Proposition de sujet de thèse 2022

(A remplir par les équipes d'accueil et à retourner à Isabelle HAMMAD : hammad@cerege.fr
(1) : A remplir lors de la campagne d'attribution des allocations, à l'issue de la session de juin des Masters

Sujet de doctorat proposé : Understanding the variability of the meteorite flux of the past 2 Myr

Encadrant(s) Jérôme Gattacceca, CEREGE (gattacceca@cerege.fr)
Laboratoire : CEREGE

Tableau récapitulatif du sujet

Candidat(e)(1)	
Nom - Prénom :	
Date de naissance :	
Licence (origine, années, mention) :	
Mention et classement au Master 1 année (Xème sur Y)	
Mention et classement au S3 du Master 2 (Xème sur Y)	
Mention et classement au S4 du Master 2 (Xème sur Y)	
Mention et classement au M2 (année) (Xème sur Y)	
MASTER (nom, université)	
Sujet de doctorat proposé	
Encadrants (2 max, indiquer si HDR ou pas)*	Jérôme Gattacceca (HDR)
Laboratoire*	CEREGE
Programme finançant la recherche (indiqué si obtenu ou envisagé) (1)	fonds propres (crédits PNP reportés)

Sujet de doctorat proposé

Understanding the variability of the meteorite flux of the past 2 Myr

Context: The Earth continuously experiences collisions with solid objects derived from asteroidal, cometary and planetary debris. This delivery of extraterrestrial matter to Earth is controlled by the complex dynamic evolution of solar system bodies. Establishing the rate at which interplanetary matter is captured by Earth is relevant to studies of the orbital evolution of asteroids and comets and the cratering history of moons and planets (including Earth). It also has implications for the quantification of meteoroid collision hazards for spacecraft.

State of the art: Presently, the Earth accretes about 4×10^7 kg of extraterrestrial matter per year, a flux broadly constant for the last 500 Myr [1]. A minor part of this incoming flux, about 5×10^3 kg, falls as meteorites [2]. These bulk numbers are still clouded by large uncertainties. Even less known is the time evolution of the flux of extraterrestrial material. Is the flux constant over geological time scales, corresponding to a smoothed transfer from the asteroid belt to the Earth? Or does our planet endure bursts of collisions with extraterrestrial rocks. If so, over what time scales? Answering these questions is important to picture the overall dynamics of the flux of solid matter in the interplanetary space of the inner solar system. This PhD will address specifically the long term (~Myr) composition of the meteorite flux to the Earth (intensity, variability).

Proposed study: The Atacama meteorite collection assembled by CEREGE over the years [3,4] offers a unique window on the meteorite flux over the last 2 Myr [5]. Studying the flux requires systematic field collection of meteorites, classification of all meteorites, identification of meteorites that are part of the same fall event (pairing), and estimating the terrestrial age of a subset of the meteorite collection. Our results from the El Médano area in the Atacama [5] suggests that the composition of the flux may have varied over the last 2 Myr (fig 2).

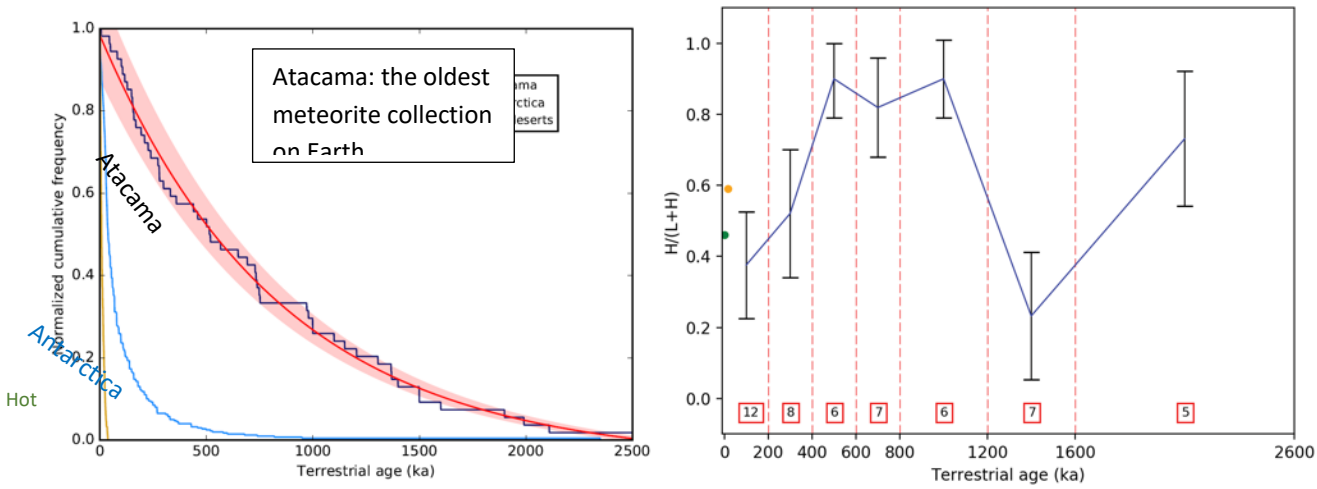

Figure 2. Left) Cumulative terrestrial age distribution of meteorites from the El Médano area (Atacama desert, our data), other hot deserts, and Antarctica. Only the Atacama collection allows investigating the Myr time scale; right) H chondrite fraction (proxy to flux composition) in the Atacama collection (in red: number of meteorites per bin). Green dot: present day ratio (from the meteorite falls of the last 200 yr). Orange dot: non Atacama hot deserts (last 20 kyr). Figure adapted from [5]

We will test this hypothesis by studying two meteorite collections assembled by CEREGE and private meteorite hunters: the Catalina and Calama collections. These collection areas are located 50 and 270 km away from the previously studied El Médano collection, and are therefore totally independent collections.

The terrestrial age of a subset of meteorites from these collections will be estimated by measuring their remaining concentrations in cosmogenic radionuclides (^{36}Cl primarily, and ^{10}Be for the oldest ones) at CEREGE with the ASTER Accelerator Mass Spectrometer.

We will further constrain the dynamics of the meteorite transfer from the asteroid belt to the Earth by estimating the transfer times in space (Cosmic Ray Exposure age, CRE age) of a small selection of meteorites. This will be achieved by measuring the concentrations in the cosmogenic noble gas ^{21}Ne at CRPG with collaborators at CRPG (Nancy).

Expected results: Estimating the terrestrial age spectrum of the Calama and Catalina collections will provide a unique dataset to infer the long term (~2 Myr) meteorite flux. The measurements of CRE ages will provide for the first time the age spectrum for the extraction of meteorites from the asteroid belt over the last 2 Myr, providing a direct picture of the dynamics of their transfer from the asteroid belt to 1 AU. We will investigate the possible astronomical processes that could be responsible for the meteorite flux variability in collaboration with Dr. Alessandro Morbidelli (OCA, Nice).

Techniques, methods and concepts that will be used during the PhD

- collecting meteorites in the Atacama Desert (field work)

- meteorite classification (petrography, microprobe, etc)

- estimating terrestrial ages of meteorites by measurement of ^{36}Cl, ^{10}Be by Acceleration Mass Spectrometry (CEREGE)

- estimating CRE ages of meteorites by measurement of ^{21}Ne (collaboration CRPG Nancy)

- understanding the astronomical processes responsible for the transfer of meteorites from the asteroid belt to the Earth (collaboration A. Morbideli, OCA Nice)

References : [1] Peucker-Ehrenbrink & Schmitz 2001 ISBN 978-1-4419-88694-8 [2] Halliday+ 1984 Science 4643:1405-1407 [3] Gattacceca+ 2011 MAPS 9:1276-1287 [4] Hutzler+ 2016 MAPS 51:468-482 [5] Drouard+ 2019 Geology 2019 47:673-676.

Détail du Programme finançant la recherche : Fonds propres (crédits acquis précédemment auprès du programme PNP et reportés pour cause de pandémie)

Directeurs de thèse proposés

Directeur HDR proposé

Nom - Prénom : Gattacceca Jérôme
Corps : DR1 CNRS
Laboratoire : CEREGE
Adresse mail : gattacceca@cerege.fr

Choix de cinq publications récentes en liaison avec le sujet (étudiants dirigés co-signataires soulignés) :

Aboulahris M., Chennaoui Aoudjehane H., Rochette P., **Gattacceca** J., Jull A.J.T, Laridhi OuazaaN., Folco L., Buhl S. 2019. Characteristics of Sahara as a meteorite recovery surface. Meteoritics and Planetary Sciences 54 : 2908-2926. doi :10.1111/maps.13398

Drouard A., **Gattacceca J.**, Hutzler A., Rochette P., Braucher R., Bourlès D., ASTER Team, Gounelle M., Morbidelli A., Debaille V., Van Ginneken M., Valenzuela M., Quesnel Y., Martinez R. 2019. The meteorite flux of the past 2 m.y. recorded in the Atacama Desert. Geology 47 (7) 673-676, doi 10/1130/G45831.1

Gattacceca J., Valenzuela M., Uehara M., Jull T., Giscard M., Rochette P., Braucher R., Suavet C., Gounelle M., Morata D., Munayco P., Bourot-Denise M., Demory F., Bourlès D. 2011. The densest meteorite collection area in hot deserts: the San Juan meteorite field (Atacama Desert, Chile). Meteoritics & Planetary Sciences 46, 1276-1287.

Hutzler A., **Gattacceca J.**, Rochette P., Braucher R., CarroB., Christensen E., Cournède C., Gounelle M., Laridhi-Ouazaa N., Martinez R., Warner M., Bourles D. 2016. Description of a very dense meteorite collection area in western Atacama: insight into the long-term composition of the meteorite flux to Earth. Meteoritics & Planetary Science 51:468-482, doi:10.111/maps.12607

Pourkhorsandi H., **Gattacceca J.**, Rochette P., et al. 2019 Meteorites from the Lut Desert (Iran). Meteoritics and Planetary Sciences, doi 10.1111/maps.13311

Thèses encadrées ou co-encadrées au cours des quatre dernières années

Toutes soutenues en 3 ans fermes

Nom : Krämer Ruggiu Lisa
Intitulé : Altération aqueuse des météorites : un traceur des circulations d'eau sur les corps extraterrestres
Type d'allocation : Ecole Doctorale 251
Date de début de l'allocation de doctorat : 1er octobre 2019
Date de soutenance (si la thèse est soutenue) : 18 octobre 2021
Programme finançant la recherche : ANR (Mars Prime, CEREGE), PNP (CEREGE), ERC Solarys (IPAG)
Situation actuelle du docteur (si la thèse est soutenue) : post-doc à ULB (Bruxelles)
Pourcentage de participation du directeur à l'encadrement en cas de co-direction : 50 %

Nom : Alexis Drouard
Intitulé : Détermination des régions sources des météorites
Type d'allocation : Ecole Doctorale 352 (Physique et Sciences de la matière)
Date de début de l'allocation de doctorat : octobre 2016
Date de soutenance (si la thèse est soutenue) : septembre 2019
Programme finançant la recherche : ANR (FRIPON, LAM/CEREGE), PNP (CEREGE)
Situation actuelle du docteur (si la thèse est soutenue) : professeur agrégé (sciences physiques)

Pourcentage de participation du directeur à l'encadrement en cas de co-direction : 50 %

Nom : Lepaulard Camille
Intitulé : Paléomagnétisme lunaire
Type d'allocation : Ecole Doctorale 251 (« bourse Président »)
Date de début de l'allocation de doctorat : 1er octobre 2015
Date de soutenance (si la thèse est soutenue) : octobre 2018
Programme finançant la recherche : ANR (MagLune, CEREGE)
Situation actuelle du docteur (si la thèse est soutenue) : enseignement secondaire
Pourcentage de participation du directeur à l'encadrement en cas de co-direction : 100 %