Acadamh Ríoga na hÉireann
Royal Irish Academy

Department for Communities

Archaeology Research Grant Report

Name of Grantee:	Dr Gerard Barrett
Title of Project:	Northern Ireland's Round Towers (NIRT): Establishing a Chronology and Technological Understanding through Mortar
Amount and year awarded:	€5,255 in 2020

Summary of report:	The following is a progress report of Northern Ireland's Round Towers (NIRT): Establishing a Chronology and Technological Understanding through Mortar. The project schedule has been severely hampered by restrictions associated with the COVID-19 pandemic. Upon completion a full report will be submitted. This report describes work carried out to date, including sampling from most proposed sites, preliminary assessment of the material and pre-treatment sample preparation methods that have been conducted. Four of the initially proposed six sites (Armagh, Armoy, Devenish and Drumbo) have been sampled, inspected and prepared for further analysis. The remaining work to be carried out, including radiocarbon dating and characterization analysis, is envisaged to be completed within another couple of months. Some preliminary observations and findings from microscope analysis are also presented and provide examples of the scope of potential findings from the complete project.
Please outline the objectives of the Project:	1. Scientific Dating and Establishing a Chronology for Irish Monastic Round Towers Round towers are some of the most iconic and exceptional architectural structures in Ireland. These late to mid-medieval freestanding stone and mortar built towers were constructed during a period of significant social and cultural change. Within the medieval heritage and built environment of Europe they are unique and have no obvious counterparts. Yet their purpose (bell towers, defensive structures, ritual) is not certain and their chronology (10th -13th century AD) is unsecure; direct dating has only been carried out in a very limited manner and, while there are some historical records that refer to events associated with the towers, chronological understanding generally relies on interpretations of architectural evidence and stylistic comparisons. A better understanding of the chronology of these structures can be provided through both the application of direct dating methods, such as radiocarbon dating, and use of mathematical methods, such as Bayesian statistics. From this, an improved dating scheme would permit a more accurate setting for the contemporary environments in which these monuments were built to be made. This would help us better comprehend why they were built, what purpose they served and, equally, how they impacted on the peoples and the surroundings they were set in. 2. Characterization and Technological Understanding of Mortars used in Medieval Ecclesiastical Structures Characterization of the mortars that bind these structures has also received scant attention, yet has the potential to reveal a wealth of information. At a broad level, characterization of the fabric of the mortar will help us gain insight into technology, provenance and resource usage. Each of these, in turn opens up fresh avenues of understanding. A better understanding of the technology will inform all of the following fields: the development of mortared buildings; the development of architectural and construction technologies; the diffusion of ideas and regional connectivity; it also is of significant value in relation to the conservation and restoration of buildings constructed using mortar.

Archaeology Research Grant Report

	Characterization will permit us to understand where the materials used came from. This can help us better comprehend and address questions related to the economics and power dynamics of the time, as well as social connectivity and other landscape archaeology questions. In the present day, it has value in relation to sourcing materials for conservation and restoration work. Finally, we can also use characterization data to better understand the resource usage required to construct these impressive structures. More specifically, the composition of the mortar can reveal useful information on the fuel types, energy usage and landscape exploitation required for their production. Again this will have important implications for our understanding of the economics, power and social dynamics of the period.

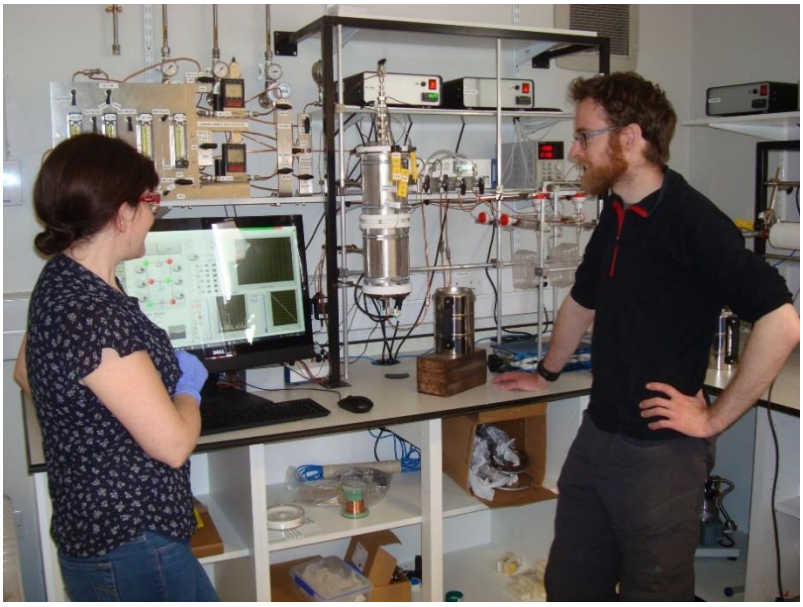
Devenish Round Tower

Please describe the methodology used in conducting the research:	In conjunction with the Historic Environment Division (Department for Communities), Northern Ireland, the following methods are applied to four round towers in Northern Ireland (Antrim, Armoy, Devenish, Drumbo). [Note, Ram's Island and Drumbo has been removed from the originally proposed test group on account of COVID-19 related delays and restrictions; they may be revisited at a later stage].

Archaeology Research Grant Report

Sampling:
Assisted by members of the Historic Environment Division, multiple samples of mortar were extracted from different locations on the structures following Daugbjerg et al. (2021). Approx. 50 - 100g per sample was removed from relatively sheltered surfaces with respect to rainfall and water percolation and as close to the surface as possible but beneath the surface layer (> 5mm and < 5-10cm). Only hand tools were used.

Dating:
Four mortar dating approaches are to be applied: organic inclusions; lime lumps, two binder-based approaches (a hybrid approach of fractional dissolution with Cryo2sonic and a ramped pyroxidation approach). The methods are fully described in Barrett et al. (2020; 2021). The project will make use of Bayesian to better constrain the age ranges. Where present, charcoal samples will be extracted and analyzed to complement the dating results and to provide information on fabrication processes.
At writing, sample material for dating has been pretreated and prepared for analysis with only the final steps, hydrolysis or ramped pyroxidation and AMS analysis, left to be conducted.



Characterisation:
Characterisation will be conducted using a suite of techniques (described in Barrett et al. 2020). Petrography will provide a description of the mortar composition. X-ray diffraction (XRD) will provide a refined picture of the mineral composition of the aggregate or binder of the mortar and complements the petrographic work in helping to understand provenance, and fabrication methods. Fourier Transform Infrared (FTIR) spectroscopy will provide information on mineral composition but in the current work will principally be used to identify if organic components are present in the mortar and to establish how successful pre-treatment methods are at isolating anthropogenic calcite. Thermogravimetric analysis (TGA) will be used to characterize aspects of the lime binder, including the identify of clays or hydraulic components.
To date, samples material has been prepared for XRD, FTIR, and TGA. Thin sections are under preparation for petrography. It is expected that the remaining dating and characterization analysis will be carried out April/May dependent on restrictions and access.

Archaeology Research Grant Report

	Barrett, G. T., Donnelly, C., and Reimer, P. J. 2020. Radiocarbon dating mortar: the identification of a medieval Irish round tower using a multi-method inter-comparative approach. Journal of Archaeological Science: Reports. 33 102538 [Accepted] Daugbjerg, T. S., Lindroos, A., Heinemeier, J., Ringbom, Å., Barrett, G., Michalska, D., Hajdas, I., Raja, R. and Olsen, J. 2021a. A field guide to mortar sampling for radiocarbon dating. Archaeometry. [Early View] doi.org/10.1111/arcm.12648
Please outline the findings of your research and/or milestones achieved:	The following outlines some of major progress stages achieved thus far as well as pending stages of analysis: • Sampling has been carried out at the sites of Antrim, Devenish, Drumbo and Armoy round towers • A total of 31 samples were taken across all sites • Typically 6-8 samples per site, usually from at least 3 different locations • Samples have been photographed and examined under microscope • Samples have undergone pretreatment procedures and are ready for dating and characterization analysis. The following are some example preliminary observations and findings that have been made regarding the material: • The composition and visible characteristics of the mortars differ significantly from site to site, for example Devenish mortar appears very well produced; it has high levels of carbonate binder and low levels of well-sorted and well-mixed aggregate. On the other hand, Drumbo mortar has high levels of aggregate material, appears rich in organic matter such as charcoal. Therefore, the technology of mortar production appears varied and regional, accepting of course that upon dating the buildings may not be contemporary with one another. • Local bedrock sources were generally used for aggregate production, e.g. limestone for Devenish and sand (sandstone) and shale for Drumbo. However, the mortar used at Antrim has well rounded, well-sorted sand as aggregate which would have required a sourcing of raw materials from coastal sites at least 20km away. This may have been less energy consuming than producing aggregate the from the hard local igneous rock sources used as the main building stone of the tower itself (which has had no stone cutting carried out). • The limestone used in lime binder production will have had to have been sourced at significant distances away, of the order of 30-40km for Antrim, Drumbo and Armoy (although for Armoy there is a small region of bedrock limestone 10km away at the coast which may have been used). This may have impacted on the nature of production of the mortar and, in particular the ratio of binder to aggregate used. Both Armoy and Drumbo have very high levels of aggregate and charcoal content relative to Devenish (constructed in a limestone region). Armoy may also feature the addition of soil or clay to the mortar (this needs further clarification). For both these sites, this may point towards minimizing the economic costs associated with obtaining limestone from sources far away. For Antrim, the aggregate content is not as high and, in combination with their sourcing of sand from the coast may indicate a better resourced (economically, labour) monastic center. The use of high aggregate content also appears to manifest in a poorer quality mortar at Drumbo and Armoy. When sampled the material was generally very poorly bound and friable unlike the material from Antrim and to some extent Devenish. The quality of the mortar originally used may,

Archaeology Research Grant Report

	speculatively, have a role to play in why some towers that appear poorly coarsed are still completely standing whereas other towers have not endured so well.
Please provide details of the dissemination of the outcomes from this project:	The findings of this work, upon completion, will be disseminated in several ways as in the original proposal: **Publication:** At least two publications will be prepared for peer-reviewed journals. On the scientific analysis and mortar dating methodology and results: Barrett, G. T., Keaveney, E., Lindroos, A., Donnelly, C., Daugbjerg, T. S., Ringbom, A., Olsen, J. and Reimer, P.J. 2021. Ramped pyroxidation: a new approach for radiocarbon dating of lime mortars. Journal of Archaeological Science. (available freely via Elsevier until 13 May: https://authors.elsevier.com/a/1cn-f15SlTrLEi) The other will focus more on the interpretation and significance of these results for our understanding of Irish Round Towers and monastic medieval Ireland more broadly; this will be submitted to Proceedings of the Royal Irish Academy: Archaeology, Culture, History, Literature. A publication will also be prepared for more popular reading in Archaeology Ireland. **Reports:** A technical report will be prepared for the Historic Environment Division and the RIA with the latter report meeting the RIA requirements (subject to their template). Conference: The results of the proposed project will be presented at both domestic and international conferences, domestically at the biannual RIA conference and internationally at the International Symposium for Archaeometry 2022 (venue not yet decided). **Social Media:** Queen's University Belfast press office will be involved in disseminating any notable findings (of more immediate public interest) through public and social media outlets. Additionally, the Historic Environment Division and the RIA may also be involved in press releases associated with the research output of the project.
How did the award enhance your professional development?	It has enhanced my professional development, particularly in relation to working and collaboration with public bodies such as the Historic Environment Division. It has also provided significant aid in development of skills surrounding the scientific analysis and treatment of mortar samples.
What plans (if any) do you have to further this project?	Provided the dating results on the four towers sampled show significant levels of success, a large scale dating project targeting Early Medieval buildings across Ireland (including both early Christian churches and round towers) will be developed with funding potentially sought from sources such as a Leverhulme Grant. This would require collaborating with and obtaining the advice of a large team of experts including, for example Dr. Tomás Ó Carragáin (early medieval Christian buildings) as well as both mortar dating and characterization experts (e.g. Dr. Alf Lindroos, Åbo Akademi University, Finland, Dr. Jesper Olsen, Aarhus University, Denmark) from the international mortar dating collaborative group that I am a member of.