Research Interests – Nicolas Bourgon

A much-discussed and highly debated key topic in the study of human evolution revolves around determining the dietary adaptation of fossil hominins, which provides crucial insights into their behaviour and ecology. For example, the response of hominin adaptations to climatic and environmental changes can sometimes show as shifts in their diet, offering a bridge between changes in prehistoric environments and changes in prehistoric technologies (e.g. lithic tools). Major dietary transitions may also be associated with key evolutionary steps in the human lineage during the Paleolithic. For example, it has been hypothesized that the introduction of meat into the diet of fossil hominins acted as a catalyst for an increase in brain size in our lineage, potentially representing the driver behind a pivotal transition in our hominin's evolution. Dietary flexibility has also frequently been associated with the evolutionary success of some early members of our lineages. However, a lack of unequivocal tracers and the persistent difficulties of relating archaeological records to past human activities complicates the study of relationships between diet, hominid evolution and behavior. Fortunately, the introduction of stable isotope analyses allowed us to directly assess the overall dietary reliance of past hominids by analysing the isotope composition of surviving tissue, primarily bone collagen and tooth enamel. While nitrogen stable isotope ($\delta^{15}N$) analysis of bone or dentin collagen is an established method for trophic level assessment, the application of this method is limited by protein preservation. Trophic level assessment of fossils beyond the Late Pleistocene, or coming from adverse taphonomic settings such as tropical and subtropical environments, is nearly unfeasible using this conventional method.

Recent developments in mass spectrometry have allowed the measurement of different stable isotope ratios for elements such as calcium, magnesium, strontium and zinc. These cutting-edge methods open new research avenues and novel applications that hold great promises for archaeological and paleontological studies. In particular, these isotope systems can be analysed from bioapatite (i.e. the mineral part of bones, dentin and tooth enamel) to assess the diet and feeding ecology of living and fossil vertebrates. The low porosity, low organic matter content and large and compact crystallites of tooth enamel make it a biogenic hard tissue resistant to diagenetic alteration and can potentially preserve biogenic diet-related isotope composition over millions of years. The combination of trophic level proxy and high preservation potential make these novel applications extremely promising paleodietary tools. They may enable us to assess diet and trophic interactions in past food webs, initially limited by the degree of protein preservation necessary to conduct traditionally-used nitrogen isotope analyses of collagen from bone and dentin. Among these isotope systems, the isotopes of the trace element zinc constitute an especially promising dietary indicator.

My primary research focuses on further elucidating the relationship between zinc isotopes and diet. Notably, my work used $\delta^{66}Zn$ values to assess the diet of fossil food webs for the first time. Combined with in situ trace element analysis of fossil teeth by LA-ICP-MS (mass spectrometry), this study confirmed the preservation potential of pristine diet-related zinc isotopic composition in fossil specimens and the potential of this method for paleodietary studies. Another study explored sampling strategies and contamination-related issues while expanding on this isotope system's interpretative framework. More importantly, the latest project I led sought to assess the diet of tropical rainforest hunter-gatherers with a multi-isotope approach focused on zinc isotopes for the first time. More specifically, this study explored how stable zinc isotope analysis can be used to assess the type of resources consumed and how such data may inform us about human adaptative plasticity. Indeed, despite evidence of rainforest occupation by our species from at least 70,000 years ago, the poor preservation of organic matter in tropical latitudes and the rarity of occupation layers in Southeast Asia greatly hinder our understanding of humans' adaptation to these habitats and their resources. Using zinc isotope ratios, the study assessed the reliance on plant or animal resources of a Late Pleistocene fossil *Homo sapiens* individual, one of the earliest-known anatomically modern humans in tropical Southeast Asia. The results highlighted a diet comprised of both plant and animal matter, which contrasts with most trophic level assessments of contemporaneous hunter-gatherer humans from other regions whose diets comprise higher proportions of animal matter. It also adds to a growing body of evidence for early human foragers' occupation and adaptation to tropical rainforest environments. These studies have far-reaching implications for the interpretative framework of variability in $\delta^{66}Zn$ values and its use to study trophic interactions in (paleo)dietary investigations. We found systematic trophic level differences between carnivores and herbivores. Perhaps more importantly, we identified isotopically distinct $\delta^{66}Zn$ values for omnivores, highlighting the potential for zinc isotopes to discern specific dietary behaviours beyond mere assessments of trophic levels. This makes stable zinc isotope analysis a particularly appealing method in paleontological and archaeological research, as fossil hominins would likely exhibit such dietary behaviours. So far, no other geochemical proxy has been able to characterise omnivorous feeding habits parsimoniously.

In addition to the studies mentioned above, I also contributed to several projects, all of which employed geochemical methods. Some of these studies further highlighted the zinc isotopes' exceptional prospect by exploring the diet and trophic ecology of medieval populations, a Neanderthal individual from Gabasa and even Neogene Megalodon sharks. Other studies served to enhance our understanding of hominins' arrival, environments and adaptations in Southeast Asia.

Further research projects are already ongoing or planned, seeking to improve our understanding of variability in $\delta^{66}Zn$ values and characterising the factors controlling zinc isotope fractionation. Among others, the combined investigation of stable zinc and nitrogen isotopes is a promising avenue. Indeed, the extensive knowledge available relative to stable nitrogen isotope variability and fractionation makes it an ideal candidate to pair with stable zinc isotope analyses. Moreover, stable nitrogen isotope values are usually much more sensitive to animal-based resources in the diet because meat almost consistently contains more protein (i.e. nitrogen), which is often more easily bioavailable than plant-based protein. While it makes distinguishing an omnivorous diet difficult using this isotopic system alone, it could be the ideal tool for assessing the validity of stable zinc isotopes' omnivorous values. Some of this work has already been initiated, while the major part of it will, hopefully, be conducted as part of a future postdoc project.

Concurrently, magnesium stable isotope ($\delta^{26}Mg$) analyses are also being conducted on fossil specimens for the first time, validating this method as a trophic proxy in fossil food webs. Lastly, two other current projects seek to investigate variability in $\delta^{66}Zn$ values and $\delta^{26}Mg$ values of soft and hard tissues relative to the food consumed (e.g. meat-based or plant-based diets) in vertebrates that were fed in controlled feeding experiments. Such studies will enhance our understanding of physiological mechanisms (i.e. element cycling and fractionation in the body) that drive variability in the zinc and magnesium isotope system within vertebrates.