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 : Champs magnétiques dans le système solaire jeune; contrainte sur l'évolution de la nébuleuse solaire et des planétésimaux / Magnetic fields in the early Solar System: constraints on the evolution of the solar nebula and planetesimals

Encadrant.e.s : Jérôme Gattacceca (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)	PNP & ANR à demander, fonds propres

Sujet de doctorat proposé

Magnetic fields in the early Solar System: constraints on the evolution of the solar nebula and planetesimals

Many sources of magnetic fields played key roles in shaping our solar system. In particular, magnetic fields likely favored the accretion of solids in the protoplanetary disk (solar nebula). They were commonly generated by planetesimals, the first planetary bodies formed in the solar system, through advection of their metallic core (dynamo effect). Meteorites are the remnant pieces of planetesimals. They possibly experienced and recorded fields generated by the nebula or the planetesimals. Because magnetic fields reflect intrinsic properties of their generating source, the meteoritic record offers the opportunity to better understand the early history of the solar system. The selected PhD candidate will use meteorite paleomagnetism to fulfill two specific objectives: 1) constrain the intensity of the nebula field as a function of time and distance from the Sun; 2) characterize the timing and intensity of dynamo fields on planetesimals.

This proposal will advance our understanding of the magnetic fields that existed in the early solar system: those sustained by the solar nebula and those generated by dynamo effect on planetesimals. The intensity of these ancient magnetic fields will be estimated using paleomagnetic analyses of selected meteorites. Combined with geochronometry and petrographic data, This data will provide time-resolved constraints on solar nebula and planetesimal dynamo fields. The PhD project is divided into two independent work packages: (WP1) Measuring the chemical remanent magnetization (CRM) and age of aqueous alteration for selected chondrites; (WP2) Analyze the NRM of thermally processed meteorites coming from differentiated and partially differentiated planetesimals to constrain dynamo processes on these planetesimals.

In WP1, the PhD candidate will study a set of magnetite-rich meteorites (LL3 and CO3 chondrites with low petrographic subtypes, CK3, CM2, …), and possibly return samples from asteroids Ryugu and Bennu (from the Hayabusa 2 and Osiris Rex space missions, sample request is pending evaluation). These samples come from different planetesimals formed at different radial distances from the Sun. Their mineralogy suggests that their magnetite crystallized within the lifetime of the solar nebula. For these meteorites we will also acquire I-Xe ages of magnetite extracts with our collaborator Olga Pravdivtseva at Washington University, to constrain the age of the magnetization. This new data will provide a temporally-resolved record of the solar nebula field.

In WP2, the PhD candidate will study the paleomagnetic record of meteorites that were thermally processed on their parent bodies. As such, they may have recorded dynamo magnetic fields. Two meteorite groups have been selected: CK chondrites and eucrites. CK chondrites: These meteorites have never melted on their parent bodies, and could come from partially differentiated bodies. They likely acquired their magnetization during retrograde thermal metamorphism. Existing paleomagnetic data on CK chondrites are limited and outdated and reached contradictory conclusions. A set of magnetite-rich CK chondrites with varying metamorphic grade will be studied through thermal demagnetization. This classic and effective method has never been used on CK chondrites. Eucrites: Eucrites are basalts that formed at the surface of Vesta, a fully differentiated asteroid of 500-km diameter. Only one eucrite has been studied in detail for paleomagnetism, suggesting an early dynamo activity on Vesta. This hypothesis will be tested by analyzing five unbrecciated eucrites selected among the hundred available. To avoid alteration of the main ferromagnetic mineral in eucrites (kamacite) during thermal demagnetization, a paleomagnetism oven with controlled oxygen fugacity will be used.

Methodology: paleomagnetism & rock magnetism (including the use a new magnetic microscopic imaging system, the *Quantum Diamond Microscope*), petrography (optical and electron microscopy, microprobe, …).

Détail du Programme finançant la recherche : Fonds propres J. Gattacecca ; Programme National de Planétologie (INSU/CNES)

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 (étudiants dirigés co-signataires soulignés) :

Cournède C., **Gattacceca** J., Rochette P., Shuster D.L. Paleomagnetism of Rumuruti chondrites suggests a partially differentiated parent body (2020) Earth and Planetary Science Letters. 533: 116042, doi 10.1016/j.epsl.2019.116042

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., Bonal L., Sonzogni C., Longerey J. CV chondrites: more than one parent body. 2020. Earth Planet. Sci. Letters, 147, 116467, doi:10.1016/j.epsl.2020.116467

Krämer Ruggiu L., Beck P., **Gattacceca** J., Eschrig J. 2021. Visible-infrared spectroscopy of ungrouped and rare meteorites brings further constraints on meteorite-asteroid connections. Icarus 362 :114393.

Lepaulard C., **Gattacceca** J., Uehara M., Rochette P., Quesnel Y. et al. 2019. A survey of the natural remanent magnetization and magnetic susceptibility of Apollo whole rocks. Physics of the Earth and Planetary Interiors 290: 36-43

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

Toutes soutenues en 3 ans

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 %