Title of Project: Resolving the impact of environmental change on Middle Stone Age humans in North Africa
Awardee: Dr Stacy Carolin, University of Oxford

Isotopic analysis of fossil rodent teeth, commonly collected alongside human artefacts at archaeological sites in NW Africa, is a novel method for resolving past local environmental conditions at these sites. The first objective of this 1-yr BILNAS-funded research project was to develop and refine the non-destructive approach of laser ablation for museum-archived small rodent teeth isotopic analysis. The second objective was to apply this technique to rodent teeth collected from the sediment levels of three archaeological sites in Northern Morocco dated to Middle Stone Age periods, and to infer past climate conditions from the measured rodent teeth isotopes with the overall goal of resolving the impact of environmental change on Middle Stone Age humans in North Africa.

The BILNAS project grant, supplemented by a previously-awarded Leverhulme Trust research grant and additional travel funds offered by collaborator Prof Scott Blumenthal, funded multiple trips for myself to travel to Prof Scott Blumenthal's Stable Isotope Lab at the University of Oregon in Eugene, Oregon, USA, along with daily instrument running consumables costs for sample analysis. The trips involved 15 instrument days using a New Wave Research CO2 10600 nm Laser, plus 20 instrument days (final trip) using a newly-installed Teledyne Fusions CO2 10600 nm Laser Stepped-Heating System. In the first half of the project, I was trained in laser ablation stable isotope analysis, and through collaborative work with Prof Scott Blumenthal and PhD student Jensen Wainwright, we optimised the laser ablation methodology for the smallest of rodent tooth samples. Notably, through various tests, we were able to reduced the background CO2 level during sample CO2 collection, which greatly improved isotopic analysis accuracy. The optimised methodology, along with the installation of the Teledyne Fusions CO2 laser, allowed for around 200 individual rodent teeth to be analysed in the second half of the project, with some teeth analysed in replicate to confirm reproducibility.

Both modern and fossil rodent teeth of three different rodent species (*Meriones*, *Gerbillus*, and *Mus*) were analysed. The project was successful in analysing carbon and oxygen isotopes in modern and fossil *Mus* incisors and *Gerbillus* molars, which are extremely small specimens (Fig. 1) and for which the traditional methodology of powdering enamel for dissolution in acid to produce CO2 is not feasible. Further, the project was successful in obtaining oxygen and carbon isotopes from the small rodent teeth with minimal destruction. The laser spots on the full tooth post-analysis are largely inconspicuous (Fig. 2), which is important for conservation of the teeth for any future studies.

Preliminary analysis of the modern enamel isotope data produced with laser ablations reveals intriguing results regarding the *Mus spretus* (Algerian mouse) diet (this study) at various sites in Morocco compared with *Meriones sp.* and *Gerbillus sp.* gerbil diets (Jeffrey et al., 2016). The results are useful in determining the relationship between site water availability and rodents' enamel oxygen isotopes of multiple species under modern conditions. Applying the information gained from the modern analyses, the new fossil enamel isotope data at the three archaeological cave sites have the potential to suggest local palaeo-humidity levels relative to today for each of the sediment levels analysed. These results are being prepared for publication in the *Journal for Libyan Studies* as well as in other multi-disciplinary journals.

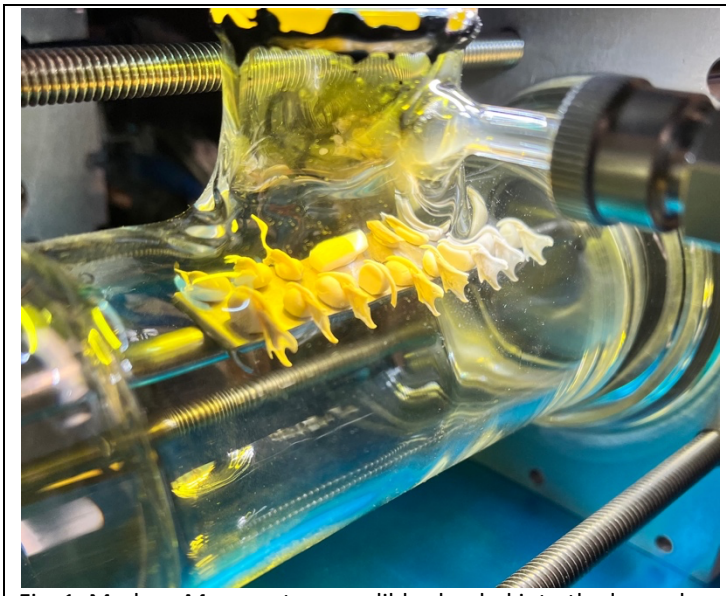

Fig. 1. Modern *Mus spretus* mandibles loaded into the laser chamber

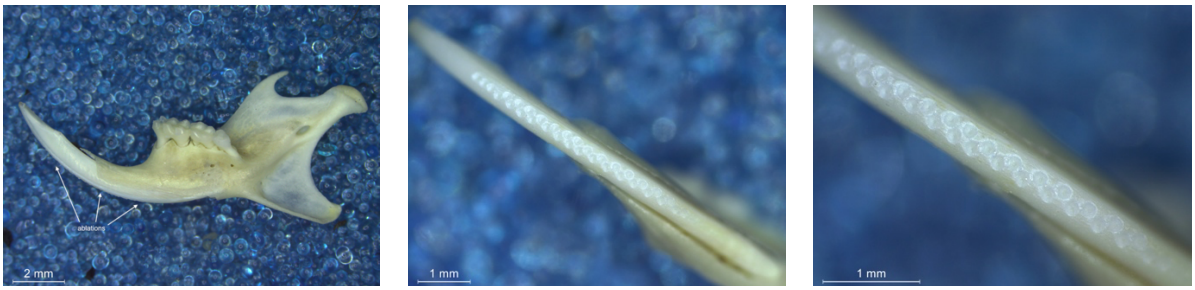


Fig. 2. Precise 150 µm diameter, 1.3 W power 10600 nm laser ablations on modern *Mus spretus* incisor enamel. CO2 produced from 32 consecutive laser shots was collected and analysed for a single carbon and oxygen isotope measurement.