Age, origin, and dynamics of carbon in the central Congo peatlands: radiocarbon dating plant leaf waxes to build a novel 10,000 year record of change. (Ref IAP2-18-08)

University of Glasgow In partnership with University of St. Andrews

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Overview

The overall aim of the project is to develop a novel, high-resolution radiocarbon framework for understanding one of the largest tropical peatland systems on Earth.

To achieve this the project will involve fieldwork, laboratory based compound-specific radiocarbon analysis of plant leaf waxes and data interpretation. Through supervisors Gulliver and Lawson and advisor Dargie, the student will be highly involved in the major NERC funded 'CongoPeat' research program, led by Prof S Lewis (University of Leeds), collaborating with the research team, including field supervision in Cuvette Central region of the Congo, and a visit to Project Partner Prof. E Schefuss' laboratory (MARUM, Bremen).

Although peatland ecosystems cover only 3% of the Earth's surface, they store one-third of all soil carbon. Our understanding of the distribution of peatlands globally is still very limited, particularly in parts of the tropics. The exciting discovery of a substantial peatland complex in the Cuvette Centrale region of the Congo Basin – the largest in the tropics – was recently published in *Nature*[1]. This peatland complex covers an area about the size of England and Wales combined and is estimated to store over 30 billion tonnes of carbon. Our understanding of the carbon cycle in central Africa is therefore currently undergoing a significant revision.

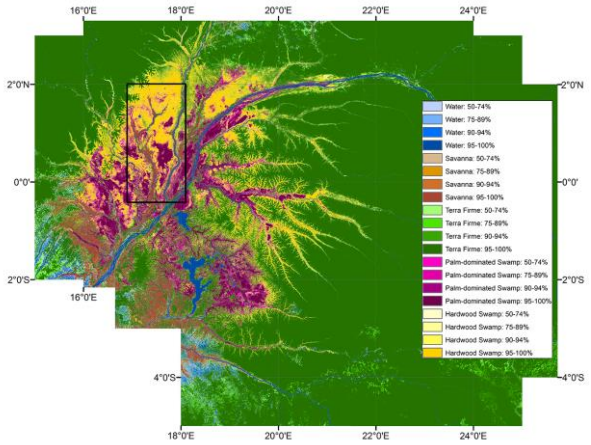

Figure 1: Modelled distribution of peat (yellow and purple) within the Congo Basin, from Dargie et al.[1].

Current knowledge of the Cuvette Centrale complex is based almost entirely on data from a pioneering PhD study carried out by *Dargie*[2] and summarised in *Dargie et al.*[2]. Radiocarbon analysis shows that peat accumulation started approx. 10,000 years ago and that accumulation rates are slow compared with many peatlands elsewhere in the tropics. It is unclear whether accumulation rates have remained steady or whether faster accumulation rates have been interspersed with losses during drier periods[1,3].

Hydrologic evidence suggests that the system is rain fed and so therefore vulnerable to dry periods and future climate change. These initial investigations have provided a foundation for further research addressing key questions including: How reliable is our present model of peat distribution in the Congo basin? How did Cuvette Central peatlands develop and how do they function today? And to what extent are they vulnerable to anthropogenic climate change or land-use change[4]. The students PhD will play a key role in addressing these issues.

One of the key gaps in our current understanding of this peatland system is lack of high-resolution dating of changes within the ecosystem, e.g. peat initiation, changes in accumulation rates. Published radiocarbon dates for the Cuvette Central are based on bulk peat samples. However, this material has numerous shortfalls and ideally dating should be carried out using discrete, short-lived, identifiable plant remains. Tropical conditions result in rapid decomposition of organic matter, resulting in very low recovery of these materials. This project will therefore apply an alternative, cutting-edge technique, known as compound-specific radiocarbon analysis (CRSA) to plant leaf waxes, (e.g. *n*-alkanes), to build chronologies from Congo peat cores in order to develop our understanding of the age, origin, and dynamics of Congo peatlands. Plant leaf waxes are very persistent in soils, and represent short 'snapshots' of time making them ideal for building this chronology. The student will use established methods for leaf wax extraction, and further isolation by Preparative Capillary Gas Chromatography (PCGC), to prepare samples for radiocarbon analysis. Quality control will be ensured by following protocols developed in-house, using materials and compounds with a known radiocarbon concentration to account for any extraneous carbon derived from sample preparation[6]. Success at this stage will allow the student to progress to the analysis of samples collected from the Cuvette Centrale.

Resulting chronologies will provide novel information about the timings of peat initiation and accumulation. In conjunction with bulk dates and palaeoecological data (including pollen data) generated by the wider research group, the leaf wax dates will yield valuable insights into the patterns and processes of peatland ecosystem development within the Cuvette Central.

The student will present results at CongoPeat meetings and other relevant national and international meetings.

Figure 2: Campsite in peat swamp forest, Republic of Congo.

Methodology

Some peat samples may be provided by the CongoPeat project, but the student will have the opportunity to participate in a field expedition, sampling peats using a closed-chamber ('Russian'-type) peat corer. Loss-on-ignition and other techniques may be used to characterise the stratigraphy of the samples.

Samples for dating will be prepared using an Accelerated Solvent Extractor to extract leaf waxes coupled with subsequent Preparative Capillary Gas Chromatography (PCGC) separation and cryogenic trapping of key leaf waxes.

The leaf wax extracts will then be converted to graphite in a process which involves vacuum technology, cryogenic separation, and scientific glass-blowing.

The final ^{14}C analysis will be carried out using Accelerator Mass Spectrometry (AMS).

Timeline

Year 1: Literature review. Laboratory training, method development and validation.

Year 2: Fieldwork. Sample processing (leaf wax extraction, radiocarbon analysis) Initiation of chronology building.

Year 3: Refine and finalise chronologies. Synthesise findings and prepare draft publications. Presentation to IAPETUS and at an international conference.

Year 3.5 – Submit thesis and manuscripts.

Training & Skills

Project Support: The facilities and instrumentation available within the supervisors and collaborative institutions will provide the student with all the necessary laboratory, field and analytical equipment to carry out this project, maximising the likelihood of a successful PhD completion.

Scholar Support: The student will join the PhD cohort at the Scottish Universities Environmental Research Centre (SUERC), which is host to the NERC Radiocarbon Facility (NRCF) where the student will be based. SUERC has a large, active research community that will provide peer-support throughout the Ph.D.

The student will join/associated the Biomarkers for Environmental and Climate Science (BECS) Research Group lead by Prof Toney and the NERC CongoPeat research group, attending annual research meetings.

All project supervisors and collaborators are highly research active; the student will frequently interact with all members of the research group providing opportunities to learn about various techniques and research areas related to their core experience.

Skills Developed: The student will receive training in world-class biomarker extractions and radiocarbon analysis, including compound-specific extraction and purification techniques, Gas Chromatography Mass Spectrometery (GC-MS), radiocarbon analysis and stable isotope ratio mass spectrometry. The student will have be trained at the University of St Andrews to gain skills in fieldwork, at the University of Glasgow to gain laboratory skills in compound specific extraction and purification and at the NERC Radiocarbon Laboratory to gain skills in in isotope (^{14}C & ^{13}C) analysis and radiocarbon calibration. In addition the student will be trained in essential research skills including scientific method, experimental design, data collection, and statistical analysis. IAPETUS, Glasgow & the University of St. Andrews each offer transferable skills programmes adding to the employability of the student after completion.

References & Further Reading

1. Dargie, GC, *et al.* (2017) Nature 542, 86-90
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Further Information

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