Analysis of archaeological charcoals from the Later Stone Age layers of Bushman Rock Shelter, Limpopo, South Africa: From the field to the laboratory work

1. Introduction

The PhD project focuses on the first charcoal analysis of the Later Stone Age (LSA) sequence of the Bushman Rock Shelter (BRS) site, Limpopo, South Africa (figure 1). The site preserves one of the rare archives of the Late Pleistocene-Holocene transition in the southern African region, a critical still poorly understood period, especially in the Limpopo area in the Summer Rainfall Zone (SRZ) (Wurz, 2019). Moreover, the LSA sequence shows a progressive transition from a microlithic industry related to the Robberg to a macrolithic one identified as the Oakhurst industry. The nature and the tempo of this change as well as the definition of the Oakhurst industry within the southern African Holocene Prehistory are still debated. Therefore, the LSA period in this area remains sparsely documented regarding human behaviours and human adaptations to the climatic change associated with this critical period (Mitchell, 2016). The abundant and well-preserved charcoal remains of the BRS site offer a unique opportunity to document the past vegetation and climate in the vicinity of the site as well as fuelwood management strategies by human groups occupying the shelter during the LSA. Charcoal remains, derived from the incomplete wood combustion, largely contribute to the deposit accumulation at the site and are considered to stem mostly if not exclusively from anthropogenic origin. Indeed, the use of fire was fully part of the daily life of past hunter-gatherer groups *e.g*. for cooking, heating, lithic raw material processing, plant-based medicine or personal ornament processing / making (Stockton, 1981). On the one hand, (1) the study of charcoals scattered in the well stratified and well dated LSA layers allow to reconstruct the past woody vegetation and past environment of the surroundings of the site. On the other hand, (2) particular attention is paid to the charcoal remains recovered from the LSA combustion structures and their organisation in relation to the other archaeological remains to understand / decipher the functions of the different hearths recognized at the site. Both study axes, combined with results of other botanical proxies from the ongoing multidisciplinary project of BRS, (3) will allow to question the nature of plant-human interactions, as well as its implications on resource exploitation and subsistence strategies during the LSA at the site. Finally, in order to carry out this PhD project, (4) new modern wood has been sampled and then charred to complement the reference charcoal collection currently available for the region.

2. Fieldwork

2.1. Archaeological charcoal material

During the last four annual campaigns of excavation, the fragments of wood charcoal have been carefully sorted by means of 3mm mesh dry sieving from the bulk sediment excavated by *"decapage"* (= planes), sub-square and stratigraphic unit (SU). A very good organic preservation and stratigraphic resolution characterized the different units, which makes them easy to trace horizontally over distances of often more than several meters (Porraz et al., 2015, Puech, 2019, figure 2). A total of 26 SU and 9 combustion features were selected along the LSA sequence for this PhD project.

2.2. Modern wood samples from the Limpopo area

This last year focused on the charcoal reference collection stored at the University of the Witwatersrand (Wits) and in particular, on those stored at the Evolutionary Studies Institute (ESI), my hosted institute in South Africa. Indeed, in this part of the world with a high woody taxa diversity with similar and overlapping wood anatomical features, the accuracy of the archaeological charcoal identification and, hence, the reliability of the reconstruction of past woody vegetation depend on the knowledge of the modern vegetation of the study area (Höhn and Newman, 2018). Modern charcoal reference collections exist for southern Africa but are often specific to relatively limited areas and are not systematically published and/or available for consultation. Since the first anatomical descriptions of South African woods by Kromhout (1977) from the University of Stellenbosch, anthracologists from Wits contributes to enhance the collection covering trees, shrubs and climbers from South Africa and Zimbabwe area.

Therefore, to carry out this project, an important survey of the surrounding vegetation of BRS site has been performed based on detailed descriptions of the Savanna and Grassland vegetation-types to identify important species that need to be implemented in the reference collection (Mucina and Rutherford, 2006). Fifty-six species of selected wood branches from different trees and shrubs have been sampled (figure 3). Then 9 other woods were sampled next to the Olieboomspoort archaeological site near to Lephalele in the Savanna biome. In addition, other modern woods from BRS surrounding (sampled previously by C. Sievers and M. Murungi for other botanical purposes) were added to the collection too. Voucher samples as leaves, seeds and or/ fruits and flowers of the each 81 specimens have been systematically collected to guarantee the accuracy of the identification helped by the botanical experts of the Moss Herbarium from Wits.

3. Laboratory work

3.1. Charcoal reference collection

All the modern wood samples were weighted and measured before and after combustion to compare the effect of carbonisation and shrinkage. They have been charred in a LENTON 0861 muffle furnace, available at the ESI, for 2 hours at 500 °C. In the same way as archaeological charcoal, the new 81 comparative reference materials (including 46 new species level taxa for the Wits collection) were viewed from the three dimensional planes, for identification based on standard techniques of optical microscopy using a reflected and polarised light at magnifications of 100x, 200x and 500x (figure 4, Leney and Casteel, 1975). Around 150 wood features were systematically recorded for each fragment according to the International Association of Wood Anatomists list (Wheeler *et al.*, 1989) and are digitally photographed using the Olympus Stream Essentials® image analysis software with extended focal image capability. Finally, around extra sixty wood specimens of the established ESI collection from previous collectors were charred again to replace the charcoals fragments missing in order to update the collection and make it available for consultation. Descriptions and micrographs from these charcoals were also performed in order to precise some anatomical features. Thus, wood and charcoal collection of both the ESI and the Department of Archaeology currently represents a total of 849 specimens, including about 600 different taxa, and 500 of which to the species level.

3.2. Data standardisation for identification key of southern African woods

All the anatomical features of new modern specimens are currently compiled in a uniform Excel database in order to use it as a computer-aided tool for fossil charcoal identification. In the manner of the identification key of the French Guiana charcoals, named CharKey, recently published (Bodin *et al.* 2018), an electronic identification key for Southern African charcoals is about to be designed using the free software Xper^{2}®, specifically conceived for taxonomic description and computer-aided identification (Ung *et al.* 2010). Alongside to the database, a photographic atlas of the charcoal collection is currently designed and aims to be incorporated in the Xper^{2}® as illustrations of the descriptor definitions as well.

3.3 Diversity and fragmentation of archaeological charcoals

Due to the abundant charcoal material retrieved along the BRS sequence, a sub-sampling strategy needed to be elaborated since an anthracological study is time consuming and all the charcoal fragments, even for one decapage from one SU from only one sub-square, cannot be totally analysed. A reproducible method for each of the SU analysed will allow to obtain a manageable sample size and to assess whether the richness of the sample adequately reflects the richness of the underlying population. Therefore, in addition to establishing the reference collection necessary for any anthracological study, this first year of thesis focused on the methodological framework to be adopted and adapted to the specificities of the anthracological material of BRS. Firstly, an exhaustive listing of previous anthracological studies from the southern African subcontinent was carried out. Similarly, a detailed classification of the different published methods for the charcoal studies according to their region of origin, their age of deposit and associated cultural period, their abundance, their preservation, etc., was also listed. Following this review of the literature, a first count and sorting by size class of the charcoals on 5 SU, *i.e.* about 20 *décapages* were carried out. This represents about 50,000 fragments that have been classified into 5 class sizes (<5 mm, 6-10 mm, 11-15 mm, 16-20 mm and >20 mm) according to their stratigraphic and sub-square unit in order to evaluate their differential chronological and spatial abundance. A "test" stratigraphic unit was then selected to assess the suitability of the method to be adopted for the entire sequence. Thus, the Blanca SU has been chosen since this layer represents a "synthetic" deposit, resulting from long-term deposition and mixing, difficult to link precisely to specific activities, but with a reliable significance concerning the environment. This protocol involves the hypothesis that no spatial variability occurred at the site for the same occupation level. Firstly, the charcoal bulk fragments were sorted, weighed and counted by size categories from different subsquares of Blanca. Then, cumulative curves have been plotted alongside their identification for each of the size categories. The representativeness of the sample is obtained when the curve reaches a saturation point where further sampling does not yield new taxa. The saturation point has not been reached even after more than 600 charcoal fragments as a result of the high diversity of the SU. Diversities and frequencies (presence/absence data) have been compared by size categories and with the total fragments. Size class, diversity, spatiality and inter-species fragmentation have been discussed to compare the effect of the method on the total assemblage per stratigraphic unit and subsquare. The results and methodological reflections

related to this test were presented at the 7th International Anthracology meeting in Liverpool and will soon be published as conference proceedings in the journal Quaternary International.

4. Next steps of the PhD research project

Based on photogrammetric surface pictures helped with Agisoft Metashape® of some combustion structures of interest from the LSA sequence of BRS, with the geoarchaeologist, Christopher Miller, new micromorphological stratigraphic blocks of identified hearths that are still preserved in the south profile will be sampled during the next excavation campaign. The microstratigraphic analysis performed by C. Miller at the University of Tübingen will aim at better interpreting the spatial and temporal uses of initial hearths and site in general (Mentzer, 2014). A last field sampling of modern woods will be realised in the surrounding of Heuningneskrans, the second site of the Ohrigstad valley excavated during the campaign. As previous modern woods they will be burnt, anatomically recorded, microphotographed and integrated to the reference collection of the ESI at Wits. The next and last mission at Wits will also allow me to finish the database compilation of the charcoal reference collections from Wits. Indeed, micropictures and recording of anatomical features will be complete before incorporating them in the Xper2® taxonomic software. Finally, the main objective of the next year will focus on the next part of the analysis of archaeological charcoals from the LSA of BRS with emphasis to the remains of combustion structures, as well as on the levels around the Pleistocene/Holocene boundary. The archaeological charcoals analysis is performed at the University of Nice Côte d'Azur where the remains are stored.

5. Communication and research outreach in South Africa

Besides, to the field and laboratory work, I also presented my research proposal as a talk to the ESI researchers at Wits. The last September, I was involved in the organisation committee of an international workshop "Around the fire" about the investigation of Prehistoric hearths in Southern African context. My both co-supervisors Prof. Marion Bamford and Dr. Isabelle Théry, as well as Dr. Chrissie Sievers, Dr. Guillaume Porraz and myself, coordinated the event that took the shape of a series of seminars and was hosted and supported by the IfAS Research (Institut français en Afrique du Sud, http://www.ifas.org.za/research/2019/around-the-fire/). The objective of the seminar was to lay the foundations for an interdisciplinary project with South African researchers investigating the role of fire as a factor in cultural transformation and diversification of technical and symbolic activities. Drawing on the very rich archaeological record from southern Africa, this future international collaboration aims to study fire and its uses as a potential marker of the cultural identities of MSA and LSA societies operating in contrasting environments between coastal and inland, and highly variable climates between Marine Isotope Stage (MIS) 6 and MIS 2.

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Figure captions:

Figure 1: Top: location of the BRS site with annual rainfall regimes and vegetation biomes (adapted from the South African vegetation map of Mucina and Rutherford 2006). Bottom left: view of the south-facing shelter. Bottom right: excavation area.

Figure2: Top: upper South profile of the Later Stone Age excavation (designed by M. Haaland & L. Feyfant). Bottom: combustion feature "Clark Lens Within" found in the Clark SU with an unusual bedding and ash deposit at the lens base.

Figure 3: Sampling of modern wood in the vicinity of the BRS site.

Figure 4: Top: Block wood diagram of hardwood with details of the different cell-types in the three sections (modified after Trouy, 2015). Bottom: Scanning Electron Microscopy (SEM) picture transversal sections of an archaeological charcoal fragment of *Boscia salicifolia.* The zoom on the right shows fungus hyphae in the vessels.