Sujet de thèse Unité Evo-Eco-Paléo – campagne 2019

Université : Université de Lille
Ecole doctorale: -
Filière doctorale : -
Titre de la thèse : - The great Silurian-Devonian terrestrial revolution: diversity and early evolution of land plants
Direction de thèse : Thomas SERVAIS (directeur de thèse) et Borja CASCALES-MINANA (co-directeur)
Email de contact: borja.cascales-minana@univ-lille.fr
Laboratoire(s) de Rattachement : Unité Évolution, Écologie et Paléontologie, UMR CNRS 8198
Programme(s) de Rattachement : -
Financement acquis ou demandé : -

SUJET DE THÈSE

Terrestrial ecosystems as we know them today did not develop until plants had colonized the land (i.e., terrestrialization[1]), a phenomenon that was therefore crucial for the evolution of global biodiversity. The progressive greening of the planet also caused major global changes through feedback effects on the evolution of the physical environment, such as climate, atmospheric composition, and geomorphology[2]. Indeed, it is currently thought that many of the major climatic transitions and faunal mass extinctions observed in the Late Palaeozoic were triggered by vegetation changes[3]. There has been considerable work on the diversity, disparity and distribution of Pennsylvanian and later Palaeozoic floras[3,4], but with only a few exceptions (see e.g., refs. 5, 6), there have been few similar studies on Silurian-Mississippian floras. This will be essential for a proper understanding of the initial covering of land environments, in particular, the transition dynamics into a forested planet. Improved modelling of the temporal and spatial distribution of these forests, especially if viewed in the context of changing hydraulic conductance within the plants, will be vital for a proper understanding of their effects on Earth's atmosphere, geomorphology and overall biosphere. However, many questions regarding the early spread of vegetation over the Earth's surface remain unsettled.

This Phd project aims to provide new fundamental data on the origin, diversification and dispersion of early floras, and to quantify their impact on the Earth System. We propose (1) to characterize the early temporal-spatial dynamics of land vegetation from when land plants first evolved until the development of well-established forests (i.e. from Silurian until Mississippian times, ~430-320 Ma); (2) to review the key steps of early plant evolution; and (3) discern the impact of plant evolution on the land biosphere and climate dynamics.

Step 1. Plant data. Analysing whole ecosystem evolution requires datasets detailing the spatial-temporal distribution of key plant clades. Raw data will be gathered from existing comprehensive plant occurrence-based datasets, primary literature and newly collected plant fossils, which will ensure the feasibility of project. The resulting datasets will be cleaned by removing unreliable occurrences and erroneous assignments. Plant fossil data will be prepared at genus and species levels for plant megafossils, and will be released to the public once the project is finished.

Step 2. Plant diversity. We will estimate the apparent diversity patterns take the fossil record[4-6] as well as several accurate patterns of diversification and extinction using sampling-standardized diversity estimates. It will be complemented with a recently developed Bayesian approach to infer the origination-extinction dynamics that provides high-quality sampling-corrected diversity estimates[7]. In addition, we will reconstruct the palaeogeographical patterns of early land plants, both globally and through time. For this, we will use standard historical approaches such as hierarchical cluster analyses, as well as stochastic Bayesian models, and the bootstrapped spanning network approach to documenting spatial diversity gradients. Distributions will be shown on current palaeogeographical maps using the GPlates and QGIS software packages.

Step 3. **Plant evolution**. We will elucidate the evolutionary relationships of early land plants, in particular the basal representatives of lineages. Cladistic analysis will be newly carried out via e.g., TNT (http://www.filogenetica.org/TNT.htm) to obtain consensus tree topologies and tests of their robustness, and assessing congruence between phylogeny and temporal distribution of known diversity. The aim is to build a comprehensive time-scaled phylogeny, i.e., against stratigraphy. Similarly to recent publications[8,9], this will be done via *strap* (https://cran.r-project.org/web/packages/strap/index.html).

Step 4. Plant-biosphere feedback. We will characterize the terrestrial trajectory of plant palaeophysiology as indicative of ecological insights of land habitats by documenting the diversity of hydraulic efficiency of early vegetation[10]. This will be done by testing key Devonian plant genera in function of their phylogenetic position obtained in step 3. Moreover, we will implement up-to-date multivariate and statistical methods to investigate the greening phytogeographical evolution and its potential palaeoenvironmental stressors. Diversity dynamics will be compared against global environmental conditions, which have likely directly or indirectly impacted plant evolution and biodiversity, such as sea-level estimates from sequence stratigraphy, estimates of tropical shallow-seawater temperatures and/or estimates of atmospheric O_2 and CO_2 concentrations.

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3. Bond and Grasby 2017. *Paleo3* 478:3-29. doi:10.1016/j.palaeo.2016.11.005
4. Cleal and Cascales-Miñana 2014. *Lethaia* 47:469-484. doi:10.1111/let.12070
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6. Xue et al. 2018. *Earth-Sci Rev* 180:92-125. doi:10.1016/j.earscirev.2018.03.004
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8. Cascales-Miñana and Gerrienne 2017. *Palaeontology* 60: 199-212. doi:10.1111/pala.12277
9. Gerrienne et al. 2018. *PLoS ONE* 13:e0198287. doi:10.1371/journal.pone.0198287
10. Cascales-Miñana et al. 2019. *IAWA*, in press. doi:10.1163/22941932-40190232

Compétences recherchées

- Paleobotany
- Plant biology
- Paleobiology