Journal of Archaeological Science 59 (2015) 132–141

Contents lists available at ScienceDirect

Journal of Archaeological Science

journal homepage: http://www.elsevier.com/locate/jas

Detection and characterisation of Black Death burials by multi-proxy geophysical methods

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ARTICLE INFO

Article history:
Received 3 September 2014
Received in revised form
22 April 2015
Accepted 23 April 2015
Available online 5 May 2015

Keywords:
Burials
Plague
Black Death
London
Geophysics

ABSTRACT

The construction of the new Crossrail railway discovered 25 well preserved skeletons shallowly buried in Central London in 2013. Subsequent carbon dating and aDNA analysis confirmed the archaeological age and presence of the *Yersinia pestis* "Black Death" plague epidemic strain. Here we present the non-invasive multi-proxy geophysical survey of the adjacent Charterhouse Square, rapidly undertaken to detect any further burials and characterise the site. Historical records suggested the area was a burial ground for Black Death plague victims, before subsequent cemetery and urban land use. Following initial trial surveys, surveys imaged ~200 isolated and similar-sized burials in the south-west of the site. There were also two contrasting burial orientations present at various depths which suggested a series of controlled phased burials. A well-defined eastern burial boundary, taking the form of a ditch and bank, was also discovered. Geophysical surveys also identified a subsequent complex site history with multiple-aged features. This study revises knowledge of Black Death aged-burials and provides important implications for successful geophysical burial detection with significant time- and space-limited site constraints.

1. Introduction

In 2013 Europe's biggest construction project, the construction of the new Crossrail railway, discovered 25 well preserved skeletons, shallowly buried in close proximity to each other, in Charterhouse Square in Central London. Historical records suggested that the site was an emergency burial ground for Black Death victims during the 1348–1349 AD plague epidemic (Porter, 2009; Sloane, 2011). A non-invasive archaeological geophysical survey of Charterhouse Square with a limited time scale was commissioned because of active construction deadlines.

There are generally accepted to be three plague pandemics in recorded human history, Justinian's Plague (541–542 AD) that was mostly contained within Mediterranean countries, the much wider European so-called Black Death plague (1345–1750 AD) and the 19th Century Chinese plague epidemic which spread globally in 1894 AD (Haensch et al., 2010). The Black Death was the first widespread outbreak of medieval plague in Europe, with recent historical research estimating that it reduced London's population by 30%–50% between 1347 and 1351 AD (Sloane, 2011). Contemporary accounts detail the sheer numbers of dead prevented Christian burials from being undertaken "*so great a multitude eventually died that all the cemeteries of the aforesaid city were insufficient for the burial of the dead. For this reason, many were compelled to bury their dead in places unseemly, not hallowed or blessed; some, it was said, cast the corpses into the river*" (Sloane, 2011).

Recent scientific advancements in dating skeletal remains have allowed research into age of mortality in London during this period (DeWitte, 2010; DeWitte and Hughes-Morey, 2012), subsequent

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http://dx.doi.org/10.1016/j.jas.2015.04.010
0305-4403/

population health improvements (DeWitte, 2014) and confirmation of plague strains to be rapidly identified, usually in the pulp of teeth (Drancourt et al., 2004; Bianucci et al., 2009; Haensch et al., 2010; Kacki et al., 2011). Research has also cast doubt on the traditionally-held premise that rats (*Rattus rattus/norvegicus*) formed the intermediate host carrier in North European countries, with pneumonic (human to human via air droplets) rather than bubonic plague now proposed to be the main dispersal method (Hufthammer and Walløe, 2013).

Current search methods to detect both archaeological and modern human burials are highly varied and have been reviewed (Hunter and Cox, 2005; Pringle et al., 2012a), with best practice suggesting a phased approach, moving from large-scale remote sensing methods (Kalacska et al., 2009), through to initial ground reconnaissance and control studies before full searches are initiated (Harrison and Donnelly, 2009; Larson et al., 2011). These full searches can involve many and varied methods, depending upon the individual target(s) and site and even seasonal parameters (see Pringle et al., 2012a; Jervis and Pringle, 2014) through to physical excavation (e.g. see Hunter and Cox, 2005).

Near-surface geophysical surveys have been often applied in archaeological site investigations, either to detect and/or characterise a site (e.g. see De Smedt et al., 2014) or to decide where to start intrusive investigations. Archaeological geophysical searches for unmarked burials are many and have had varied success, for example, locating archaeological graves in Jordan (Frohlich and Lancaster, 1986) and Turkey (Arisoy et al., 2007), Kings' Mounds in Sweden (Persson and Olofsson, 2004), Icelandic Viking/Medieval graves (Damiata et al., 2013), North American Indian historic burial grounds (Bigman, 2012), 19th century cemeteries and graveyards in New Zealand (Nobes, 1999), the USA (Bevan, 1991; Ellwood et al., 1994; Doolittle and Bellantoni, 2010; Dalan et al., 2010; Honerkamp and Crook, 2012; Bigman, 2014), Australia (Buck, 2003), the UK (Hansen et al., 2014), to 19th century Irish Famine victims (Ruffell et al., 2009) and 20th century Svalbard Spanish Flu victims (Davis et al., 2000). The advantages of archaeological surveys are that there is usually little time constraint; however for forensic and time-limited geophysical surveys the need to rapidly characterise a site and identify potential burial position(s) is paramount (e.g. see Nobes, 2000; Pringle and Jervis, 2010; Novo et al., 2011).

Due to the limited survey time and site constraints, a multi-proxy geophysical rapid assessment approach had to be used in this study. Study aims were: ***firstly*** to determine if non-invasive geophysical methods could both detect and characterise the historic burial ground; ***secondly*** to detect any further unmarked burials within the survey area and if there were any particular concentrations and orientations; ***thirdly*** to determine the optimum geophysical technique(s) for such an archaeological time-limited scenario and finally; **fourthly** to compare results to other published studies.

2. Material and methods

2.1. Study site

The study site was at Charterhouse Square near St. Bartholomew's Hospital in Central London, UK, situated ~1 km north of the Thames river and ~15 m above sea level (Fig. 1). Charterhouse Square is a 4 acre urban grassed park containing isolated mature deciduous trees, surrounded by roads and buildings with Charterhouse hospital itself to the north-west (Fig. 2). Available British Geological Survey boreholes detail an organic-rich silty topsoil succeeded by unconsolidated fluvial sands, gravels and alluvium from previous courses of the River Thames that overlie Eocene London Clay and Cretaceous Chalk bedrock types at ~30 m and ~50 m below ground level (bgl) respectively.

Historical records showed a 13 acre area north of the city walls (Fig. 1) was leased by Sir Walter de Mauny in 1349 AD from St. Bartholomew's priory as a burial ground for The Black Death plague victims (Hope and John, 1925). In 1371 AD de Mauny also sponsored a Carthusian priory and enlarged the site by 4 Acres to the east, the boundary between these areas being a parish boundary that still remains today (Porter, 2009), with a chapel built in 1481 AD and the priory's meat kitchen (Temple, 2010). The priory was dissolved in 1538 AD with the 1348 AD chapel demolished in 1545 AD and the chapel erected in 1481 AD pulled down in 1615 AD; the meat kitchen was probably demolished c.1545 AD (Barber and Thomas, 2002). The buildings of the former priory were rebuilt as a mansion, which was adapted in 1614 AD as an almshouse and school, and after the priory's dissolution the periphery of its outer precinct was built upon, enclosing the modern Charterhouse Square. The construction of the London Metropolitan Railway and a new street built in the 1860s–1870s AD encroached upon the southern area of the site (Porter, 2009). In 1939 AD as part of World War Two air-raid precautions, six underground emergency water tanks were installed in the square. Lastly an exploratory excavation was undertaken in 1997–8 AD with an isolated skeleton discovered in the north-east of the site (MoLAS, 1998).

2.2. Archaeological excavations

As part of the new Cross railway, a 4.5 m diameter vertical shaft was dug on the road to the south-west of the Square (Fig. 2). At 2.3 m bgl below compacted clay soil, eight isolated earth-cut graves containing eleven relatively well preserved predominantly human remains were encountered aligned east–west (Fig. 3a). These did not show any signs of trauma although further disarticulated human remains were also recovered from two of the grave fills. At 2.5 m bgl a double burial earth-cut grave containing two relatively well preserved incomplete human remains was also encountered, aligned northeast–southwest. At 2.7 m bgl nine isolated earth-cut graves and one double-grave containing eleven well preserved predominantly adult human remains were encountered aligned northeast–southwest (Fig. 3b). The shallowest burials had two graves with multiple burials, one with remains on top of the first and the other having them side by side (Fig. 3b). Recovered pottery shards from the 2.3 m bgl burials estimated a burial date of 1270–1350 AD.

Subsequent radio-carbon dating of the 2.5 m and 2.7 m bgl burials gave date ranges of 1275 AD–1405 AD ±20BP, with the 2.3 m bgl burials having a date range of 1430 AD–1485 AD ±21BP (see MoLA, 2013). Rapid aDNA analysis (see Kacki et al., 2011) of the recovered human remains confirmed the presence of the *Yersinia pestis* Black Death plague epidemic strain in all three burial phases (Fig. 3 and MoLA, 2013).

2.3. Near-surface geophysical investigations

After initial trial surveys showed detectable anomalies following best practice (see Milsom and Eriksen, 2011), a two day time-limited survey was then undertaken. 2D profile positions (Fig. 2a) were all surveyed using a Leica™ 1200 total station theodolite and reflector prism with an 0.005 m average position accuracy before being integrated with the digital sitemap in ArcGIS™ ArcMap v.10 software.

A bulk ground conductivity survey was undertaken over the whole square using a Geonics™ EM-31-Mark2 conductivity meter (Suppl. mat.), not to identify individual grave positions but in order to