Chapter 2

New approaches to the bioarchaeology of complex multiple interments

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2.1. Introduction

This chapter presents the approaches and methods used for the recent scientific study of the human remains assemblage from the Circle underground burial complex. This study formed part of the ERC-funded *FRAGSUS Project* ('Fragility and Sustainability in restricted island environments'). We describe here the aims of the *FRAGSUS Project* and the questions addressed specifically by the Population History Workgroup, in order to contribute to the Project's wider research agenda. This chapter first outlines the complex multiple interments from the prehistoric burial caves of the Circle, and the challenges posed by the modes of deposition at the site and the density of human remains within the deposits, for subsequent post-excavation bioarchaeological analyses. We then detail the approaches and methods employed in the study of the human remains assemblage between 2013–2020, which will be expanded on in the following chapters within this volume.

2.2. The research questions of the *FRAGSUS* Population History Workgroup

The Population History Workgroup represents one of the key study areas in the *FRAGSUS Project.* The other four areas of focus were Environmental Reconstruction (Volume 1), Chronology, Archaeology (Volume 2), and Landscape History (Volume 1). As described elsewhere (Volume 1, Introduction; Volume 2, Chapter 1; This volume, Chapter 1), scientific techniques applied in an interdisciplinary manner aim to explore and present a detailed understanding of the prehistoric environment on the Maltese Islands, addressing how environmental changes impacted on the islands' early inhabitants. Through interdisciplinary work, archaeologists and scientists have together sought to identify any noticeable influences on the prehistoric population caused by settlement, land-use and a variety of other factors.

More specifically, the Population History Workgroup aimed to explore five questions that built on the preliminary results presented in the first publication of the Circle's human remains (Stoddart *et al.* 2009a):

(1) Are there particular pathological conditions in the Circle human remains assemblage which could shed more light on the health and lifestyle of the prehistoric population?

(2) Do the human remains reveal signs that this population experienced episodes of stress, perhaps caused by a change in the climate or available subsistence resources?

(3) Is there bioarchaeological evidence for particular occupational, cultural or technological practices which identify specific lifestyles or social groups within the population?

(4) Will further stable isotopic analysis of the human remains coming from numerous contexts support initial results by Richards *et al.* (2001) and Lai *et al.* (2009) that the diet of the Circle burial population consisted mainly of terrestrial food sources?

(5) Is there morphological or biochemical evidence for the burial population's ancestral origins? Specifically, was the population genetically diverse during the late Neolithic?

2.2.1. The complex multiple interments at the Circle

Through an assessment of the range of Maltese funerary sites with assemblages of human remains, it becomes clear that the prehistoric period is poorly represented when compared with the later Punic-Roman period (Chapters 1, 14 & 15). The Ħal Saflieni Hypogeum

Figure 2.1. *The site under excavation (Photo Cambridge Gozo Project).*

(Paola, Malta) is among the most notable of the Maltese Neolithic funerary sites, but was excavated in the first quarter of the 20th century, when very few human remains were retained or preserved (Evans 1971, 44–5). Zammit (1928) the final excavator, dismissed human remains as uninformative at a time when bioanthropology was in its infancy. Other Neolithic funerary sites include the still largely unexplored Santa Luċija Hypogeum (Magro-Conti 1997; Museum Annual Report 1973) and the human remains from the more recently excavated rock-cut chamber tombs from Kerċem in Gozo (excavated 2009 and 2010, see *Times of Malta* 2009), and currently under study (B. Mercieca-Spiteri, pers. comm). Between 1987 and 1994, the prehistoric human remains assemblage at the Circle in Gozo was discovered, partially excavated (Fig. 2.1), studied for the purpose of the first excavation report (Stoddart *et al.* 2009a; this volume, Chapter 1), and retained at the National Museum of Archaeology (Valletta) for future scientific research (Stoddart *et al.* 2009a, 315–340).

Only in the past few years has there been growing incentive among local osteologists and archaeologists to study human remains spanning the histories of Malta and Gozo. This is partly a result of the growing number of funerary features, mainly from the Roman Classical period, which have been unearthed from the intense construction development across the islands. It is also a result of trained personnel in place to assemble and study Malta's osteoarchaeological material. It is reassuring that ongoing research will contribute to comparative cross-period population studies and future discoveries in the coming years.[1]

The assemblage of Neolithic human remains from the Circle is probably the largest assemblage of prehistoric human remains in the southern Mediterranean, and its size makes comparative approaches possible even within its own data. The 2009 publication estimated that around 220,000 human bone fragments were unearthed by the end of the final excavation season in 1994 (Stoddart *et al.* 2009a, 315), and (depending on various MNI formulae) that a provisional estimate of 1001 corpses (when age is considered (Stoddart *et al.* 2009a, 321)) were deposited in the underground caves during the Tarxien period. This collection of human remains merits not only comparison across its own stratigraphic sequence (as already achieved in outline in the 2009 publication), but also eventual comparison with other Maltese assemblages from the period, which are now under study. Most notably, the Kerċem remains discovered in 2008 will offer valuable comparative material to the Circle assemblage, as one of the only other excavated prehistoric funerary sites on Gozo. In particular, they will enable an assessment about the degree to which prehistoric individuals were formally buried in rock-cut tombs and hypogea (an issue also explored in Chapter 12), and how ritual action was distributed across the landscape.

As already described (Stoddart *et al.* 2009a; Thompson *et al.* 2020), the Circle assemblage contains a good, *natural* representation of the Neolithic population demographic, since individuals of all ages, from foetuses to older adults (Chapter 8) have been identified in the assemblage. Additionally, where biological sex can be determined, there is an almost equal representation of male and female individuals. The assemblage indicated that the individuals deposited at the Circle experienced a range of pathological conditions as well as other occupational and anthropological skeletal markers. These were noted in the 2009 publication and will be further detailed below (Chapters 4, 5, 6, 8). As our knowledge has accumulated, our views have fluctuated about the broader, representative character of the buried population (Stoddart & Malone 2015). The data currently suggest that the Circle was not merely a depositional space for selected individuals forming an in-group, but rather was used for the members of a whole, small, Neolithic community in Xagħra (Gozo). The current hypothesis is that the scenography of the Circle was a substantially self-contained locale belonging to one of a series of very small communities engaged in the funerary rites of the long-lived Maltese Neolithic, and a locale which arguably practised democratic theatre rather than executed the materialized memory of an elite democracy. Each small community on Gozo probably had a similar funerary locale, varying in the degree of investment in monumental scenery (Chapters 11 & 12). Nevertheless, as already discussed (Stoddart & Malone 2015), there is a reasonable assumption that not all the dead of the prehistoric community have yet been discovered, either at the Circle or in the wider surrounding islandscape. Recent discoveries at Triq il-Qacca about 50 m from the main Circle deposits show how the data set is likely to expand as the built environment extends into the Gozitan landscape (Arena 2020), so that our current interpretations are likely to be modified by further research.

As detailed below (Chapter 3) the extensive dating programme has established that the earliest funerary activity at the Circle started *c.* 3700 BC (the end of Żebbuġ phase/commencement of the Ġgantija phase (Volume 2, Chapter 2) during the infancy of the megalithic temple building around the islands. The dates have been revised through additional estimates and new calibration methods, and the late 5th millennium start-date originally proposed is now revised (Malone *et al.* 2009e). The first funerary activity comprised deposition inside a rock-cut tomb and similar structures, now incorporated within the cave system (South Niche). The rock-cut tomb consisted of a vertical cylinder cut in the rock (a shaft) that opened into two separate burial chambers (Malone *et al.* 1995; Malone *et al.* 2009f). These burial chambers continued in use and were probably periodically cleared of remains over the centuries. From the current chronological assessment, the formerly Żebbuġ burial activity (mid-4th millennium BC) is now considered mainly of the Ġgantija phase in the second half of the *c.* 4th millennium BC. Later, during the Tarxien Phase from *c.* 2800 cal. BC until *c.* 2400 cal. BC, the focus of burial shifted to the large underground complex (the modified natural cave system with its insertion of architectural elements) and in this larger space intense communal deposition and funerary practices were carried out.

The primary depositional practice typically consisted of laying out the corpse on its right side and in a flexed position (Stoddart & Malone 2010). This practice was revealed during excavation through the rare preservation of articulated and undisturbed skeletons (Figs. 2.1, 2.2, 2.3). Archaeologists also recorded partially articulated skeletons (Fig. 2.2), including complete limbs or complete torsos but with other skeletal elements missing (Stoddart *et al.* 2009a, 329–30; Chapter 12). This pattern suggested that funerary practices during the Tarxien Phase also included secondary treatment to the decomposing corpse or skeletonized remains, involving the movement of body parts to other areas at the Circle (described in greater detail in the 2009 publication, and Chapter 12). Other areas of the cave complex included heaps of disarticulated elements which implied that bones were also often moved when skeletonized or in the final stages of decomposition (Stoddart *et al.* 2009a, 319–25).

The movement and rearrangement of remains is also evident in the earlier rock-cut tomb where disarticulated bones were recorded as stacked around the sides of the burial chambers (Fig. 2.3). This may have resulted from a process of clearing space within the chambers for other corpses; a form of ossuary management. It is abundantly clear that the practice became more complex and incorporated more stages over time (discussed further in Chapter 12). Additionally, such extended post-depositional practices were not just motivated by the practicalities of making room for more interments, but were also socially embedded ritual events which would have been central to the processes of grieving and managing the transformation of the dead (Stoddart *et al.* 1999; Malone *et al.* 2018; Chapter 12).

Figure 2.2. *Skeletons* in situ *showing partial articulation (Photo Cambridge Gozo Project).*

Figure 2.3. *Disarticulated bone* in situ *(Photo Cambridge Gozo Project).*

2.3. Methods employed by the *FRAGSUS* Population History Workgroup

Unless one was involved in the original excavation itself, one cannot grasp fully the quantities of bone and teeth in a large assemblage until the moment one starts opening up the boxes of bones and unpacking the remains on the laboratory table. The Circle assemblage was no exception. The human remains excavated from the Circle by the Cambridge Gozo Project team had last been examined during the excavation and post-excavation sessions in the 1980s–90s. Following excavation, all remains were packed in plastic or paper bags and placed in medium sized and then larger boxes for storage at the National Museum of Archaeology in Valletta, Malta. The ToTL (Time of their Lives) Project, another ERC-funded project, immediately preceded the *FRAGSUS* research and made a brief examination of the store to obtain radiocarbon dating samples. This was a highly targeted search for articulated remains by Dani Hoffmann, Frances Healey and Simon Stoddart in 2013, designed to provide the chronological framework for a Bayesian analysis of the Circle (Malone *et al.* 2019; Whittle 2018)

The initial publication of this assemblage as part of the excavation report (Stoddart *et al.* 2009a) prepared the *FRAGSUS* Population History group for the huge undertaking of the tasks at hand. Nonetheless, since none of the group members had worked on the original excavation, it was only during the first days of research that they realized the marvellous preservation and extent of the assemblage. Since most of the assemblage was commingled and rarely in anatomical association, it was only when the bags of bones and teeth were laid out for examination that the full realization of the large quantities of individuals deposited at the site became clear. Because the excavated contexts mainly consisted of disarticulated remains, most bags contained fragmented elements from individuals of all ages. The contents of the bags were identified by labels noting their archaeological context, grid reference, and in some instances the individual bone number assigned during excavation (Fig. 2.4). The more complete skeletons were stored in individual boxes; these articulated remains had been collected separately by the excavators, so further identification and analysis alongside a detailed excavation record was available (Malone *et al.* 2009b).

The initial stage of study involved the development of numerous methods which would address the research aims outlined above, whilst acknowledging the highly fragmented nature and large number of bones to study within the available timeframe (Fig. 2.4).

Figure 2.4. *Commingled bones with original label (Photo Ronika K. Power).*

The approaches took into account the experience of the researchers in careful discussion with the custodians of the assemblage (Heritage Malta/National Museum of Archaeology and the Superintendence of Cultural Heritage). Given the complexity of the assemblage and its archaeological record, it was essential that a transparent and meticulously organized system was devised to hand on to future managers and researchers. Time constraints for the personnel were fundamental since one specialist researcher (Power) had specific years of allocated ERC funding, before taking up a teaching position and another was not full time on the project (Mercieca-Spiteri). The senior specialist (Stock) had an oversight role whilst other assistants were recruited through the duration of the project, including two PhD Students (Parkinson and Thompson) and an intern placement (Marabelli). Within these parameters, the team developed a highly ambitious programme that aimed to assess the full assemblage in a series of five intensive museum study campaigns between 2014 and 2017, each approximately eight weeks long, that would isolate samples for further analysis. This work, mainly covering phases 1 and 2 (see below) was carried out by Power and Mercieca-Spiteri. They were assisted by volunteers and other specialists as required. During the project, further archaeometric analyses were carried out in various institutions in the United Kingdom and Republic of Ireland, whilst data processing continued throughout the project in Malta, the UK, Australia and Ireland.

These campaigns identified remains for detailed study, namely elements exhibiting indicators of stress, extreme pathology, behaviourally related changes of skeletal or dental morphology, remains that could inform about diet, environment and possible geographical provenance as detailed further (Chapters 4, 5, 6, 8, 9, 10, 11). Table 2.1 presents the various studies implemented on the isolated skeletal elements, as well as their outcomes.

2.4. The first phase: isolation and archiving

The lengthiest process of analysis was the first phase. First, the boxes had to be inventoried and stored systematically to enable rapid retrieval from the museum storage, and shelf references provided precise inventoried storage locations. Each box was numbered and linked to the inventory. The contexts contained within all boxes and their location in the NMA storage facilities were digitally inventoried to enable their easier location in current and future research. Only one box was opened at a time to prevent the misallocation of material, and each bag was studied individually. When opened, the remains were spread out on a clean surface for examination, retaining its original labels of stratigraphic provenance (Fig. 2.5). Although extensively cleaned following excavation, many of the bones were observed to be covered in chalky dust resulting from the adhering soil matrices. Some human remains were more substantially embedded within concreted soil matrix and required additional cleaning with a dry toothbrush. This was especially the case where identification of pathological lesions, such as eburnation, had been noted.

As shown in Table 2.1 above, the identified remains which were isolated for further study included:

(1) teeth both loose (exfoliated post-deposition) and still in occlusion in mandibles or maxillae; maxillae without dentition but presenting pathology; and all mandibles (intact or fragmentary) without *in situ* dentition (Fig. 2.6);

Table 2.1. *Studies carried out on the Circle assemblage.*

Skeletal elements	Studies implemented			
	Extreme pathology	**Skeletal morphology**	**Modification *in vivo***	**^{14}C, isotopes, aDNA**
Isolated teeth	✓	✓	✓	✓
Mandibles with or without teeth	✓	✓	✓	✓
Maxillae with teeth and/or pathology	✓	✓	✓	✓
Cranial elements	✓	✓	✓	✓
Non-cranial elements	✓	✓	✓	
Outcomes	Identification of individual or population stress, health, diet and congenital variation throughout Circle use-life	Estimation of ancestral affinities, provenances and population diversity	Evidence of behavioural, cultural and technological practices	Chronology, palaeodiet, lifetime mobility, and ancestry

Figure 2.5. *Population History Workgroup examining bone and cleaning (Photo Bernardette Mercieca-Spiteri).*

Figure 2.6. *Population History Workgroup isolating teeth (Photo Ronika K. Power).*

(2) bones identified to be of special interest because of extreme pathology, evidence of behavioural or cultural change and congenital variation.

During the process of isolation, the researchers also extracted some remaining faunal fragments and cultural material including pottery, which were isolated and passed to other specialists.

Once isolated, the special interest bones and teeth were placed in laboratory quality self-seal bags and labelled clearly with the provenance recorded on their original excavation label. The details of the isolated remains were entered into a digital database (the inventory) and the special interest bones and teeth were photographed with a scale. During this stage of isolation researchers also re-bagged and re-labelled, where necessary, those bags which had begun to disintegrate after 20 years in storage.

Once the digital archive was created for the isolated bone or tooth, the element in its labelled bag was placed in a designated depository. This archive of isolated remains was categorized and curated according to either dentition, pathology or other type of interest. In addition, the archive was organized according to archaeological context, forming an easily accessible library. The inventory system tracked both the quantities of isolated samples, as well as the isolation categories (Table 2.2). In total this project isolated over 11,500 teeth, 1,500 mandibular fragments and 600 maxillary fragments. In addition, over 2,800 other bones of special interest were isolated, alongside more than 700 faunal bones and other cultural material such as pottery.

2.5. The second phase: analyses of the isolated elements

Following the isolation process (phase 1), the analyses of the isolated elements (phase 2) commenced. A series of specifically designed databases were used for each of the analyses carried out. As described by Power *et al.* (Chapters 4, 5 & 6), an analytical workflow was developed that facilitated sequential data collection for dental pathology, modification and anthropology. Teeth of all types and articulation states (in occlusion or exfoliated *postmortem*) were examined individually within their context batches. The quantity and strength of expression for each analytical modality was recorded for each batch in a Microsoft Excel spreadsheet. Once analysis was complete, each batch was marked and curated in the *FRAGSUS Project* archive. For further details pertaining to the methodologies of individual analytical modalities, please see the relevant chapters of this volume, as indicated above.

Table 2.2. *Isolated bone elements.*

Types of isolated elements	Number of isolated elements
Teeth (loose and *in situ* in the mandible/maxillae)	11,706
Mandibular fragments	1,554
Maxillary fragments	628
Special interest bone fragments	2,819
Faunal bones and other cultural material	700
Total isolated elements	17,407

Studies of the other elements of special interest took place alongside the dental and taphonomic research workflow. Within project parameters, a sub-sample of elements were identified for inclusion in the current volume owing to their novelty or significance, or potential to serve as examples for broader biological or cultural patterns observed within the burial population. Detailed pathological descriptions were carried out in collaboration between Power, Mercieca-Spiteri and Thompson in alignment with disciplinary scientific reporting protocols. These processes are further specified in Chapter 8.

During this phase of study, a group of elements were selected for radiological analysis at the Cambridge Biotomography Centre, University of Cambridge, following approval for transport and non-destructive examination by Heritage Malta and the Superintendence of Cultural Heritage in July 2015 and July 2017. With the aid of Laura T. Buck, Jaap Saers and Jay Stock from the Department of Archaeology, the CT-scans recorded data which confirmed previous observations and analysis (Figs 2.7, 2.8) and revealed new information (Chapters 4, 5 and 8).

A series of teeth from the isolation archive were selected for radiocarbon dating and isotopic analyses. The approach to this study required consultations with and formal applications to Heritage Malta and the Superintendence of Cultural Heritage in order to adhere to stringent requirements for best practice in ethical approaches to destructive analyses of archaeological human remains. In alignment with ethical strategies to ensure limited destruction of samples wherever possible, one tooth (for example, the right permanent mandibular second molar) was subject to multiple destructive analyses to reduce the likelihood of duplication of single individuals amongst the analytical sample, minimize possibilities of so-called palaeodietary isotopic 'weaning signatures' in early-erupting permanent teeth, and minimize the overall invasive impact on the burial population (Fig. 2.9). Since the chronology of the assemblage extended over

Figure 2.7. *Population History Workgroup CT scanning (Photo Bernardette Mercieca-Spiteri).*

Figure 2.8. *Population History Workgroup CT scanning (Photo Bernardette Mercieca-Spiteri).*

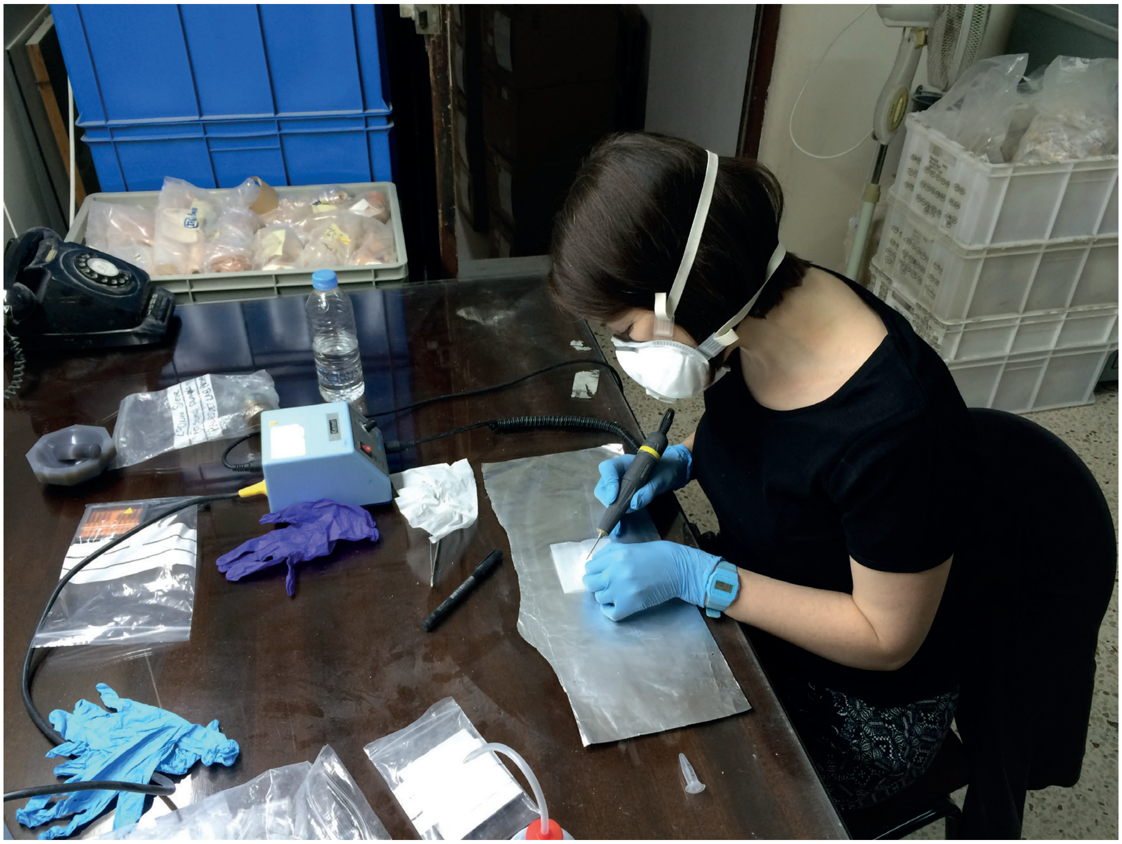

Figure 2.9. *Population History Workgroup sampling (Photo Bernardette Mercieca-Spiteri).*

centuries, it was important that samples from across the entire use-life of the site were selected for analysis, so that the isotopic mapping (of both diet and geographical provenance) was representative. The original excavators (Malone and Stoddart) and the coordinating scientific manager of the project (McLaughlin) identified the key contexts to ensure that the spatial and stratigraphic questions were properly addressed. As mentioned above, since the assemblage mainly comprised disarticulated and commingled remains, the ethical approach for the selection criteria focused on identifying suitable tooth samples for both radiocarbon dating and isotopic analyses. For some contexts or individuals, selecting a single tooth was not always possible, and therefore other teeth were chosen. Only a few contexts proved impossible to sample because they contained no suitable teeth. The condition of the teeth was also assessed during the selection process, and if the tooth appeared damaged through chemical abrasion from environmental factors during burial and taphonomic processes, it was considered unsuitable.

The sampling strategy for all *FRAGSUS Project* analytical protocols involving human remains from the Circle was co-ordinated and executed by Power and Mercieca-Spiteri with the formal permission of Heritage Malta and the Superintendence of Cultural Heritage. Once sample selection for the chronometric and isotopic testing was complete, the teeth were analysed for pathology, modification and population affinities using the methodologies described in Power *et al.* (Chapters 4, 5, & 6), and finally photographed. Any visible adhering calculus was removed from teeth to be subjected to destructive sampling and curated for future testing. Once these processes were complete, the dating and isotope sampling of the teeth was carried out. Following destructive analyses, often remnants of the tooth remained and these were packed and returned to the Circle assemblage in the NMA for further future testing if necessary. The sampling processes were carried out between 2015 and 2018 at the National Museum of Archaeology in Valletta, the University of Cambridge, Trinity College Dublin, and Queen's University in Belfast. Radiocarbon dating and isotopic analyses of collagen were carried out at Queen's University in Belfast, and isotopic analysis of tooth enamel was implemented at the University of Cambridge. These studies are detailed further in Chapters 9 and 10. A pilot study was also carried out on the assemblage for aDNA preservation. The selection criteria for this study was the preservation (preferably on intact crania) of the petrous portion of the temporal bone, since this element reports the highest success rate because of its density, and is least likely to be contaminated as it is located intra-cranially. This study was subject to the same stringent formal application process from Heritage Malta and the Superintendence of Cultural Heritage for ethical approaches to destructive analyses of ancient human remains from archaeological contexts, as described for the radiocarbon and isotopic protocols identified above. Following permission from Heritage Malta and the Superintendence of Cultural Heritage, this work was carried out at Trinity College Dublin and is reported in Chapter 11, Ariano (2021) and Ariano *et al*. (2022).

2.6. The third phase: data analysis and interpretation

The data generated by this programme of work were stored in various databases that could be related to the original excavation archives via stratigraphic context and position within the site. Together with the large number of radiocarbon dates, these databases enabled diachronic analyses of trends in health, activities, and diet across the Circle's main phase of use in the Tarxien period. In some special cases, the size of the dataset presented an opportunity for the development of new statistical tools for visualization, especially certain dental pathologies which could be mapped in terms of the position on the dental arcade where pathologies presented themselves most frequently in the population (Chapter 4). This epidemiological approach to bioarchaeology is only possible with such an exceptionally large sample, such as the remains from the Circle.

2.7. Other studies

During the work phases mentioned above, other studies were carried out on the Circle human remains assemblage. These included two doctoral projects funded by the Arts and Humanities Research Council pursued by researchers from the University of Cambridge (Parkinson and Thompson), whose studies are published within this volume (Chapters 7 & 12, respectively). Their project aims and methodologies are described below.

2.7.1. Funerary taphonomic analysis

Over recent decades, the application of taphonomic analysis has become more common in bioarchaeology, particularly because of its utility to aid in analyses of complex, commingled assemblages (for example Smith and Brickley 2009; Osterholtz *et al.* 2014; Knüsel and Robb 2016). Building upon the French tradition of archaeothanatology which explicitly links the treatment of the dead with cultural and ritual practices (Duday 2009), a sociological understanding of death and dying as significant events which transform both the deceased and society has emerged (Kellehear 2007). Funerary taphonomy provides a methodology to analyse skeletal and funerary assemblages holistically, linking the pattern of preservation and condition of human skeletal remains to their depositional environment and cultural practices (Knüsel and Robb 2016).

Taphonomic analysis has previously been applied to human remains from the Circle, principally to examine the representation of skeletal elements in the rock-cut tomb (Duhig in Malone *et al.* 1995; Duhig 1996). This work investigated both the depositional modes employed in the rock-cut tomb and cave complex (Duhig in Malone *et al.* 1995; Duhig 1996; Stoddart *et al.* 2009a) and the redistribution of human remains throughout the Circle (Stoddart *et al.* 2009a). Building upon this earlier research, a more extensive range of taphonomic methods were applied in this study, including analysis of element completeness, preservation, fragment size, fracture morphology, and cortical modifications. A sample of human remains from 16 archaeological contexts within both the rock-cut tomb and cave complex were selected for analysis. Contexts were chosen (by reference to the 2009 publication) spanning the full use-life of the site, allowing for the investigation of funerary practices over the long term, and seeking to test the provisional conclusions in the earlier publications. To infer patterns of deposition, emphasis was placed on skeletal element representation, comparing the results from the Circle with a range of sites with known funerary practices. Finally, these results are compared with those from the Xemxija Tombs, another late Neolithic burial site on Malta to which taphonomic analysis has been applied (Thompson *et al.* 2018). The methods and results of taphonomic analysis are discussed further in Chapter 12 and presented in full in Thompson (2020).

2.7.2. Metric analysis of the long bones: long bone cross-sectional geometry and body size

When the Population History group began to evaluate the available human material, a further initiative was developed to include the study of the limb bones in order to estimate body size and infer habitual behaviour of the Neolithic population buried at the Circle. Similar studies for other populations and periods (for example Stock and Macintosh 2016) have been carried out, and the opportunity of a doctoral study (Parkinson 2019) took place during the ongoing work of *FRAGSUS* (Chapter 7).

Metric analysis of humeri, femora and tibiae was undertaken to investigate temporal trends in body size and habitual behaviour; however, the fragmentary and commingled nature of the Circle collection presented considerable methodological challenges. Accurate estimations of metric data from fragmented long bones were achieved using 3D laser surface scanning, which allowed for the application of methods in 3D digital reconstruction and superimposition (Benazzi *et al.* 2009; Senck *et al.* 2015). Fragmented long bones were digitally reconstructed and superimposed using RapidForm XOR and individual bone fragments were aligned and positioned according to anatomical landmarks and fracture congruence. Given the size and complexities of the late Neolithic assemblage, the sampling strategy was directed towards specific areas and some contexts from the site (contexts (960), (1206) and (1268), from the 'Shrine' area, and context (1241) from the East Cave) since these contained higher frequencies of humeri, femora and tibiae. In addition, all contexts from the earlier rock-cut tomb were sampled. Further discussion and results are presented in Chapter 7.

2.7.3. GIS digitizing

A Geographical Information System (GIS) study was carried out using the database and records of the 1987–1994 excavation archive to investigate the spatial relationships between the commingled human remains, finds and structural features within the caves (§3.1.4.2.). During the archaeological excavations the site was excavated on a one-metre grid, and skeletal elements were recorded as 'units' within individual spits within each 1x1 metre (Malone *et al.* 2009b). These grid/spits were recorded on an individual context sheet (Fig. 1.11), which included a drawn plan, with numbered and listed skeletal units, context number, date of excavation and 3D coordinates. These records were digitized with the drawn plans and all available contextual information entered into the database. Digitization of the archive records was undertaken in ArcGIS 10.6.1 and spatial analysis was conducted in QGIS 2.18.3. To enhance the visual and spatial effect, the data was imported into ArcScene 10.2 allowing the human remains to be viewed in 3D space.

2.8. Challenges and concluding thoughts

The following chapters in this volume will tackle the details of these numerous studies and their results, but it is already very evident that the Circle human remains assemblage is an abundant source of scientific data. The early context and large size make it one of the most precious assemblages in the Maltese Islands, if not in the Mediterranean.

The site itself (the Circle) should also not be forgotten, as is it is inscribed as a UNESCO World Heritage Site, and still houses further human remains within as-yet unexplored areas. Its fragile nature calls for continued curation by Heritage Malta in communication with the Superintendence of Cultural Heritage to find solutions to protect it further. In addition, the new discoveries continue to emerge as a result of the constant surveillance by the Superintendence of Cultural Heritage (e.g. Arena 2020) in Xagħra and other parts of the Maltese Archipelago, offering opportunities to understand better the landscape and the prehistoric and historic context locally. With new discoveries and investigations come also new funerary assemblages, often of a complex nature, which require study and conservation. The tools acquired from projects such as *FRAGSUS* are already aiding in assisting the development of excavations and analyses of newly discovered prehistoric funerary sites. The data produced will create further insight into the ancient past of the Maltese Islands and the central Mediterranean region.

Note

1. For instance: Project Title: *The Sentinels of Ħal Saflieni, Malta: Science Facts versus Science Fiction*. This project is a Union Académique Internationale-funded collaboration between Principal Investigators from Heritage Malta (Sharon Sultana, National Museum of Archaeology), the Superintendence of Cultural Heritage Malta (Bernardette Mercieca-Spiteri), and Macquarie University, Sydney (Ronika K. Power), and Co-Investigators from the Universities of Cambridge, Western Ontario and Queens University Belfast. It will carry out the first-ever interdisciplinary analyses of the surviving fragmentary human skeletal remains excavated from the Ħal Saflieni Hypogeum UNESCO World Heritage. The project commenced in 2019, but has been on hold since 2020 until the time of writing because of the COVID-19 pandemic.