effects of salt on the stability field of the superionic phase and on its dynamical properties.

Mots-Clés: ice, first, principles, high, pressure

*Intervenant

Deep alteration of the Martian crust: insights from a cross section between Hellas and Isidis basins

Benjamin Bultel*[1], Cathy Quantin-Nataf[1], and Muriel Andreani[1]

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Abstract

Both OMEGA (Observatoire pour la Minéralogie, l'Eau, la Géologie et l'Activité) and CRISM (Compact Reconnaissance Imaging Spectrometer for Mars) spectrometers onboard respectively Mars Express and MRO (Mars Reconnaissance Orbiter) have revealed detections of alteration minerals witnesses of water- rock interactions. The proportion of carbonates and serpentine seem to be low compare to other alteration phases. During Early Mars, the production of carbonation and serpentinization are suspect to be more ubiquitous than actually reported. We describe here our spectroscopic investigation of alteration minerals on the crustal outcrops of a large region of Mars between Isidis and Hellas impact basins with CRISM data. We focused our study on the oldest and/or deepest crust exposures. Because of the absence of graben and faults in the region, this study focuses on impact craters as natural drills. We study 40 impact craters from 6 and 80 km diameter. 26 craters reveal alteration phases with the following assemblages: chlorite-carbonates (5), chlorite-serpentine (4), chlorite-serpentine-carbonates (5), and smectite-chlorite-carbonates (5) and smectite-chlorite-serpentine with carbonates (6) and without carbonates (1). There is no-correlation between mineralogical assemblages detected and the size of the crater. Most of the time, we detect the same mineralogical assemblages in the ejectas, the walls and the central peak of the craters suggesting that the alteration mineral we are analyzing may have been exhumed by the impact craters formation. Using the current position of the outcrops and the crater size, we estimate the pre-impact elevation of the rocks hosting altered minerals. By this technique over the 26 studied impact craters, we tentatively reconstruct the about 15 first kilometers of the crust from west to east starting at 60° of longitude to 140° of longitude.We study the regional repartition and the distribution as function of the depth of the different mineralogical assemblages. The carbonates, serpentine and chlorites are widespread distributed while smectites seems to be restricted to the west flank of Tyrrhena Patera. The carbonates, serpentine and chlorites are also widespread with depth while smectite are in the shallower part of the crust. The smectites production is more efficient at T< 100°C and under a high W:R ratio. Chlorite and serpentine productions are more efficient at greater temperature (~350°C) and low W:R ratio. The presence of smectite restricted at shallower depth is consistent with a high W/R and a low temperature close to the surface. We so suggest a heat source from depth possibly linked to Tyrrhena Patera and a source of water from the surface or the subsurface. The carbonation implies CO2 rich fluids. Such fluids may be linked to a CO2 rich atmosphere or be link to a regional alkali magmatism. Our results show that serpentinization/chloritization and carbonation of the Noachian crust occur in a very large region of Mars. The widespread detection of carbonates raises the question of

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the interaction between the Noachian crust and CO2 rich fluids. In addition to evidences of warm water circulation, serpentine formation attests of possible reducing conditions with H2 production. The presence of carbonate attests of CO2-rich fluid circulation either during or after the main hydration stage. If carbonation and serpentinization of the Martian crust are not restricted to our study area, the primitive Martian crust could have hosted environmental conditions favorable for emergence of life.

Mots-Clés: Serpentine, Carbonates, Hydrothermalisme, Mars, Exobiologie

High-precision chronometry of volatile element depletion in the early Solar System

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Abstract

A common feature of all terrestrial planets and most asteroids is their significant depletion in volatile and moderately volatile elements compared to the Sun. Two end-member hypotheses have been identified. Volatile loss can occur through partial condensation of the nebular material meaning that the hot volatile-rich gas was removed from the inner solar system before the cooling of the nebula and that volatiles had never been held in the precursor materials of terrestrial planets. An alternative scenario is a complete condensation of nebular gas followed by later evaporation of volatiles by heating of the precursors. Volatile loss induces elemental fractionation, but it can also fractionate isotopes following a mass- dependent fractionation line. This is the case between the moderately volatile alkali and refractory alkaline-earths. Our work focuses on two radioactive chronometers 87Rb-87Sr and 135Cs-135Ba which both have moderately volatile parents and refractory daugthers. Any loss of volatiles should fractionate the parent to daughter ratio and change the temporal evolution of the daughter isotopic composition, allowing us to date the volatile depletion of the sample. This study focuses on the measurements of Sr, Ba, Mo and Sn isotopes to study volatile element depletion. Whereas Sr purification protocols have already been ex- tensively investigated, no convincing protocols for the separation of Ba and Sn exist. We have developed a new separation protocol for high-precision isotopic measurements of Sr, Ba, Mo and Sn. Our method allows the separation and purification of all three elements from the same aliquote of sample following a seven step ion-exchange technique. Sn iso- topic compositions are measured by MC-ICP-MS. Sr and Ba isotopic ratios are analyzed by TIMS using the latest improvements on these instruments. Our standard measurements yield 135Ba/136Ba = 0.839313 +/- 0.000024 (2sd) , 87Sr/86Sr = 0.710248 +/- 0.000010 (2sd) and 84Sr/86Sr = 0.055173 +/- 0.000006 (2sd) on in multidynamic mode, and 130Ba/136Ba = 0.013483 +/- 0.000001 (2sd) and 132Ba/136Ba = 0.012902 +/- 0.000001 (2sd) for the low p-process isotopes in static mode using the virtual amplifiers for each mode. Barium isotopic composition of geological standard (BHVO1, AGV1) and one ordinary chondrite are indis- tinguishable within error. Our work now focuses on the analysis of various extraterrestrial samples: ordinary and carbonaceous chondrites, basaltic achondrites, SNC meteorites and lunar samples. Our results will be used to constrain much more precisely the timing and the processes of volatile depletion. Our ultimate goals are to answer the following questions: (1) Is there a direct link between time and volatile depletion? (2) How much of the volatile depletion takes place prior to planetary accretion or large impacts such as the one forming the Moon? (3) What does the history of volatile depletion tell us about the history of the solar nebula?

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Photophoresis effects in protoplanetary disks

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Abstract

It is thought that planets are formed in the inner regions of protoplanetary disks (PPD) about 1 - 10 AU from the star. However, the migration of solids sometimes carry them onto the star in a very short time. This is a problem for planet formation known as the radial-drift barrier. This phenomenon prevents planetesimal formation which is a major obstacle for planet formation. Many processes such as particle traps, meridian circulation, turbulence effects and magnetic break have been put forward as possible candidates to stop the inward drift of solid bodies. In this work, we explore the star's irradiation effect on the inner regions of PPD, namely the photophoresis effect on dust grains. Photophoresis is the thermal creep towards the outer parts of the disk. It is due to the combination of the stellar irradiation and the gas pressure effects on the dust particle. It is mainly driven by the temperature gradient over the surface of the grain, which depends on its chemical composition and porosity. Based on recent experiments (Duermann et al. 2013) and on analytical calculations, it is possible to show that photophoresis is able to revert the inward motion of solid bodies at different locations in the disk. It is important to note that photophoresis effects are only observed for particles with a size ranging from a millimeter to a meter. We include this effect in our two-fluid (gas+dust) SPH code in order to study the structure and the dynamics of the dust particles in the inner regions of PPD.

Mots-Clés: hydrodynamics, stellar radiation, protoplanetary disks, planet formation, numerical simulations

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A detailed study of a young and distant galaxy

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Abstract

With the exception of a few exceptionally bright sources, these galaxies are too faint to study in detail their properties. Gravitational lensing offer us a path to overcome this problem. Massive galaxy clusters, at a relatively low redshift, deform space-time and act as cosmic lenses, magnifying dim sources on their background. We can then investigate the very young and distant galaxies that are serendipitously magnified by the clusters, deriving stellar a gas properties that would only be possible to distinguish with the next generation of telescopes. I will present one of such studies, of a galaxy at z=3.507, when the universe was only 2 billion years old. The data was obtained with the Multi Unit Spectroscopic Explorer (MUSE), a large field spectroscope built by a consortium led by CRAL, and recently installed in the Very Large Telescope, in Chile.

Mots-Clés: High, redshift galaxies, graviational lensing, galaxy resolved properties

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Tectonique des plaques

Plate tectonics of convection models

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Abstract

Since the 80's, significant progress has been made in the reconstruction of global tectonics since Pangea breakup (Pilger, 1982; Lithgow-Bertelloni and Richards, 1998; Seton et al., 2012). However, these reconstructions still face several challenges: (a) reconstructing the motion of plates that have been subducted, (b) taking into account the uncertainties in the motions of some plates and continents (for instance Vissers and Meijer, 2012; Verges and Fernandez, 2012), (c) characterizing the diffuse plate boundaries that do not fit plate tectonics theory (Gordon, 1998). Mantle convection models with pseudo-plasticity produce tectonic evolutions together with mantle dynamics consistent, to a first order, with seafloor spreading and continental drift on Earth (Rolf et al., 2014). Hence, they open new perspectives to describe how plate motions and plate boundaries can evolve over geologic time scales. The tectonics of the models can also be compared to the plate reconstructions for the real Earth. In this study, we apply plate tectonics theory to interpret the surface motions of 3D spherical models of convection generating plate-like motions. First, we produce synthetic kinematic and heat flow data from convection calculations with pseudo plasticity and continents using StagYY (Tackley, 2008). Then, we process the synthetic data with the GPlates software (Williams et al., 2012) to determine plate boundaries and plate rotations over the duration of the simulation. We compute paleomaps, plate numbers, plate sizes, relative rotations evolutions, plate velocities and boundary lengths. We compare these time-series with those corresponding to plate reconstructions for the Earth (Seton et al., 2012). We explore the limitations of the plate tectonics approach on models where boundaries are diffuse, and discuss to what extent these limitations could also apply to the Earth.

Mots-Clés: Plate tectonics, Mantle convection models, Middle ocean ridges, Subduction zones

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Concomitant melting of the crust and the mantle in the Variscan French Massif Central: a coupled U-Pb and Lu-Hf isotope study of late-collisional granites and high-K mafic intrusives

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Abstract

The Variscan nappe pile of the Eastern French Massif Central was built up during the Devonian and Carboniferous as a result of subduction and subsequent collision between Gondwana, Laurussia and several microcontinents. During the late- to post-collisional stage associated with orogenic collapse (330—290 Ma), the nappe pile was intruded by numerous granite plutons and reworked by the rise of a 100km-round migmatite-granite dome, the Velay Complex. Granites in the area belong to two main suites, namely: (i) peraluminous two-micas or cordierite-bearing leuco- and monzogranites (MPG and CPG) and (ii) meta-luminous, sub-alkaline granites and granodiorites (KCG) often associated with Mg-K-rich mafic intrusives of enriched mantle origin (locally referred to as vaugnerites). In order to (i) constrain the spatial and temporal framework of crust- and mantle-derived magmatism and (ii) characterize the source of the magmas, we conducted a coupled U-Pb and Lu-Hf study on zircon from 30 granites and vaugnerites. Both systematics were measured in situ by LA-(MC-)ICPMS. This new dataset shows that: (i) ages of both granites and vaugnerites range between 340 and 300 Ma; (ii) in a given geographic area, granites and vaugnerites are roughly coeval which suggest that mantle magmas played a role in triggering anatexis through heat diffusion and advection; (iii) age data show a two-stage sequence, first characterized by a southwards migration and followed by a general melting event at 305—300 Ma; (iv) zircon inheritance and Hf isotope compositions of both granites and vaugnerites are strikingly similar and point to the involvement of older crust in magma genesis, especially of "Cadomian" age (500—660 Ma), either as the source itself (in the case of granites) or as enriched material that interacted with the mantle (in the case of vaugnerites). The observed

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ages and Hf isotope compositions comply with the progressive southwards retreat of the Eo-Variscan slab proposed by Vanderhaeghe et al. (2014). Such an event would have caused uplift of hot asthenospheric material, triggering partial melting of (i) lithospheric mantle remnants or tectonic mélanges of subducted crust and mantle slices (producing vaugneritic magmas) and (ii) the overlying crust (generating anatectic granites and ultimately giving rise to the Velay complex).

MCT location and thermal structure of the Jaljala klippe : insights from RAMAN spectrometry

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Abstract

The Himalayan orogen is the paradigm of collision belt. However, some important questions are still debated. Among these questions is the precise geometry of the Main Central Thrust (MCT) and the South Tibet Detachment (STD) and wether they were passive or active structures. In the Himalayan belt, high – grade metamorphic rocks, the High Himalaya Crystalline (HHC) overthrust less metamorphosed rocks along the MCT and are overlain by unmetamorphosed or poorly metamorphosed rocks above the STD. Two models are proposed in order to explain these observations. In the first model, MCT and STD are boundaries of a crustal wedge formed by the HHC and played an active role for its extru- sion. In the second model, HHC is part of a lower crustal partially melted layer expulsed outward from beneath the Tibet, and guided by the climatically – driven erosion on the front of the belt. In this second model, MCT and STD are boundaries of the rock channel but play a passive role. The MCT and the STD have mostly been studied in the internal parts of the belt, however HHC klippes, which represent shallower parts have been poorly investigated to answers those questions. In these klippes such as Jaljala klippe, structural studies show a tectonic structures similar to the MCT. The thermometry on carbonaceous material on metasediments using RAMAN spectrometry (Beyssac et al., 2002) gives peak metamorphism temperature reached by the rocks. It can help to constraint precise MCT location and thermal structure of the zone by obtaining the variation of the evolution of temperature along cross sections and linking it with the structural observations. Results are available along two cross – sections (Lungri khola and Dhansi khola), but need to be refined by more analysis (Rhéty, 2011). Thin sections from two other Jaljala klippe cross – section are in realization and will be available to analyze soon. Results for the Jaljala klippe will be compared to those of Bollinger et al, 2004 for the Kathmandu klippe in order to map the location of the MCT along klippes and study the evolution of the deformation along the MCT and the STD along a large part of the belt.

Mots-Clés: Himalaya, MCT, STD, Jaljala klippe, Raman

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Petro-geochemical study of a cratonic eclogite suite - Roberts Victor Mine (Kaapvaal, South Africa)

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Abstract

Roberts Victor mine (South Africa) is considered as a type-locality for cratonic eclogite xenoliths due to a broad sampling by the kimberlitic magma. The samples register a wide variety both texturally and chemically, with a typical mineral assemblage constituted of Pyrope-Almandine Garnet and Omphacite Pyroxene, besides which some may contain Kyanite, Corundum, Coesite, Spinel, Sanidine and Diamond. A discrete extensive metasomatism allowed the preservation of a small number of pristine samples – key in understanding this cratonic suite. The present study comprises a thorough major and trace elements composition analysis, correlated with mineralogical textural aspects, throwing a new light upon the admitted classification criteria. Based on chemical behavioural differences and textures, three groups are distinguishable: the previously described type I – type II and high-silica-high-aluminium eclogites. Most samples have equilibrated in the same temperature range, at similar depths 145-190km, intercepting the 39mW conductive geogradient and corresponding to the Lithosphere-Astenosphere Boundary. The type I eclogites have been intensively metasomatised by the kimberlitic fluids and the isotopic composition has been reset just before the eruption. The type II eclogites show no trace of contamination. The ages of the pristine samples are of 886Ma898 Ma SmNd; 15051698 Ma LuHf. The corundum bearing type II samples give even older ages (15442204 Ma SmNd; 2462 ± 12 Ma LuHf). The isotope composition is consistent with the DMM reservoir evolution and the trace elements analysis contours positive Sr and Eu anomalies leading towards a plagioclase-rich protolith. The results obtained as well as the calculated spectrums for whole rock trace element composition for type II and high-silica-high aluminium samples are valid arguments for a subduction model origin.

Mots-Clés: Bimineralic eclogites, Kyanite eclogites, Xenoliths, Thermobarometry, Geochemistry, Isotope dating

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Permeability and transport properties of serpentine in subduction zones

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Abstract

Fluid circulations are a major feature for subduction zone dynamics. In the mantle wedge and along the subducting plate interface, seismologists observed tremors, which constitute a type of earthquakes induced by fluid circulations. The slab ejects fluids during subduction, when temperature and pressure conditions affect the stability of hydrated minerals. It is mostly made of serpentinite, which is a hydrated rock with a lamellar structure. Some authors assume that once ejected, the aqueous fluids travel along the plate interface through serpentinite. But the pathways of these fluids are poorly understood, as well as fluid-rock interactions at the temperature and pressure conditions of the plate interface (T = 300-600°C and P = 1-5 GPa). We collected samples from former subduction zones in Baja California, Mexico, in Erro Tobbio and Monviso, Italy. Focused ion beam (FIB) dig very flat surfaces and scanning and transmission electron microscopy (SEM and TEM) reach resolutions large enough to observe veins and porosity at a submicrometer scale. From the outcrop to the submicrometer scale principal circulation paths mostly follow the principal orientation of serpentine crystals. Smaller veins or pore successions link the principal axes of circulation showing that variations of fluid pressure and local precipitation-dissolution thresholds control opening and closing of circulation paths between crystals, crosscutting crystal principal orientation. We also ran diffusion experiments at high pressure and high temperature on serpentinite samples saturated with deutered water. From Raman spectroscopy mapping on serpentinite grains we calculate diffusion coefficients of water, which are around 10-15 m2.s-1 at 540±20°C and 2 orders of magnitude smaller for profiles perpendicular to the foliation. At the plate interface conditions, the fluids circulate mostly parallel to the subducting plate but can also find a way perpendicular to the subduction interface, hydrate the overlying mantle and reach the mantle wedge.

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Poster

Life habits and Taphonomy of Palaeoscolecid Worms

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Abstract

Palaeoscolecids are long cylindrical annulated vermiform ecdysozoans with an eversible proboscis comparable with that of priapulids. Their most conspicious external feature are aligned knob-like sclerites of assumed primary phosphatic origin associated to the annulations of their molting cuticle. Their fossil record ranges from the early Cambrian to the late Silurian, but only isolated sclerites or small clusters of sclerites are usually found in sediments as Small Shelly Fossils or Small Carbonaceous Fossils. The world-wide occurrence and abundance of palaeoscolecid remains suggest that these organisms were an important component of marine communities in the Lower Palaeozoic, possibly playing a critical role in the substrate colonization initiated at the beginning of the Cambrian. However, many aspects of the biology and ecology of these organisms remain poorly known. This contribution presents some preliminary results of our study concerning seven recently collected and virtually complete Lower Palaeozoic specimens. Two specimens were recovered from the Issafen Formation (Cambrian Series 2, Stage 3) near Timkit township, Morocco. Three others were found in the Weeks Formation (Cambrian Series 3, Guzhangian) in the central House Range of Utah (USA). One comes from the Ferrals Formation, (Cambrian Series 3, Guzhangian) of Montagne Noire in France and another was discovered in the Lower Fezouata Formation (Early Ordovician, Late Tremadocian) of the Zagora area in Morocco. In the light of these new observations, the diversity of lifestyles of palaeoscolecids, their modes of preservation, and the original biomineralization of their sclerites are discussed.

Mots-Clés: Palaeontology, Palaeozoic, Palaeoscolecid, Taphonomy, Palaeoecology

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2.7 Ga heating event and P-T-t evolution of the Southern marginal belt of the Limpopo belt, South Africa: Consequences for Neoarchean continental accretion

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Abstract

The Kaapvaal craton (KC) in South Africa is bounded to the North by the Southern Marginal Zone (SMZ) of the Limpopo belt, which has been regarded as the reworked equivalent of the Kaapvaal craton basement, consisting of TTG granitoid gneisses (Baviaanskloof gneiss) and infolded metasediments (Bandelierkop formation) both of which were metamorphosed and deformed during ~2.7 Ga orogeny. Metamorphic and geochronologic data collected in metapelites, demonstrates that sediments from the SMZ underwent a very fast (~40Ma) clockwise P-T-t loop at ca. 2.7Ga, with burial rate of (0.17 to > 4cm/y) to achieve peak metamorphic conditions at 2713±8 Ma. Phase equilibria modeling constrains peak conditions to 845±15C and 10.8±1.6 kbar. This was followed by isothermal decompression to 805±10C and 6.6±0.63kbar, with subsequent isobaric cooling to amphibolite facies conditions, below 610C, prior to 2680±6 Ma. This evidence argues strongly that the SMZ contains sediments deposited in an active margin during convergence, and that the metapelites were metamorphosed and underwent anatexis as a consequence of continental collision along the northern margin of the KC at ~2.7 Ga.Several simultaneous high-temperature geological events occurred in the KC at this time: (1) widespread Ventersdorp Supergroup mafic to intermediate volcanism; (2) local plutonic activity both north and south (Swaziland) of the edges of the KC (2670-2680Ma) with man- tle component signature; (3) granulite-facies metamorphism in Swaziland at ~2.7 Ga due to crustal thinning. Collectively, the data demonstrate that at ~2.7 Ga, the portions of the lower and mid-crust of the KC, underwent a significant heating event. The combination of information from these different rocks has the potential to provide detailed information on neo-Archaean orogenic style.

Mots-Clés: Archean, P, T, t path, continental collision

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Partenaires