DOCTORAT ECOLOGIE
BRETAGNE GEOSCIENCES
LOIRE AGRONOMIE ALIMENTATION

PhD PROPOSAL FOR THE DOCTORAL SCHOOL

« Ecologie, Géosciences, Agronomie, ALimentation »

GENERAL INFORMATION

Thesis title: Evaluation of the seismic energy released in the West of Metropolitan France
Acronym: ESOF
Disciplinary field : Geosciences
Three keywords: Seismicity – Armorican Massif – RESIF
Research unit : Laboratoire de Planétologie et Géodynamique (LPG, UMR 6112), Nantes University
Name of the thesis director: MOCQUET Antoine **Email address of the thesis director :** antoine.mocquet@univ-nantes.fr **Name of the thesis co-supervisor :** BONNIN Mickaël **Email address of the thesis co-supervisor :** mickael.bonnin@univ-nantes.fr
Thesis grant (funding origin and amount): EroSeis (project ANR-20-CE01-0005-02), 162 216,00 €
Contacts (mailing address and E-mail): - Thesis supervision : Antoine MOCQUET/Mickaël BONNIN antoine.mocquet@univ-nantes.fr/mickael.bonnin@univ-nantes.fr - Administrative manager : Sophie HUGUET sophie.huguet@univ-nantes.fr ; +33(0)2.51.12.53.15 Laboratoire de Planétologie et Géodynamique (LPG, UMR6112) UFR des Sciences et des Techniques 2 rue de la Houssinière, BP 92208 44322 Nantes Cedex 3, France
Recruitment process: ☐ **Doctoral school contest** ☒ **Interview** ☐ **Other (indicate) :**

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SCIENTIFIC DESCRIPTION OF THE PhD PROJECT

Socio-economic and scientific context

The Laboratoire de Planétologie et Géodynamique (LPG), a joint research unit of Nantes University, Angers University, and CNRS, is involved for more than ten years in the seismological instrumentation of the West of France. Its area of intervention covers almost a quarter of the metropolitan territory (New Aquitaine, Pays de la Loire, Brittany, Normandy, Centre Val de Loire). This action is carried out in support of the Observatoire des Sciences de l'Univers Nantes-Atlantique (OSUNA), of which LPG is a founding member. It is carried out within the framework of the National Action for Observation (ANO) "Seismology" of the French Research Institute INSU - CNRS, within the RESIF-EPOS Research Infrastructure (French Seismological Network). Thanks to this action, the West of metropolitan France is now covered by a network of 26 permanent very broad band seismological stations.

Assumptions and questions

The current seismological network shows a high rate of seismicity, but events of moderate to low magnitudes. The vast majority of the earthquakes occur in ancient basement outcrops (Armorican Massif), the adjacent sedimentary basins being almost entirely aseismic. The processes at the origin of this seismicity are very poorly known, both for its long-term causes (past tectonic stresses, influence of ancient geological structures, erosive phenomena, post-glacial rebound, ...) and for its current triggering factors (hydraulic loads and unloads in continental or marine contexts). Some of these phenomena, such as the role played by erosion, are still only hypotheses and are the subject of the ANR EroSeis, which is funding this thesis. Their understanding requires a precise assessment of the energy released by the earthquakes, and by the characterisation of the associated deformations.

The main steps of the thesis and scientific procedure

- *First year* -

- Bibliographical study on the tectonic history and seismicity of stable continental zones in general and of the West of metropolitan France in particular.

- Theoretical and practical training in the determination of earthquake source parameters.

- Compilation of existing databases (magnitudes, focal mechanisms) and critical analysis of these data.

- *Second year* -

- In collaboration with the people working on the localisation of the events, systematic evaluation of their magnitudes, mechanisms and other source parameters.

- Critical re-evaluation of the mechanisms published in the literature in the light of these new determinations.

- *Third year* -

- Relating seismicity to the different phenomena that may be at its origin, proposals and perspectives on the characterisation and causes of seismicity in stable intracontinental domains.

This provisional programme is intended to evolve according to the progress of the research work. The results will be communicated in national and international congresses, and published in peer-reviewedinternational journals.

Methodological and technical approaches considered

This work will be conducted in the frame of the EroSeis project, in particular with the Institute for Radioprotection and Nuclear Safety (IRSN) for the study of seismic sources. A related thesis work, focused on the detection of events and their precise location, begun in 2020. It will provide these input parameters, which are essential for the assessment of seismic source parameters. These will be evaluated using existing software. Methods will also be developed to evaluate the accuracy of the mechanisms at the focal point and to compare them with other measurements of displacement (e.g. GPS) or deformation.

Scientific and technical skills required by the candidate

- Academic cursus and initial training, either in Earth sciences with a good level and a pronounced taste for physics (in particular mechanics), or in physics with a complementary training in Earth sciences (useful but not essential).

- Practical skills or learning facilities in signal processing and scientific programming (Matlab, Python, Fortran, ...) are recommended.

THESIS SUPERVISION

Unit name: Laboratoire de Planétologie et Géodynamique (LPG, UMR6112)	**Team name:** Earth
Unit director name: Antoine MOCQUET	**Team director name:** Éric BEUCLER & Olivier BOURGEOIS
Mailing address of the unit director: dir.umr6112@univ-nantes.fr	**Mailing address of the team director:** eric.beucler@univ-nantes.fr/olivier.bourgeois@univ-nantes.fr

Thesis director

Surname, first name: MOCQUET Antoine

Position: Professor

Obtained date of the HDR (Habilitation thesis to supervise research): 1997

Employer: Nantes University

Doctoral school affiliation: EGAAL

Rate of thesis supervision in the present project (%): 50%

Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%): 0

Number of current thesis supervisions/co-supervisions: 0

Thesis co-supervisor

Surname, first name: BONNIN Mickaël

Position: Associate Physicist

Habilitation thesis to supervise research ☐ yes ☒ no If yes, date diploma received:

Employer: Nantes University

Doctoral school affiliation: EGAAL

Rate of thesis supervision in the present project (%): 50%

Total rate of thesis supervision in ongoing theses (co-supervision) (%): 50%

Number of current thesis co-supervisions: 1

Professional status of previous PhD students supervised by both director and co-supervisor (from 5 years)

- Surname, first name: GAUDOT Ianis

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Date of PhD beginning and PhD defence: 01/01/2013 - 22/01/2016

Thesis supervision: Éric BEUCLER/Antoine MOCQUET

Professional status and location: Geophysicist Engineer, BRGM, Orléans

Contract profile: permanent

List of publications from the thesis work:

Bonnin, M., S. Chevrot, **I. Gaudot**, M. Haugmard, and the PYROPE Working Group (incl. E. Beucler & A. Mocquet), Upper mantle deformation beneath the Pyrenean domain inferred from SKS splitting in northern Spain and southern France, Geophys. J. Int., 210, 898-910, doi:10.1093/gji/ggx193, 2017.

Gaudot, I., E. Beucler, A. Mocquet, M. Schimmel, M. Le Feuvre, Statistical redundancy of instantaneous phases : Theory and application to the seismic ambient wavefield, Geophys. J. Int., 204, 1159-1163, doi:10.1093/gji/ggv501, 2016.

Gaudot, I., E. Beucler, A. Mocquet, M. Drilleau, M. Haugmard, M. Bonnin, G. Aertgeerts, D. leparoux, 3-D crustal V_S model of western France and the surrounding regions using Monte-Carlo inversion of seismic noise cross-correlation dispersion diagrams, Geophys. J. Int., 224(3), 2173-2188, doi:10.1093/gji/ggaa552, 2021.

- Surname, first name: HAUGMARD Méric

Date of PhD beginning and PhD defence: 01/01/2013 - 14/10/2016

Thesis supervision: Antoine MOCQUET/Éric BEUCLER

Professional status and location: Independent contractor

Contract profile: -

Liste des publications issues de ce travail de thèse :

Bonnin, M., S. Chevrot, I. Gaudot, **M. Haugmard**, and the PYROPE Working Group (incl. E. Beucler & A. Mocquet), Upper mantle deformation beneath the Pyrenean domain inferred from SKS splitting in northern Spain and southern France, Geophys. J. Int., 210, 898-910, doi:10.1093/gji/ggx193, 2017.

Cara, M. et al., dont **M. Haugmard**, E. Beucler & A. Mocquet, SI-Hex : A new catalogue of instrumental seismicity for metropolitan France, Bull. Soc. géol. France, 186(1), 3-19, 2015.

Gaudot, I., E. Beucler, A. Mocquet, M. Drilleau, **M. Haugmard**, M. Bonnin, G. Aertgeerts, D. leparoux, 3-D crustal V_S model of western France and the surrounding regions using Monte-Carlo inversion of seismic noise cross-correlation dispersion diagrams, Geophys. J. Int., 224(3), 2173-2188, doi:10.1093/gji/ggaa552, 2021.

Five main recent publications of the supervisors on thesis subject:

Beucler, E., **A. Mocquet**, M. Schimmel, S. Chevrot, O. Quillard, J. Vergne, M. Sylvander, Observation of deep water microseisms in the North Atlantic Ocean using tide modulations, Geophys. Res. Lett., 42, doi:10.1002/2014GL062347, 2015.

Bonnin, M., S. Chevrot, *I. Gaudot*, *M. Haugmard*, and the PYROPE Working Group (incl. E. Beucler & **A. Mocquet**), Upper mantle deformation beneath the Pyrenean domain inferred from SKS splitting in northern Spain and southern France, Geophys. J. Int., 210, 898-910, doi:10.1093/gji/ggx193, 2017.

Cara, M. et al., dont *M. Haugmard*, E. Beucler & **A. Mocquet**, SI-Hex : A new catalogue of instrumental seismicity for metropolitan France, Bull. Soc. géol. France, 186(1), 3-19, 2015.

Chevrot, S. et al., dont PYROPE Working Group (incl. E. Beucler & **A. Mocquet**), The Pyrenean architecture as revealed by teleseismic P-to-S converted waves recorded along two dense transects, Geophys. J. Int., 200, 1096-1107, doi:10.1093/gji/ggu400, 2015.

Gaudot, I., E. Beucler, **A. Mocquet**, M. Schimmel, M. Le Feuvre, Statistical redundancy of instantaneous phases : Theory and application to the seismic ambient wavefield, Geophys. J. Int., 204, 1159-1163, doi:10.1093/gji/ggv501, 2016.

Gaudot, I., E. Beucler, **A. Mocquet**, M. Drilleau, *M. Haugmard*, **M. Bonnin**, G. Aertgeerts, D. Leparoux, 3-D

crustal V_S model of western France and the surrounding regions using Monte-Carlo inversion of seismic noise cross-correlation dispersion diagrams, Geophys. J. Int., 224(3), 2173-2188, doi:10.1093/gji/ggaa552, 2021.

Maguire, R., J. Ritsema, **M. Bonnin**, P.E. van Keken, S. Goes, Evaluating the resolution of deep mantle plumes in teleseimic traveltime tomography, J. Geophys. Res. : Solid Earth, 123(1), 384-400, doi: 10.1002/2017JB014730, 2018.

Petit, C., L. Le Pourhiet, B. Scalabrino, M. Corsini, **M. Bonnin**, A. Romagny, Crustal structure and gravity anomalies beneath the Rif, northern Morocco : Implications for the current tectonics of the Alboran region, Geophys. J. Int., 202(1), 640-652, doi:10.1093/gji/ggv169, 2015.

THESIS FUNDING

Origin of the thesis funding: EroSeis (project ANR-20-CE01-0005-02), 2021 - 2025
Gross monthly salary: currently 1768,55 €, awaiting information on the impact of the LPR law on the remuneration of doctoral students.
Thesis funding state : Acquired
Funding beginning date/Funding ending date: 1st October 2021 / 3 years

Date: 18th February 2021

Name, signature of unit director:

Benoit LANGLAIS (Associate Director)

Benoit LANGLAIS

Name, signature of team director:

Éric BEUCLER

Name, signature of thesis project director:

Antoine MOCQUET