## ■ UGANDA

# Analysis of Iron Working Remains from Kooki and Masindi, Western Uganda

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### Introduction

Western Uganda, and the kingdom of Bunyoro in particular, is renowned among neighbouring kingdoms for the production of iron (Chrétien 2003; Iles 2013). Trade in iron, as well as salt, was a crucial economic asset to the 19th century kingdom (Connah 1991), and probably had been a valuable resource since at least the mid 2nd millennium AD. Unlike other areas of the Great Lakes, there is currently no evidence for iron production much earlier than this, and as yet the earliest date associated with iron production in the region is from a furnace at Munsa (Figure 1), dating broadly to the 14th century AD (Robertshaw 1997). However, despite its late emergence, the development and organisation of such a critical industry has the potential to shed light on the flourishing of the Bunyoro kingdom in the later 2nd millennium and the nature of the local political structures that preceded it.

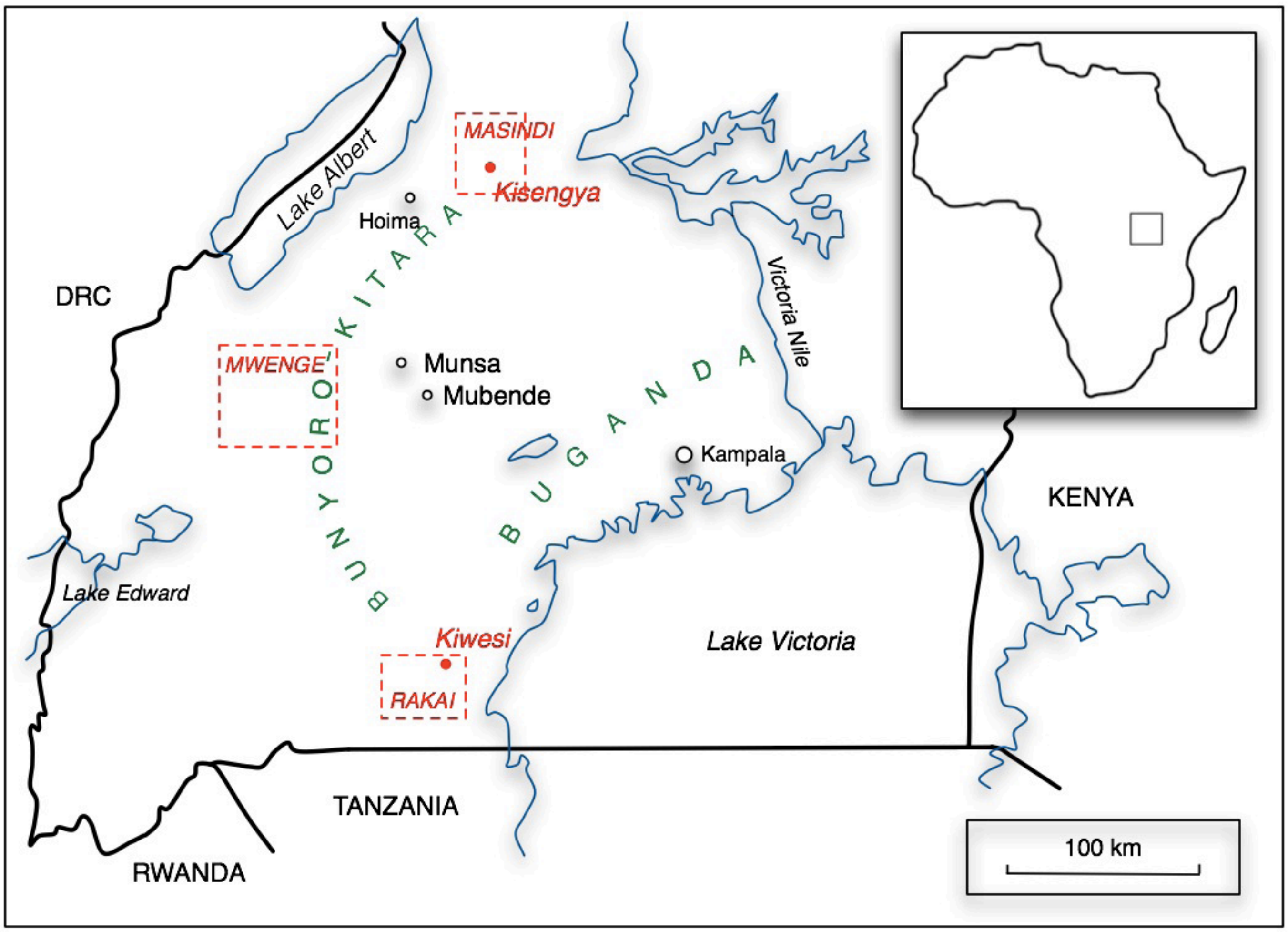


**Figure 1:** Sites and survey zones mentioned in the text.

Unlike knowledge of other key industries, namely salt production (e.g., Connah 1991, 1996), comparatively little was known about the production of iron prior to this research. In order to rectify this, oral histories, clan histories, ethnohistorical accounts, archaeological survey data and local place names were methodically examined (e.g., Buchanan 1974; Childs 2000; Robertshaw 1991, 1994; Roscoe 1923; Tantala 1989). On the basis of this literature-based assessment, three regions that appeared to have been a focus for past iron production was chosen for further investigation. These three regions were Mwenge (in the district of Kyenjojo), Kooki (in the district of Rakai) and Masindi (Figure 1). In 2007, survey and excavation were carried out in these areas in order to generate archaeometallurgical samples for an examination of the pre-colonial iron industries of the Kingdom of Bunyoro, western Uganda as part of the authors PhD research (Iles 2011). An initial fieldwork report has been published previously (Iles 2009), and the results from Mwenge are to be published elsewhere (Iles and Martinón-Torres, forthcoming). This article presents the data generated from Kooki and Masindi.

## Applied Archaeological and Archaeometallurgical Methods

A two-tiered survey strategy was undertaken to identify iron production sites for this research, combining systematic, road-, track- and path-based survey in conjunction with a more flexible, informant-led approach (see Iles 2009). Major and minor roads and paths within the designated survey areas were traversed by a survey team, as were areas of open land that were adjacent to a road or pathway. Exposed land and road cuttings were inspected for archaeological remains, and local residents were asked whether they knew of concentrations of slag (*inyanga, ibyanga, byenga)* or old or unusual pottery in the vicinity. Excavation was undertaken at selected sites, including the excavation of all visible archaeological features and test pits as appropriate, and the sampling of slag remains. All features were half-sectioned and recorded prior to being fully excavated, and were excavated by context with reference to the Museum of London archaeological site manual (MoLAS 1994). Hard copies of excavation notes and recording sheets are held at the Uganda Museum, Kampala.

In order to reconstruct the technologies undertaken at each site, representative samples of slag, ore, tuyère, furnace ceramics and domestic pottery were shipped to UCL Institute of Archaeology for bulk chemical analysis (PED-XRF). This approach would allow for a discussion of the resources used and operating parameters of each smelt. Samples were prepared as compressed powder pellets using standard sample preparation procedures. Fifteen to 20gm of representative material were removed per sample, avoiding areas of slag samples bearing visible corrosion products, and avoiding ceramic samples that showed vitrification. These were crushed and milled to produce a powder with a grain size of less than 50µm, before being mixed with a wax-binding agent and compressed in a hydraulic press. A Spectro Lab XPro 2000 instrument with an evaluation programme for iron rich materials (Veldhuijzen 2003) was used to generate the PED-XRF compositional data. Three measurements were taken from each sample, which were averaged to give a final result. Major and trace elements were converted to oxides by stoichiometry, and the results normalised to 100%. Three calibration standards of agreed chemical compositions were run alongside each category of sample (i.e., ceramic, slag, ore) in order to identify any instrumental errors. Silica was the only problematic compound, with consistent overestimations ranging between 10 and 27% in samples with low silica content (i.e., slag and ore), effecting changes in estimated composition ranging up to around 4wt%. In order to compensate for this, silica levels in the slag and ore samples were adjusted on a sliding scale (Tables 1 and 2, *cf.* Iles 2011). No microscopy was undertaken on these samples.

| | Major and minor compounds | | | | | | | | | | | | | | Trace compounds | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **KIWESI** | $Na_2O$ | MgO | $Al_2O_3$ | *$SiO_2$* | $SiO_2$ | $P_2O_5$ | S | $K_2O$ | CaO | $TiO_2$ | $V_2O_5$ | $Cr_2O_3$ | MnO | FeO | $Co_3O_4$ | NiO | CuO | ZnO | $Rb_2O$ | SrO | $Y_2O_3$ | $ZrO_2$ | BaO | $La_2O_3$ | $CeO_2$ | $Nd_2O_3$ | Analytical |
| (KWI) | wt% | wt% | wt% | *wt%* | wt% | wt% | wt% | wt% | wt% | wt% | wt% | wt% | wt% | wt% | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | total (wt%) |
| | | | | *original* | adjusted | | | | | | | | | | | | | | | | | | | | | | |
| Slag a | 0.24 | 0.39 | 10.47 | *31.85* | 31.85 | 1.52 | 0.08 | 3.27 | 3.58 | 0.47 | 0.01 | 0.05 | 0.08 | 47.62 | 581 | / | 49 | 64 | 37 | 310 | 172 | 338 | 416 | 696 | 769 | 280 | 106.50 |
| Slag b | 0.34 | 0.37 | 10.00 | *31.32* | 31.00 | 2.25 | 0.08 | 3.30 | 4.94 | 0.59 | 0.00 | 0.06 | 0.14 | 46.25 | 458 | / | 49 | 45 | 27 | 504 | 99 | 415 | 642 | 452 | 509 | 165 | 107.72 |
| Slag c | 0.25 | 0.32 | 11.26 | *24.14* | 20.76 | 2.28 | 0.09 | 2.79 | 2.82 | 0.45 | 0.03 | 0.13 | 0.10 | 55.17 | 526 | / | 28 | 45 | 6 | 162 | 33 | 214 | 286 | 106 | 142 | 22 | 107.54 |
| Slag d | 0.32 | 0.49 | 12.22 | *32.87* | 32.87 | 2.12 | 0.08 | 4.10 | 5.17 | 0.62 | 0.01 | 0.11 | 0.11 | 41.51 | 483 | / | 38 | 85 | 63 | 487 | 64 | 326 | 626 | 219 | 304 | 22 | 106.92 |
| Slag e | 0.34 | 0.32 | 9.35 | *28.92* | 27.48 | 1.51 | 0.12 | 3.11 | 2.51 | 0.48 | 0.01 | 0.09 | 0.08 | 52.94 | 550 | / | 45 | 147 | / | 224 | 97 | 295 | 362 | 197 | 247 | 32 | 109.82 |
| Slag f | 0.16 | 0.24 | 11.47 | *28.09* | 26.41 | 1.32 | 0.10 | 3.43 | 1.86 | 0.46 | 0.03 | 0.15 | 0.06 | 52.45 | 443 | / | 24 | 75 | 31 | 169 | 84 | 248 | 306 | 213 | 278 | 79 | 108.71 |
| Slag g | 0.34 | 0.21 | 10.45 | *28.88* | 27.44 | 1.50 | 0.10 | 3.56 | 2.18 | 0.45 | 0.02 | 0.10 | 0.07 | 51.92 | 453 | / | 31 | 61 | 31 | 213 | 108 | 293 | 367 | 238 | 345 | 80 | 108.33 |
| Slag h | 0.19 | 0.27 | 9.83 | *28.50* | 28.07 | 1.71 | 0.13 | 3.83 | 2.69 | 0.45 | 0.02 | 0.09 | 0.07 | 51.93 | 419 | / | 54 | 70 | 35 | 259 | 146 | 284 | 288 | 604 | 607 | 170 | 110.45 |
| Slag i | 0.25 | 0.52 | 9.14 | *28.73* | 27.29 | 1.80 | 0.11 | 3.17 | 5.24 | 0.46 | 0.01 | 0.07 | 0.15 | 50.10 | 499 | / | 36 | 39 | 22 | 499 | 52 | 303 | 737 | 124 | 288 | 23 | 108.06 |
| Slag j | 0.29 | 0.31 | 8.87 | *27.36* | 25.17 | 2.64 | 0.11 | 3.25 | 3.55 | 0.45 | 0.00 | 0.04 | 0.11 | 52.84 | 518 | / | 20 | 35 | 21 | 273 | 33 | 246 | 356 | 119 | 163 | 33 | 110.27 |
| Furnace Slag | 0.13 | 0.20 | 8.44 | *24.48* | 21.55 | 1.80 | 0.11 | 2.15 | 2.57 | 0.38 | 0.01 | 0.13 | 0.11 | 59.25 | 648 | / | 61 | 225 | / | 213 | 48 | 237 | 379 | 159 | 240 | 64 | 108.55 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ore (from furnace) | / | / | 8.35 | *5.88* | 4.12 | 0.80 | 0.04 | 0.14 | 0.04 | 0.38 | 0.02 | 0.20 | 0.05 | 83.44 | 729 | 247 | 84 | 721 | / | / | 174 | 173 | 7 | 1758 | 1903 | 823 | 97.58 |
| Ore (from slag) | 0.10 | / | 8.19 | *30.07* | 29.17 | 1.30 | 0.11 | 2.16 | 0.13 | 0.31 | / | 0.02 | 0.03 | 57.42 | 567 | / | 72 | 246 | / | / | 36 | 201 | 386 | 47 | 127 | 0 | 100.61 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pot A | 0.33 | 0.60 | 21.46 | *68.09* | 68.09 | 0.14 | 0.06 | 2.51 | 0.81 | 0.95 | 0.00 | 0.02 | 0.02 | 4.79 | 69 | / | / | 58 | 167 | 176 | / | 713 | 604 | 115 | 177 | 92 | 95.71 |
| Pot B | 0.17 | 0.46 | 19.75 | *70.61* | 70.61 | 0.05 | 0.03 | 3.20 | 0.69 | 0.91 | / | 0.02 | 0.04 | 3.83 | 73 | / | / | 484 | 170 | 159 | / | 627 | 566 | 136 | 227 | 146 | 100.60 |
| Tuyère | 0.28 | 0.40 | 22.81 | *68.19* | 68.19 | 0.04 | 0.02 | 2.35 | 0.32 | 0.92 | 0.01 | 0.02 | 0.03 | 4.36 | 74 | / | / | 89 | 194 | 85 | / | 758 | 552 | 259 | 279 | 175 | 101.50 |
| Furnace Wall | 0.34 | 0.30 | 20.83 | *65.66* | 65.66 | 0.13 | 0.07 | 1.66 | 0.50 | 1.57 | 0.01 | 0.03 | 0.31 | 8.33 | 144 | / | / | 110 | 136 | 107 | / | 1021 | 504 | 168 | 343 | 112 | 93.11 |

**Table 1:** PED-XRF compositional data for all samples from Kiwesi, normalised to 100%. All values are the average of three analyses of each sample. 'Analytical total' shows the analytical total prior to normalization.

| | Major and minor compounds | | | | | | | | | | | | | | Trace compounds | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **KISENGYA** | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | *$SiO_2$* | $P_2O_5$ | S | $K_2O$ | CaO | $TiO_2$ | $V_2O_5$ | $Cr_2O_3$ | MnO | FeO | $Co_3O_4$ | CuO | $Rb_2O$ | SrO | $Y_2O_3$ | $ZrO_2$ | BaO | $La_2O_3$ | $CeO_2$ | $Nd_2O_3$ | Analytical |
| (KSG) | wt% | wt% | wt% | wt% | *wt%* | wt% | wt% | wt% | wt% | wt% | wt% | wt% | wt% | wt% | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | total (wt%) |
| | | | | original | *adjusted* | | | | | | | | | | | | | | | | | | | | |
| KSG Slag a | 0.24 | 0.44 | 7.53 | 26.97 | *24.82* | 0.68 | 0.08 | 2.32 | 4.15 | 0.21 | / | 0.02 | 4.58 | 52.27 | / | 36 | / | 255 | 50 | 307 | 3645 | 117 | 412 | 269 | 109.30 |
| KSG Slag b | 0.15 | 0.75 | 7.76 | 21.15 | *17.55* | 0.64 | 0.07 | 2.32 | 5.30 | 0.17 | / | 0.02 | 4.32 | 56.99 | / | 26 | / | 350 | 42 | 233 | 2516 | 107 | 357 | 140 | 114.93 |
| KSG Slag c | 0.25 | 0.53 | 8.38 | 27.71 | *25.77* | 0.79 | 0.08 | 2.11 | 4.36 | 0.37 | 0.00 | 0.03 | 2.29 | 52.56 | 292 | 47 | / | 265 | 55 | 373 | 3061 | 294 | 631 | 215 | 107.50 |
| KSG Slag d | 0.21 | 0.59 | 7.17 | 22.28 | *18.94* | 0.67 | 0.08 | 2.10 | 4.04 | 0.25 | 0.01 | 0.02 | 1.64 | 60.66 | 500 | 29 | / | 222 | 51 | 241 | 1197 | 132 | 287 | / | 115.51 |
| KSG Slag e | 0.18 | 0.39 | 5.33 | 22.49 | *19.12* | 0.92 | 0.07 | 1.48 | 2.97 | 0.13 | / | 0.02 | 3.19 | 62.38 | 274 | 39 | / | 182 | 48 | 177 | 3221 | 42 | 273 | 169 | 112.67 |
| KSG Slag f | 0.25 | 0.45 | 7.70 | 30.59 | *29.98* | 0.76 | 0.07 | 1.79 | 3.35 | 0.19 | / | 0.02 | 4.06 | 50.00 | / | 33 | / | 235 | 54 | 324 | 5847 | 147 | 622 | 355 | 105.83 |
| KSG2 Slag a | 0.25 | 0.77 | 7.78 | 26.00 | *23.40* | 1.93 | 0.06 | 0.76 | 6.53 | 0.45 | 0.01 | 0.03 | 1.46 | 53.47 | 471 | 27 | / | 407 | 63 | 444 | 3080 | 94 | 250 | 252 | 105.93 |
| KSG2 Slag b | 0.23 | 1.19 | 7.43 | 28.55 | *26.84* | 2.21 | 0.06 | 0.83 | 8.69 | 0.45 | 0.00 | 0.03 | 1.00 | 48.88 | 583 | 29 | / | 527 | 57 | 420 | 2205 | 143 | 229 | 244 | 106.12 |
| KSG3 Slag a | 0.31 | 0.51 | 11.12 | 25.72 | *23.15* | 2.13 | 0.09 | 2.85 | 4.05 | ≤0.05 | / | 0.04 | 6.47 | 45.81 | / | 47 | / | 807 | 44 | 272 | 6280 | 215 | 693 | 392 | 111.73 |
| KSG3 Slag b | 0.16 | 0.71 | 7.11 | 16.76 | *13.24* | 1.17 | 0.06 | 1.97 | 4.30 | 0.23 | 0.00 | 0.02 | 1.32 | 65.92 | 594 | 40 | / | 252 | 36 | 212 | 1367 | 31 | 157 | / | 115.37 |
| KSG3 Slag c | 0.18 | 0.51 | 7.99 | 25.05 | *22.17* | 1.21 | 0.09 | 2.20 | 4.97 | 0.23 | / | 0.02 | 3.53 | 53.50 | 139 | 33 | / | 389 | 57 | 348 | 3385 | 116 | 524 | 280 | 110.92 |
| KSG3 Slag d | 0.13 | 0.63 | 8.07 | 24.93 | *22.06* | 1.31 | 0.09 | 2.20 | 5.47 | 0.22 | / | 0.03 | 3.59 | 52.82 | 133 | 29 | / | 442 | 57 | 364 | 3311 | 119 | 498 | 212 | 110.76 |
| KSG3 Slag e | 0.23 | 0.47 | 9.78 | 20.36 | *16.74* | 0.93 | 0.07 | 1.50 | 3.18 | 0.25 | 0.01 | 0.05 | 3.08 | 59.72 | 258 | 53 | / | 223 | 43 | 305 | 2184 | 76 | 379 | ≤232 | 109.36 |
| KSG3 Slag f | 0.19 | 0.46 | 7.63 | 21.47 | *17.92* | 1.57 | 0.08 | 2.20 | 3.08 | 0.15 | / | 0.03 | 4.34 | 57.77 | / | 63 | / | 169 | 46 | 276 | 9049 | / | 348 | 491 | 114.71 |
| KSG Pot A | 0.25 | 0.65 | 20.04 | 63.32 | *63.32* | 0.05 | 0.04 | 1.81 | 1.06 | 1.21 | 0.01 | 0.01 | 0.03 | 11.29 | 134 | 42 | 70 | 139 | / | 862 | 670 | 126 | 210 | 105 | 92.42 |
| KSG Pot B | 0.16 | 0.51 | 18.48 | 71.17 | *71.17* | 0.19 | 0.04 | 1.74 | 1.14 | 1.06 | 0.00 | 0.02 | 0.03 | 5.24 | 70 | 41 | 52 | 156 | / | 852 | 559 | 143 | 221 | 140 | 97.28 |
| KSG2 Furnace Wall | 0.22 | 0.17 | 10.10 | 84.35 | *84.35* | 0.01 | 0.04 | 0.29 | 0.12 | 1.14 | / | 0.01 | 0.03 | 3.39 | 60 | 14 | 24 | 17 | / | 852 | 114 | 38 | 69 | 92 | 100.00 |
| KSG2 Tuyère | 0.14 | 0.44 | 20.17 | 71.31 | *71.31* | 0.04 | 0.06 | 0.88 | 0.37 | 1.35 | 0.01 | 0.02 | 0.02 | 4.97 | 89 | 59 | 60 | 62 | / | 935 | 439 | 159 | 276 | 147 | 96.36 |
| KSG3 Furnace Wall | 0.20 | 0.39 | 14.08 | 78.29 | *78.29* | 0.04 | 0.04 | 0.80 | 0.35 | 1.01 | / | 0.01 | 0.04 | 4.59 | 78 | 28 | 57 | 38 | / | 734 | 255 | 107 | 161 | 124 | 97.54 |

**Table 2:** PED-XRF compositional data for all samples from Kisengya, normalised to 100%. All values are the average of three analyses of each sample. 'Analytical total' shows the analytical total prior to normalization.

**Kooki, Rakai District**

*Survey and excavation.* As described in detail in Iles 2009, the survey zone in Rakai district was located within the county of Kooki, and covered an area of approximately 20km by 30km. Within this area, 44 sites were found that related to iron production. Most of these were characterised by the presence of large slag blocks, whereas others constituted smaller scatters of slag fragments (see map in Iles 2009, Figure 3 and Iles 2011, Appendix C for full survey results and GPS location data). All sites in Kooki were provisionally dated to the Late Iron Age (i.e., post *c.* 800 AD) due to their association with ceramics decorated with knotted strip roulette.

Two sites in Kooki – Kiwesi and Nsozibiri – were found to contain furnace bases visible in the ground surface. Kiwesi was selected for excavation based on the density of the archaeological remains and a seemingly well-preserved furnace base. Iron production remains extended throughout the modern village, which were planned and recorded (Figure 2). Also present were mounds of slag, as well as several large pit features that remained as

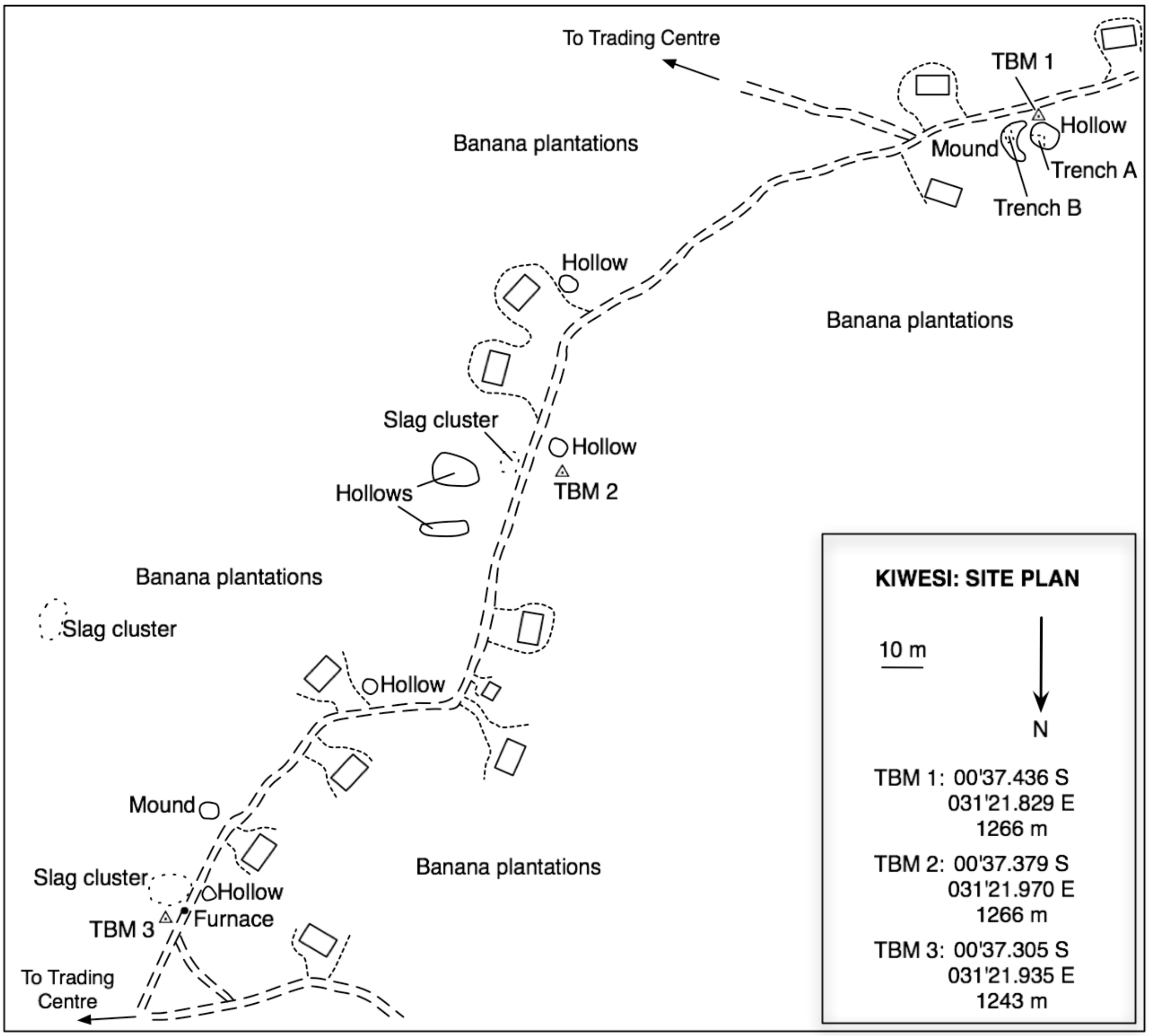


**Figure 2:** Site plan of Kiwesi.

hollows in compounds and banana plantations. Local inhabitants associated these hollows with past smelting activity and as such they were also planned. Similar hollows had been noted throughout the Kooki survey, yet were absent from the survey in Mwenge and Masindi. If there function is confirmed, they may provide a valuable tool for identifying iron production sites in future studies of the Kooki region.

Several features at Kiwesi were chosen for excavation including the furnace base, one of the hollows (Trench A, Figure 2), and one of the mounds (Trench B, Figure 2). The fully excavated furnace pit was found to be approximately 1m in diameter, and over 1m deep with a stepped profile (Figures 3 and 4). It is not inconceivable that the lower step was once a ritual pit into which medicines were put to encourage the success of a smelt, as has been seen elsewhere in the Great Lakes and sub-Sahara Africa in general (e.g., van Noten 1983). However, there was no notable variation in this lower fill of the furnace, which comprised a homogeneous dark loose silt, friable and very charcoal-rich, with frequent occurrences of well-preserved charred papyrus. This lower fill was sealed by a large slag block approximately 60cm in diameter and 20cm deep. On removal, it was found to be bowl-like in shape, with a mass of approximately 70kg, and covered in papyrus impressions, especially on its

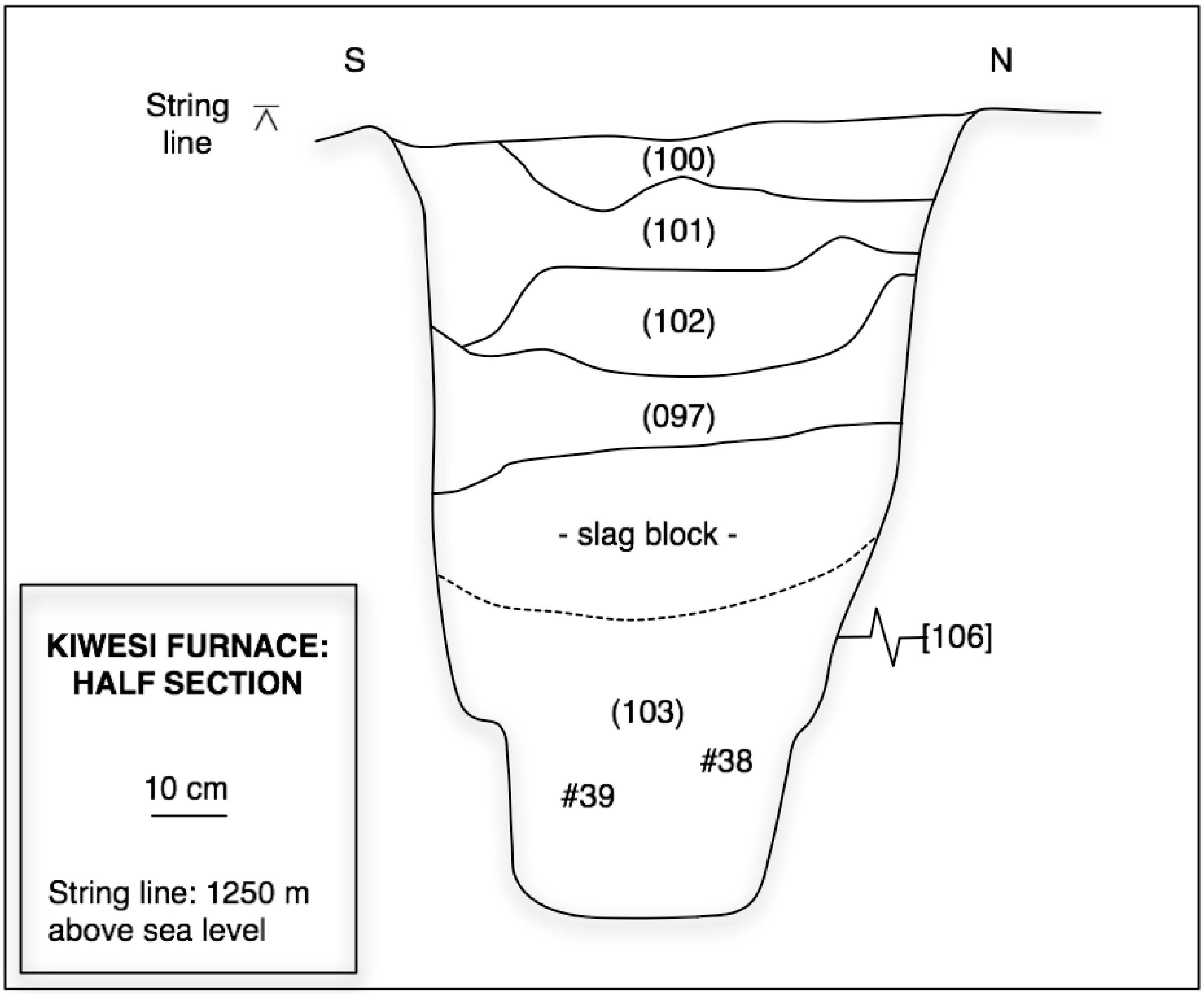


**Figure 3:** Composite section drawing of fully excavated furnace at Kiwesi, Kooki.

**Figure 4:** Furnace at Kiwesi, fully excavated.

upper surface. Above the slag block, the upper fills of the furnace were somewhat mixed. A charcoal sample taken from the lower furnace fill (#38, *cf.* Figure 3) generated a radiocarbon date of 122 ± 29 BP (OxA-20939), which was calibrated to 1697-1940 cal. AD with a 95.4% probability (OxCal 4.1; IntCal09; Bronk Ramsey 2009).

Excavation of two further features was also undertaken, a small mound and a small hollow approximately 200m to the southwest of the furnace. Trench B transected a mound in the south of the village. The mound was found to comprise a built-up pile of mostly unbroken slag blocks arranged in a semi-circle. Beyond this was a shallow hollow, which was quarter-sectioned and found to comprise several thin lenses of deposits, some of which indicated burning. A large volume of tuyères and slag fragments were recovered from both of these features. No furnace remains were discovered in the vicinity, however these features were located in banana plantations with thick ground coverage of plant material. The purpose and formation of these features could not be ascertained during the course of this research, but the regular occurrence of these features in the area suggests that they might present a valuable opportunity to examine the organisation of local iron production on a household scale.

Fifteen slag blocks from Kiwesi were fully recorded, and 11 of these were sampled for bulk chemical analysis. Several had been excavated from the features described above, and several were collected from a cluster of slag blocks located close to the furnace remains (*cf.* Figure 2). The average weight of a single slag block was approximately 45kg. All of the recorded blocks were relatively complete with few fractures, all were similar in size and shape to that excavated from the furnace, and all bore frequent impressions of papyrus, from which it can be deduced that papyrus had predominantly been used to pack the furnaces bases. On sampling, all were found to be very brittle.

*Archaeometallurgical analysis and interpretation.* PED-XRF compositional analysis was undertaken on these 11 slag samples as well as two ore samples (one taken from the furnace and one that was attached to a slag block) and several ceramic samples (a tuyère sample, a sample of furnace wall and two domestic pottery samples). The results of these analyses are presented in Table 1. It is immediately of note that the chemical compositions of the slag samples are remarkably similar across the sample set, indicating that there was minimal deviation from a smelting recipe at this site, even though the sampled slag blocks were obtained from several parts of the modern village.

Looking at the slag chemistry in more detail, the iron oxide contents are relatively low (averaging 51wt%), suggesting that there is not much unreduced iron remaining in the slag, and indicating a fairly chemically efficient process. The low iron oxide levels may be due to the somewhat elevated lime contents of these samples (which average 3wt%). The presence of lime may have been beneficial to the smelts, lowering the melting temperature of the slag and forming calcium-rich olivines (e.g., kirschsteinite) rather than iron-rich olivines (e.g., fayalite), thus freeing up more iron oxide to reduce to iron metal. There is general correspondence between higher lime levels and lower iron oxide levels in these samples, which appears to corroborate this hypothesis in the absence of microstructural analyses.

It is relevant that the analysed ceramics contain very little lime. Technical ceramics can make a significant chemical contribution to slag formation, as they can melt in the high temperature of the furnace and become incorporated into the molten slag (Crew 2000), sometimes deliberately (e.g., David *et al.* 1989). Lime is one of the components of the slag that can be derived from the ceramics in this way. However, in this instance the lime is unlikely to have come from this source as the ceramics were not calcareous, particularly as the high alumina contents of the ceramics indicate that they would have been highly refractory and resistant to melting. Instead, the high alumina to silica ratio in the ore sample from the furnace, and the high alumina levels in the slag suggest that these smelts would have operated at a relatively high temperature. This may have resulted in high fuel consumption, and consequently a high fuel ash contribution to the slag, potentially accounting for the raised levels of lime in the analysed slag samples (see Iles and Martinón-Torres 2009). A considerable fuel ash component may also account for the relatively high potash levels as well as phosphorous and strontium oxides (Paynter 2006).

The analysed ore samples both show viable iron oxide contents, of 83 and 57wt%, suggesting that they may well be representative of the iron ores that were used in these past smelting episodes. They also appear to account for several other components of the slag compositions, namely alumina as well as phosphorous, cobalt and some of the rare earth elements. The phosphorous levels in the slag (averaging 1.9wt%) are of particular note as phosphorous can have a measurable effect on the quality of the iron that is produced. High-phosphorous iron is thought to be more resistant to corrosion (Dillmann *et al.* 2002), but it is also commonly associated with 'cold shortness', i.e., brittleness at low temperatures. With no analyses of iron objects from this region, it is difficult to suggest whether the iron produced at Kiwesi would have displayed the detrimental effects of a high phosphorous content, but it is something that would be worth examining if iron objects are excavated in the future.

*Discussion.* Considering the density of remains at the site and the low level of compositional variation present from slag block to slag block, it is feasible to suggest that an efficient and effective smelting industry was in place in Kiwesi by the late 2nd millennium AD. The families now living there say their ancestors had been smelting on this land for many generations. They associate themselves with Nyoro heritage and say their families moved to Kooki from Bunyoro in the 18th century AD (Iles 2011). Indeed, several western Ugandan smelting clans trace their movements from Bunyoro into this area through the later 2nd millennium AD (Buchanan 1974). By the 18th century AD, Kooki was one of several "autonomous peripheral principalities" (Chrétien 2003: 148), linked to the Bunyoro Kingdom but operating independently of it, retaining its own king and council (Roscoe 1911: 234). The people of Kooki continued to maintain strong links with Bunyoro, through, for example, regular visits to ritual sites such as Mubende (Ingham 1975: 13). What might have encouraged these smelting groups to move from Bunyoro? During this period, droughts and crop failures were a significant problem in western Uganda, and frequent wars are thought to have periodically interrupted trade networks (Bessems *et al.* 2008; Chrétien 2003; Doyle 2000; Iles 2013; Robertshaw *et al.* 2004). Kooki, with access to the food resources and trading opportunities of Lake Victoria, may have been an attractive prospect for metalworking families seeking to improve their fortunes in a time of upheaval and uncertainty.

By the late 18th century AD, Kooki had fallen to Ganda raiding and was paying tribute (in iron hoes and cowrie shells) to the Buganda Kingdom. Buganda, with few iron resources of its own, was keen to acquire the ability to manufacture its own iron. As the historical records suggest strong links between the iron production technologies in this part of Uganda, those further west in Mwenge, and potentially also those to the north in Buganda, it would be valuable to explore further the relationships between smelters in these regions, and the impact these relationships had on smelting styles and technologies. If the Kiwesi smelters had originated in Bunyoro, it is interesting that the style of smelting bears little resemblance to many of the technologies seen further to the west in Mwenge, closer to the Bunyoro heartland (see Iles 2011, 2013). The most immediate difference is the depth and size of the furnace pits. Furnaces in Mwenge measured on average 65cm in diameter and 40cm deep.

The Kiwesi furnace does however bear similarities to the description provided by Reverend John Roscoe of the smelting technology practiced on the border of Kooki and western Buddu in the early 20th century AD. Kiwesi is approximately 10km from the county border over some relatively hilly terrain. Roscoe reports that smelting took place within a pit furnace of about 2 to 3ft deep and 3ft in diameter, which was packed with papyrus stems or grass. A clay rim was built above this pit about 1ft thick and 4in high, and this was used to form the basis of a wall around the top of the furnace, constructed from slabs 4in thick, and made from the soil from anthills (Roscoe 1911: 379-80). Roscoe also reports that two ores were combined in the Kooki-Buddu smelting – one female and one male – a technology that was also in use in Mwenge, where the same gendered associations were also applied (Childs 1998a, 1998b, 1999, 2000; Iles 2011; Iles and Martinón-Torres, in press). Further archaeometallurgical investigation may be able to clarify whether two ores were being used in the Kiwesi smelting technology, thus linking it to the smelting that Roscoe reported, and potentially also the smelting technologies in the core Bunyoro area.

**Masindi District**

*Survey and excavation.* The survey zone in Masindi district covered an area of approximately 30km by 30km, described in full in Iles 2009. Fifty-nine sites relating to iron production were located in this survey zone, mostly characterised by scatters of slag fragments and pottery with occasional furnace bases, as well as a single iron-ore mining site (see map in Iles 2009, Figure 4 and Iles 2011, Appendix C for full survey results and GPS location data). Again, most sites were provisionally dated to the LIA, due to the presence of carved wooden roulette and knotted strip roulette decorated ceramics. The greatest concentration of sites appeared to cluster in the northeastern section of the survey zone. However, this may have been a product of the prolific sugar cane plantations in the south and west of the survey area disturbing archaeological remains and impeding ground visibility.

Iron production remains at one village, Kisengya, on the southern outskirts of Masindi town, were selected for excavation based on the amount of iron production remains in the vicinity and the accessibility of the site. Two furnace bases were excavated, along with a single $2m^2$ test pit; all of these were situated in different areas of the modern village (Figure 5). The test pit excavation, Kisengya 1, revealed an unstratified dumping area of slag blocks in a compound floor. Nine large slag blocks were recorded from this site, of which six were sampled for analysis, but no further excavations were carried out.

The first furnace to be excavated was at Kisengya 2, which was located towards the top of a steep ridge to the south of the Ihungu-Kijunjubwa road. The vegetation was very dense, but there was a concentration of small slag fragments, and on closer inspection furnace remains were faintly visible. The remains were excavated to reveal a circular furnace pit around 50cm in diameter, with vertical sides to about 45-60cm deep (Figure 6). The furnace wall was thickly lined with about 3cm of clay, which was baked hard; the base was unlined, and the dark brown, charcoal-rich, friable furnace fill came down directly onto orange, stony natural. Thirteen kilograms of slag fragments were recovered from the furnace fill, but no coherent slag block. One of these fragments plus a nearby slag block were sampled for further analysis. A charcoal sample was taken from the bottom of the furnace fill (#40, *cf.*

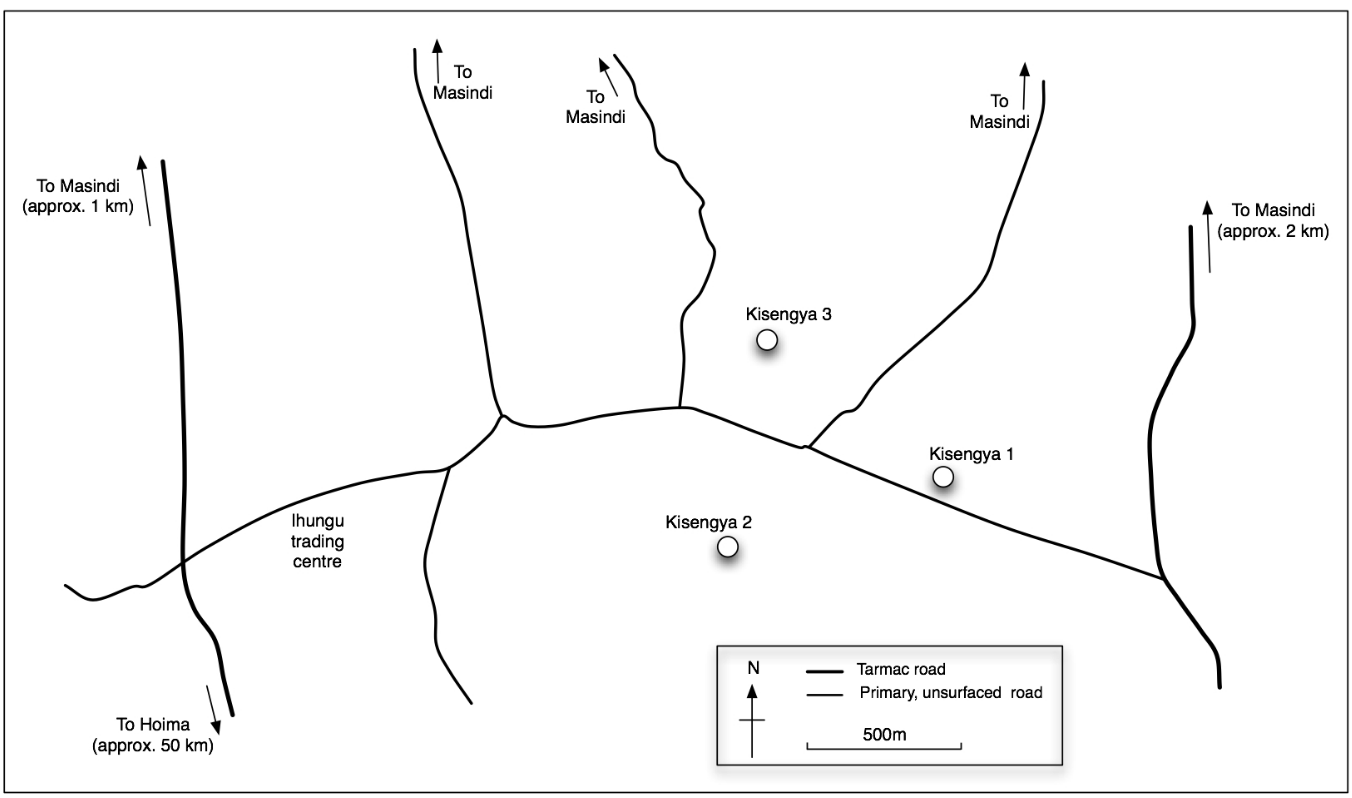


**Figure 5:** Plan of areas of excavation in Kisengya.

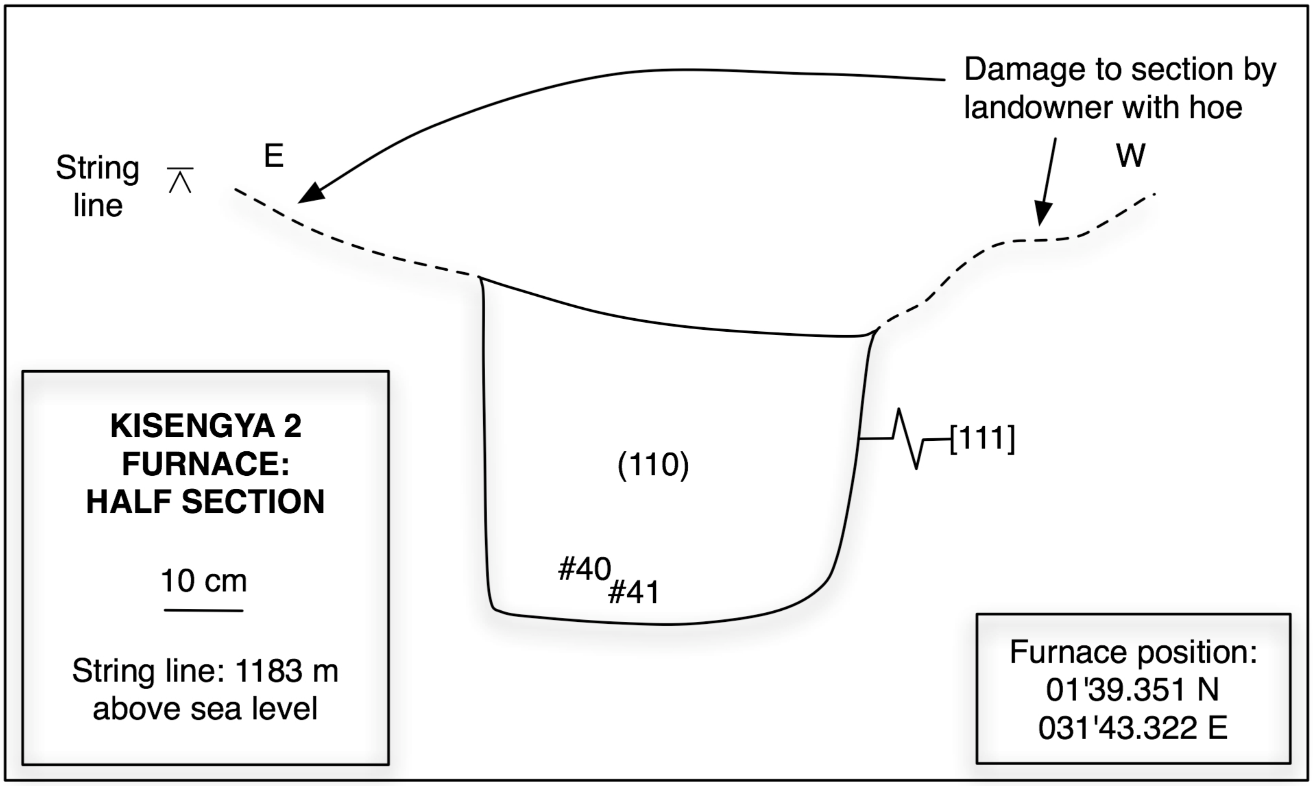


**Figure 6:** Section drawing of excavated furnace at Kisengya 2.

Figure 6), which generated a radiocarbon date of 154 ± 25 BP (OxA-20940), which was calibrated to 1684-1929 cal. AD with a 95.4% probability (OxCal 4.1; IntCal09; Bronk Ramsey 2009).

A second furnace was found next to a narrow pathway at Kisengya 3, less than a kilometre to the north of Kisengya 2 (*cf*. Figure 5). On excavation, the furnace pit was revealed to have a pronounced bowl shape with distinct undercutting, suggestive of a lipped or lidded furnace (Figures 7 and 8). There were no tuyère ports apparent, although these may originally have been above the level of the surviving furnace superstructure. Two slag blocks completely filled the furnace structure, each weighing approximately 30kg. The lower slag block clearly mirrored the shape of the furnace base. A nearby slag cluster contained blocks that were very similar in dimension and weight. Several of these were recorded in detail, and were sampled for further analysis. In total, 14 slag samples were taken from Kisengya for PED-XRF analysis.

*Archaeometallurgical analysis and interpretation.* PED-XRF compositional analysis was undertaken on these 14 slag samples as well as several ceramic samples (1 tuyère sample, 2 samples of furnace wall and 2 domestic pottery samples). The results of these analyses are presented in Table 2. There were several points apparent from the results of the bulk chemical analysis. Firstly, although there is variation within all three groups of slag (Kisengya 1, 2 and 3), within each group there are also some broad similarities that serve to distinguish them from the other groups. However, the samples from Kisengya 1 and 3 are much more similar to each other than the samples from Kisengya 2. This correlates with the consistency in slag morphology between these sites, which might relate to a similar (though not identical) smelting procedure being carried out at these two sites, both of which are situated very close to water sources on relatively low land. Conversely, the slag remains, furnace remains and bulk chemical analysis of slag from Kisengya 2 – situated towards the top of a

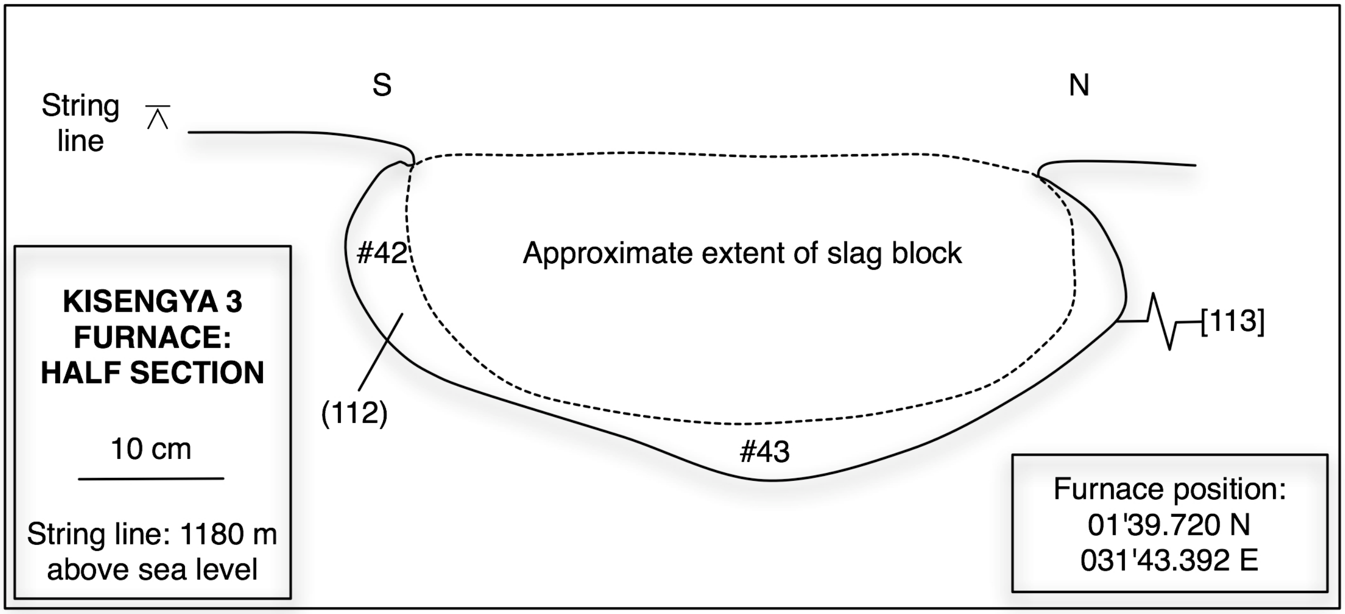


**Figure 7:** Section drawing of excavated furnace at Kisengya 3.

**Figure 8:** Fully excavated furnace at Kisengya 3, looking south.

high ridge – indicate a different technology to those in operation (not necessarily concurrently) in the valley below.

Similar to the Kiwesi slag, iron oxide levels were relatively low (averaging 55wt%), and lime levels were particularly and consistently high in samples from all groups, averaging 4.6wt% and ranging up to c. 8wt%. Also like at Kiwesi, none of the analysed ceramics were calcareous, indicating either a large contribution of fuel ash to the melt or the use of a very lime-rich fuel (see Iles and Martinón-Torres 2009), or perhaps the separate addition of a lime-rich flux. Levels of manganese oxide were also significant. Manganese oxide behaves similarly to lime in a smelt, also lowering the melting temperature of the slag thereby aiding the physical separation of the slag from the iron bloom, as well as forming manganese-rich olivines (e.g., knebelite) freeing up a higher proportion of iron oxides to reduce to iron metal and thus improving the yield. Those samples with high levels of both lime and manganese oxide tended to have the lowest iron oxide.

Manganese oxide levels in these slag blocks were highly variable, ranging from 1wt% to over 6wt%, with variation apparent within as well as between sites. A similar range of manganese oxide levels had also been observed in slag blocks from Mwenge, where it was found that a manganese-rich ‘flux’ was being added to some smelts, potentially correlating with the male ore reported in the ethnographic literature (Iles and Martinón-Torres, forthcoming), and resulting in manganese-rich slags. Although some of the same compounds correlate with manganese oxide in the Kisengya data and the Mwenge data (e.g., barium, neodymium, cerium oxides) it does not appear that a separate manganese-rich flux was being added in the Kisengya smelting episodes. Instead, smelters may have simply been utilising an ore body with variable manganese content. However, a larger sample set would be needed to confirm this hypothesis.

Unlike the slag samples, all the ceramics samples appeared very similar except in silica content. It is feasible that the furnace wall samples, which contained around 80 to 85wt% silica, may have been more heavily tempered with silica than the tuyères, which contained just under 70wt% on average. Conversely, this may reflect a choice of quartz-rich termite clay for this purpose, a strategy that has been documented elsewhere for the preparation of furnace walls (*cf*. Brown 1995: 25). The tuyère sample was fairly refractory with an alumina content of around 20wt%.

*Discussion.* Although the temporal relationships between the Kisengya smelts cannot be resolved at this time, their differences from each other indicates the very high likelihood of smelting variation being encountered within a very small locale. The furnace at Kisengya 3 was of particular interest, as it appeared very similar to Roscoe’s descriptions of smelting furnaces in Hoima. Roscoe documented the royal smelters in Hoima, whose furnaces consisted of round pits, about 50cm deep and about 50cm in diameter. These were lined and covered with clay, which was then baked hard. A hole was left in the cover, which served as a chimney, but also acted as the opening through which the charge of ore and charcoal was fed. Grass and reeds were then lit in the pit to dry out the clay and to warm the furnace prior to smelting. When the smelt was complete, the furnace was broken open and the bloom levered out with green branches (Roscoe 1923: 220-221). The furnaces that Roscoe describes are of a very unusual shape, which corresponds closely to that excavated at Kisengya 3. Unfortunately no date was associated with this furnace.

**Conclusions**

The above analyses have provided a glimpse into the pre-colonial smelting technologies of Kooki and Masindi. Both of these areas were found to be very rich in iron production remains, and warrant a thorough investigation into their industrial histories. In particular, the regional contacts of these locations – the proximity of Masindi to the major salt production site of Kibiro, and the position of Kooki as a link between Bunyoro and Buganda – may prove valuable in understanding the social and economic interactions and exchanges of western Uganda. Only with a much more detailed archaeometallurgical dataset can these broad topics be addressed, but it is hoped that this small study has demonstrated the potential of future archaeological research in these two areas.

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