Mercury Intrusion Porosimetry analysis of human bone, Watermead Country Park, Leicestershire (Accession no. A57.1996)

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Figures

Figure 1: HgIP data for small find samples SF 50, 52, 55. Pore diameters (assuming a nominal cylindrical radius) are expressed on a logarithmic scale. The large peak at > 1000 nm is attributed to the Haversian canal, whilst the pore sizes < 100nm are attribute.3

Summary

This report documents mercury intrusion porosimetry (HgIP) analysis of three small finds of human bones from Watermead Country Park, Leicestershire, on behalf of University of Leicester Archaeological Services.

The results indicate an atypical pattern of intrusion, which is rarely seen in human bones in a larger European study.

It is concluded that the bones have not suffered putrefaction, but may have suffered heating. As a consequence the corpses were not simply buried intact but underwent some form of treatment which removed the gut contents or cut the blood supply prior to burial.

In the context of previous studies of human burial by HgIP, the current bone samples are considered unusual and worthy of further study.

Keywords

Mercury Intrusion Porosimetry

Bone

Materials

A total of three samples were provided for analysis

- 50 Right tibia
- 52 Right radius
- 55 Right femur (possible female)- Possible female femur, GrA-23588 (date 3030 - 2710 cal BC) (δ^{15}N 10.9)

Method

The samples were freeze dried prior to analysis. Mercury Intrusion porosimetry (HgIP) measurements were made on a Micrometrics Autopore II 9220 at the University of Newcastle upon Tyne by Oliver Craig.

The method estimates porosity by assuming cylindrical pores and therefore mercury penetration of a sample is governed by the capillary law [1]. For a non-wetting fluid, such as mercury, this law can be expressed

$$D = -\frac{4\gamma Cos\Theta}{p}$$

where D is the pore diameter (nm), p is the applied pressure (psi), γ is the fluid surface tension (0.48 N m^{-2}) and θ is the contact angle between bioapatite and mercury (163.1°; measured for a pressed plate of sintered (anorganic) bone apatite [2]), see also [3]. Data are reported as ml of Hg intruded per ml of bone (the latter calculated from the simultaneous bulk density measurement).

Results

The results, summarised in Figure 1, are atypical of human bone. There is no evidence of microbial attack in any of the bones ('m' porosity between 600 and 1500 nm[4]) and all have lost collagen, as evidenced by the pores at < 100 nm.

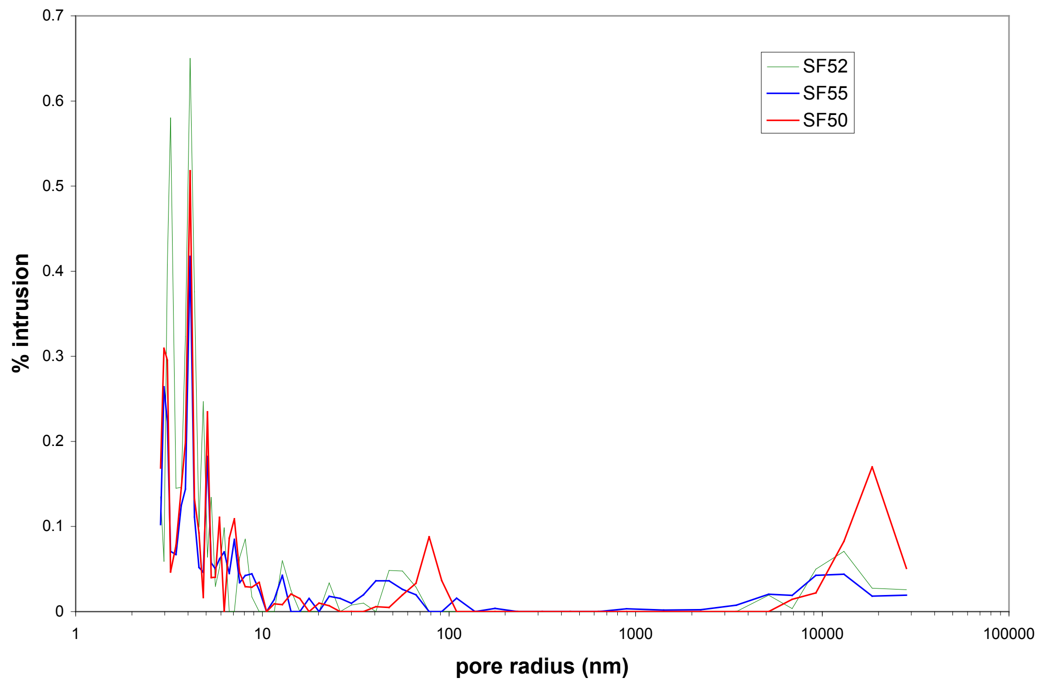

Figure 1: HgIP data for small find samples SF 50, 52, 55. Pore diameters (assuming a nominal cylindrical radius) are expressed on a logarithmic scale. The large peak at > 1000 nm is attributed to the Haversian canal, whilst the pore sizes < 100nm are attribute

Discussion

Turner-Walker et al. [5]have observed that microbial attack of bone leads to pore sizes of between 600nm and 1.5µm. This intermediate or 'm' porosity is typical of intact buried corpses and is much less common in butchered animal remains. From this observation they developed an argument, based upon earlier work by Bell et al. [5] that this microbial attack is caused by collagenolytic gut bacteria entering the bone post-mortem via the blood supply.

The absence of any such 'm' porosity in the three bones from Watermead Country Park indicates that they have not suffered microbial attack. The most plausible explanations for this are

Excarnation: Excarnation would lead to the removal of the gut contents, and thus cessation of this type of attack. However in previous (very limited) analysis of unusual pre-Christian burials there is some initial microbial attack evident, none is evident in this case.

Butchering: The pattern of attack is commonly seen in butchered animal remains. Butchering both removes flesh and disconnects the blood supply contact between the gut and the bone; it is assumed that the blood supply is the route used by the collagenolytic microbes that attack the bone. A similar type of porosity (albeit with much greater loss of collagen) has been observed in the medieval site of Apigliano [6] in this latter case liming was suggested as a means of accelerating collagen loss.

Cooking: Unlikely, as the loss of collagen observed is remarkably similar in all three samples. In order to assess cooking rather than long-term burial other approaches would have to be adopted.

It is perhaps interesting to note that bones suffering this form of alteration appear to be more appropriate for other forms of molecular analysis than ‘typical’ human burials which have large amounts of ‘m’ porosity.

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Appendix: Full HgIP results.

Diameter (µm)	SF 52 Density Distribution	SF 55 Density Distribution	SF 50 Density Distribution
43.73370	0.026	0.019	0.051
31.23840	0.028	0.018	0.170
21.86680	0.071	0.044	0.083
15.61920	0.050	0.043	0.022
12.14820	0.003	0.019	0.014
8.74670	0.019	0.020	0.000
5.46670	0.000	0.008	0.000
3.64450	0.000	0.002	0.000
2.18670	0.000	0.002	0.000
1.45780	0.000	0.003	0.000
1.09330	0.000	0.000	0.000
0.72890	0.000	0.000	0.000
0.54670	0.000	0.000	0.000
0.39760	0.000	0.000	0.000
0.31240	0.000	0.004	0.000
0.24300	0.000	0.000	0.000
0.19880	0.000	0.016	0.000
0.16820	0.000	0.000	0.036
0.14580	0.000	0.000	0.088

0.12150	0.029	0.020	0.033
0.10410	0.048	0.026	0.020
0.08750	0.048	0.036	0.005
0.07540	0.000	0.036	0.006
0.06430	0.010	0.020	0.000
0.05610	0.008	0.010	0.000
0.04860	0.000	0.016	0.000
0.04290	0.034	0.018	0.007
0.03770	0.000	0.000	0.010
0.03360	0.000	0.016	0.000
0.03000	0.000	0.000	0.015
0.02700	0.025	0.000	0.021
0.02430	0.060	0.043	0.008
0.02210	0.000	0.014	0.009
0.02010	0.000	0.000	0.000
0.01840	0.000	0.025	0.034
0.01680	0.017	0.044	0.029
0.01560	0.085	0.042	0.029
0.01460	0.063	0.034	0.046
0.01370	0.000	0.085	0.109
0.01290	0.000	0.045	0.086
0.01210	0.099	0.070	0.000
0.01150	0.052	0.062	0.111
0.01090	0.029	0.050	0.040
0.01040	0.134	0.057	0.040

0.00990	0.064	0.182	0.234
0.00940	0.247	0.046	0.017
0.00890	0.099	0.052	0.092
0.00840	0.376	0.111	0.132
0.00800	0.650	0.417	0.518
0.00750	0.323	0.144	0.199
0.00720	0.146	0.125	0.145
0.00660	0.145	0.067	0.078
0.00630	0.580	0.071	0.047
0.00610	0.407	0.223	0.295
0.00580	0.059	0.264	0.309
0.00560	0.135	0.102	0.169