**Research Article**

# THE ORIGINS OF LATE NINETEENTH-CENTURY MIGRANT DIAMOND MINERS UNCOVERED IN A SALVAGE EXCAVATION IN KIMBERLEY, SOUTH AFRICA

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**ABSTRACT**

*The metric analysis of phenotypic variation observed in human skeletons is valuable for the determination of biological relatedness or ancestry, particularly when testing specific hypotheses concerning the possible ancestry of individuals from unmarked graves. The purpose of this paper is to determine the possible ancestry of unknown individuals excavated from an area next to the fenced Gladstone Cemetery in Kimberley, South Africa, using cranio-morphometry. The skeletons are thought to be those of migrant diamond mine labourers who died between 1897 and 1900. Two historical statements will be tested: firstly that black labourers came to work in Kimberley from various regions in Africa south of the equator and secondly that the local Khoe-San people did not participate in significant numbers as mine workers. Standard craniometric measurements were taken from 59 well-preserved male crania. These measurements were compared to craniometric data of eight modern and archaeological groups of males of known origin from Africa and Asia. Descriptive as well as univariate and multivariate statistical analyses were performed using SPSS. Eleven craniometric variables were selected for analysis. Results obtained are in accord with the historical documents stating that the majority of labourers at the Kimberley mines were migrant workers and that the local communities (including Khoe-San) did not contribute much to the workforce. Many of the labourers came from elsewhere in southern Africa (e.g. KwaZulu-Natal), but some may have originated from further afield. The heterogeneous nature of the sample reflects the varied origins of workers in Kimberley as well as some possible genetic admixture. This study reiterates the value of craniometric analyses as a tool to determine the probability of ancestry of unknown individuals when viewed in the light of contextual historical information.*

Keywords: craniometry, population affinity, multiple discriminant analysis, skeletal remains.

## INTRODUCTION

Phenotypic variation, as observed in human skeletons, and the metric analysis thereof can be a useful tool for the determination of biological relatedness or ancestry of unknown individuals, as it is highly correlated with geographic origin as well as the genetic characteristics of those being investigated (Relethford & Harpending 1994; Roseman & Weaver 2004; Pietrusewsky 2008). Although morphological variation among population groups is continuous and does not reflect clear discontinuous groupings or 'races' in a strict sense, the craniometric investigation of unknown skeletons can still provide researchers with valuable information in terms of probabilities of the ancestry of individuals, when used in conjunction with available historical, archaeological or genetic information (Konigsberg *et al.* 2009; Relethford 2009). This method of investigation is particularly valuable when testing specific hypotheses that can help to trace back the possible origins of individuals from unmarked graves.

Two aspects should be kept in mind when investigating the possible biological affinities of unknown individuals based on their cranial morphology: firstly that the 'real' levels of population diversity present within a region for a specific period in time, although never precisely known, should be taken into consideration during interpretations, and secondly that 'real' levels of population diversity, as predicted by comparative data sets, are dependent on the sample size and nature of the comparative population samples. Despite these methodological difficulties inherent to morphometrical assessment as a tool for the determination of possible ancestry, studies of this kind on past and recent populations are possible (i.e. Franklin *et al.* 2004; Morris & Ribot 2006; Stynder 2009). In fact, these studies prove to be especially valuable in the investigation of unknown population samples from the African continent since these population groups present with high levels of biological diversity and relatively large comparative data sets are available, especially in South Africa (i.e. Howells 1996; Froment 1992; Ribot 2002, 2003, 2004).

The purpose of this paper is to determine, as far as possible, the geographical origins of unknown individuals, whose graves were disturbed during the construction of a storm-water trench alongside the fenced Gladstone Cemetery in Kimberley, by assessing their cranio-morphometric dimensions. The skeletons are thought to be those of migrant diamond mine labourers who died between 1897 and 1900 (Van der Merwe 2007; Van der Merwe *et al.* 2010).

The discovery of diamonds in the central interior of South Africa in the late 1860s sparked not only international interest, with thousands of hopeful diggers swarming to the diamond fields in pursuit of fortune, but also drew labour from African communities of the subcontinent and even beyond, as they moved to exploit the opportunities for material benefits. Describing The Diamond Mines of South Africa, De Beers

Consolidated Mines general manager Gardner Williams recalled, "there (were) adventurers from the United States, Mexico and South America; and white men from all the Colonies of South Africa (mingled) with native Africans (coming from) the Cape to the equator" (Williams 1902: 407).

Most of the labour in the Kimberley mines was provided by migrant black workers. Numbers fluctuated: in 1881 as many as 17 000 "African natives" were employed on the mines, this figure dropping back to some 11 000 in the late 1880s and to around 7000 to 8000 for the period represented by the Gladstone graves (Turrell 1987: 228). From the outset workers were bound by contract to work on the mines for fixed periods, usually for at least three months, after which they could return to their rural villages with their earnings. Labourers from more distant parts would often elect to remain for longer: from the 1880s some workers remained at the mines for up to 18 months or more (Turrell 1987).

From the mid-1880s, 'black' labourers were accommodated in closed compounds, where limited contact with the outside world was a measure for preventing illegal diamond trade as well as increasing company control over the workforce (Turrell 1987; Worger 1987). The compounds were intended also to provide labourers with food and accommodation, and workers' medical needs were additionally taken care of in compound hospitals, in association with the Kimberley Hospital (Williams 1987) – although, in reality, the compounds were overcrowded, the diet inadequate, and medical care deficient (Turrell 1987: 162). In the unfortunate event of death – in a context of notoriously high mortality rates – the black labourers were buried as paupers, wrapped in blankets, often in unmarked graves which often could contain more than one individual, in specified parts of local cemeteries. One of these was the Gladstone Cemetery in Kimberley (Swanepoel 2003).

This study will attempt to test two statements emerging from historical records concerning the origins of the migrant labourers in Kimberley at the close of the 19th century. Firstly, where the documentary evidence of the time suggests that the 'native Africans' coming to the Kimberley mines originated in various regions of Africa south of the equator (Williams 1902: 407; Turrell 1987; Worger 1987), this study seeks to determine the broad geographical origin (within or outside of South Africa) represented by the remains of migrant labourers excavated alongside Kimberley's Gladstone Cemetery. Secondly, it will assess to what extent local Khoe-San communities also laboured on the mines and were accommodated in the compounds. Contemporary records suggest that they did not, in fact, participate in appreciable numbers in mining activities but, like the nearby Tlhaping and Rolong Tswana-speakers, engaged rather in supplying Kimberley with fresh produce and firewood (Kallaway 1981; Worger 1987).

It can be expected that the discovery of diamonds will have had a huge impact on communities living in Kimberley's hinterland, including people of Khoe-San ancestry, and on other African groups who migrated from more distant regions in response to the opportunities in Kimberley for wage labour (Worger 1987). So far, little research has focused on the perspectives offered by the study of skeletal remains on these questions and the role of indigenous miners in late 19th-century Kimberley. This study contributes to the understanding of some of the dynamics of population movements at the time and the involvement of labourers of local origin.

## MATERIALS AND METHODS

One hundred and seven exceptionally well-preserved skeletons, currently housed at the McGregor Museum in Kimberley, were excavated after unmarked graves had been accidentally disturbed by a trench alongside the fenced Gladstone Cemetery (Morris *et al.* 2004). They comprise 86 males, 15 females and 6 individuals of unknown sex. The large number of males in the sample reflects the fact that most of the individuals under study were probably migrant labourers on the mines (Van der Merwe 2007; Van der Merwe *et al.* 2010).

Due to the unequal sex distribution of this sample population a decision was made to include only male individuals in this study. Standard craniometric measurements were taken from 59 males (Knussman & Barlett 1988). Unfortunately 27 (31%) had to be excluded from the study because of poor preservation of the necessary cranial landmarks (De Villiers 1968; Howells 1996).

In order to assess the possible population affinity of the well-preserved male crania from the Gladstone sample, craniometric data of eight modern and archaeological male groups of known origin, mainly from Africa and one from Asia, were used for comparative purposes (see Fig. 1). They correspond to specific regions within Africa ($n$ = 279) and one outside the continent ($n$ = 53). The largest sample comes from South Africa ($n$ = 152), and is represented by at least three modern language groups (Sotho/Tswana, Zulu and various Khoe-San speakers) (see Table 1). The Sotho/Tswana and Zulu data correspond to sub-groups of Bantu-speakers living in the northeastern interior and the central parts of South Africa (De Villiers 1968; Howells 1996). The Khoe-San data correspond to two different samples: a group of various modern San-speaking individuals originating from locations not very precisely documented (Howells 1996); and an archaeological (11th to 19th centuries AD) population from the Riet River site in the Northern Cape Province (Maggs 1971; Morris 1992). People of Khoe-San descent made up a significant component of the indigenous population of the area around Kimberley. Also in Kimberley's near hinterland were Tswana-speaking groups including Rolong and Tlhaping. The Sotho/Tswana comparative sample also represents groups from further away, and the Zulu-speaking component a yet more distant group expected to be present amongst migrants working in the Kimberley mines originating from regions within South Africa (eastern and northern areas including the coast).

Two other regions of sub-Saharan Africa are represented by data originating from two modern Bantu-speaking groups ($n$ = 70), the Suku from Central Africa (central region of the Democratic Republic of the Congo) and the Hutu from East Africa (Rwanda) (Ribot 2003, 2004). These two population samples represent possible migrant labourers originating from more distant regions of sub-Saharan Africa, outside of South Africa itself. Two other comparative groups, originating from North Africa and Asia ($n$ = 110), have been added, as it is known that people working on the Kimberley mines originated from a wide range of countries and every continent (Williams 1902). Although no large Indian sample was available for statistical analysis, late dynastic Egyptian and modern Indonesian data were selected here to detect something of the potentially far wider range of possible geographical origins (Von Bonin 1931; Howells 1996). According to Howells (1996), Indian populations are extremely diverse craniometrically, showing affinities with both Egyptians and various South Eastern Asians.

Statistical analyses were performed using SPSS (version 11.5), and all graphs were generated with SYSTAT (version 10.0). In order to maximise the sample size of the eight comparative groups, 11 craniometrical variables were selected (see

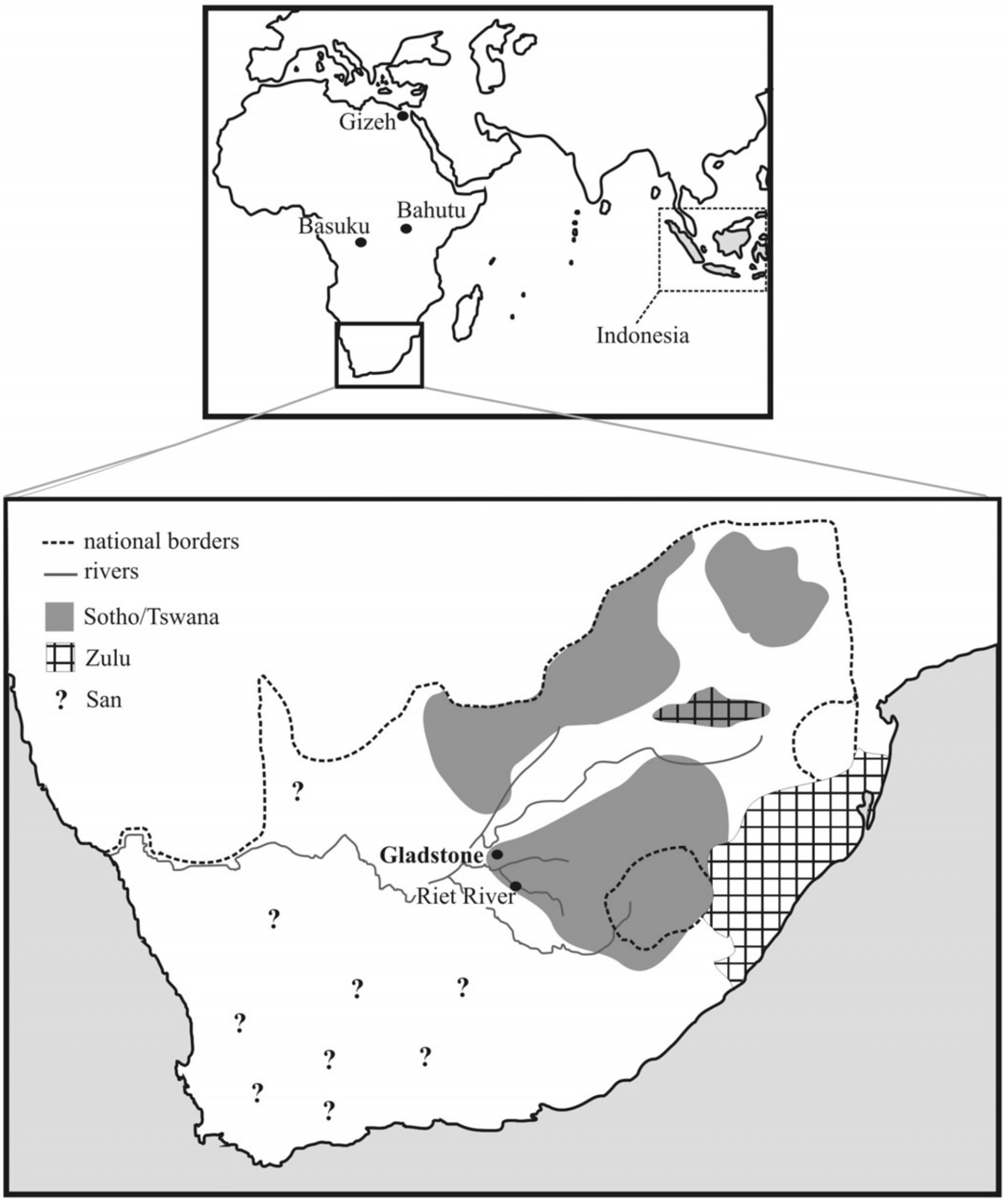


**FIG. 1**. *Geographical distribution of the sample under study: Gladstone Cemetery (Kimberley, South Africa) and worldwide comparative groups (after Giles* et al. *1997; Olson 1996).*

Table 2): cranial length (g–op), cranial breadth (eu–eu), basion–bregma height (ba–b), cranial base length (b–n), basion–prosthion length (b–pr), upper facial height (n–pr), nasal height (n–ns), nasal breadth (al–al), orbital breadth (obb), orbital height (obh) and bizygomatic breadth (zy–zy).

The whole sample was evaluated for normality (i.e. through stem-and-leaf displays) and descriptive data are presented in Table 9. Results obtained from craniometric analyses of the Gladstone crania were compared to the various other populations described above with both univariate and multivariate statistics.

One-way analyses of variance (ANOVA) were performed to assess the differences between various groups by testing the equality of group means. *Post hoc* multiple comparison tests (Scheffe's or Tamhane's tests) were also done in order to localise group differences and similarities. When Levene's test (for homogeneity of variance) was significant, Tamhane's test was used instead of Scheffe's test.

Multiple discriminant function analyses were performed (with sample sizes more or less equal), including a stepwise method and Mahalanobis distances ($D^2$) as it serves as a basis for classifying unknown cases (such as those from Gladstone) into one of the defined groups (such as the eight comparative populations used in this study) (Pietrusewsky 2008). The stepwise method was used to maximise group differentiation: variables were selected individually and evaluated in relation to all other variables to assess whether they meet the criteria of good discrimination between populations. A linear combination of independent variables was produced which corresponded to the best predictive model for population differences. Summarised classifications in percentages were obtained for each group as well as for the unknown specimens. The largest *a posteriori* probabilities (based on discriminant scores) were used to provide an estimate regarding the likelihood of an unknown case belonging to a certain comparative group. In addition, the jack-knifing method was used to cross-validate the final classification results (i.e. misclassified individuals were excluded to provide a less biased estimate of the misclassification rate). Finally, the degree of overlap and range of variation between the various groups was also assessed visually (i.e. plots of two functions with 95% confidence ellipse and centroid for each group).

**TABLE 1**. *List of the comparative male cranial series under study.*

| Region | *n* | Geographic or 'ethnic' origin | Country | Date | References |
|---|---|---|---|---|---|
| Southern Africa | 31 | Sotho/Tswana | South Africa | 20th c. AD | De Villiers 1968 |
| | 55 | Zulu | South Africa | 20th c. AD | Howells 1996 |
| | 48 | Various San | Various | 19th–20th c. AD | Howells 1996 |
| | 18 | Riet River, Orange River Valley (Khoe-San) | South Africa | 11–19th c. AD | Morris 1992 |
| Central Africa | 44 | Suku | Democratic Rep. Congo | 20th c. AD | Ribot 2003, 2004 |
| East Africa | 26 | Hutu | Rwanda | 20th c. AD | Ribot 2003, 2004 |
| North Africa | 57 | Gizeh | Egypt | 7th – 3rd c. BC | Howells 1996 |
| Asia | 53 | Various | Indonesia | 19th – 20th c. AD | Von Bonin 1931 |

**TABLE 2.** *One-way analyses of variance for testing all group differences.*

| Variables[6] | *n*[1] | *F*[1] | Sig.[2] | L.[3] | Groups compared[4] | Significant differences (from highest to lowest) of Gladstone with comparative groups[5] |
|---|---|---|---|---|---|---|
| g–op | 384 | 28.79 | *** | NS | all | IND, BAS, KHS |
| eu–eu | 384 | 22.92 | *** | NS | all | IND, NAFR, BAS |
| ba–b | 384 | 25.78 | *** | NS | all | KHS, BAH, RRV, BAS |
| b–n | 384 | 7.78 | *** | NS | all | KHS, BAS |
| b–pr | 384 | 19.56 | *** | ** | all | KHS, IND, NAFR, RRV |
| n–pr | 384 | 26.34 | *** | ** | all | KHS, BAS |
| n–ns | 331 | 31.56 | *** | NS | all without IND | KHS, RRV, IND, BAS |
| al–al | 383 | 17.74 | *** | ** | all | NAFR, IND |
| obb | 330 | 2.84 | ** | NS | all without IND | no differences |
| obh | 331 | 9.96 | *** | NS | all without IND | KHS |
| zy–zy | 322 | 12.92 | *** | NS | all without IND | KHS, BAS |

[1]$n$ = number of measurements investigated, $F$ = $F$-ratio.
[2]Level of significance (*$P$ <0.05; **$P$ < 0.01;*** $P$ < 0.001).
[3]Levene's test of homogeneity of variances.
[4]Groups with a minimal number of individuals ($n \geq 15$) have been selected for analysis and they are coded as follows: GLD = Gladstone, STW = Sotho/Tswana, South Africa, ZUL = Zulu, South Africa, KHS = Khoe-San, Southern Africa, RRV = Riet River, South Africa, BAS = Suku, Democratic Republic of Congo, BAH = Hutu, Rwanda, NAFR = Gizeh, Egypt, IND = various Indonesia.
[5]Significant differences ($P$ < 0.001) between groups are evaluated with the post hoc multiple comparisons tests.
[6]g–op = cranial length or glabella–opistocranion, eu–eu = cranial breadth or euryon–euryon, ba–b = basion–bregma height, b–n = basion–nasion length, b–pr = basion–prosthion length, n–pr = nasion–prosthion distance, n–ns = nasal height or naso–spinale, al–al = nasal breadth or alare–alare, obb = orbital breadth, obh = orbital height, zy–zy = bizygomatic breadth or zygion–zygion.

In order to investigate the two statements made in historical documents regarding the population composition, two multivariate analyses were done: Analysis I included all data sets (groups within and outside of the African continent) in order to assess the possible multiple origins of individuals within the Gladstone sample population. Analysis II only included data from Africa ($n$ = 322), in order to assess what proportion of the individuals in the Gladstone sample was of local Khoe-San origin.

Analysis I was conducted using only seven variables (instead of all 11 selected initially). Four measurements (nasal length, orbital breadth, orbital height and bizygomatic breadth) were excluded, as they showed only slight differences between comparative populations.

## RESULTS

Descriptive data resulting from the comparison of the Gladstone sample with the eight comparative data sets are presented in detail in Table 9. As was expected, the Gladstone sample appeared to be very diverse (presenting with relatively high standard deviations) for most of the variables, especially for g–op, ba–b and n–pr dimensions (S.D. > 6) (landmark abbreviations as given in the Material and Methods section, also see notes for Table 2). The results obtained from the one-way analyses of variance reflected high levels of group differentiation as the tests for the 11 craniometrical variables are all significant at the highest levels of probability (at least $P$ < .01) (see Table 2). The *post hoc* multiple comparisons tests indicated that the sample from Gladstone Cemetery was very similar to South African Bantu-speaking groups (Sotho/Tswana, Zulu), and significantly different from the other six comparative groups (Khoe-San, Riet River, North Africa, Hutu, Suku and Asian).

Tables 3 to 5 show the results of the multiple discriminant analysis for Analysis I, which compared the Gladstone individuals with all African and other comparative groups, using seven variables (g–op, eu–eu, ba–b, b–n, b–pr, n–pr, al–al). Each function accounts for a percentage of the total variance with the first ones, having the highest 'eigenvalues', being the most important. The eigenvalues (ratio of the between-groups to

**TABLE 3**. *Multiple discriminant analysis I: eigenvalues and percentage of variance for the seven first canonical discriminant functions used in the analysis.*

| Function | Eigenvalue | % of variance | Cumulative % | Canonical correlation |
|---|---|---|---|---|
| 1 | 1.625 | 44.8 | 44.8 | 0.787 |
| 2 | 0.923 | 25.5 | 70.3 | 0.693 |
| 3 | 0.723 | 19.9 | 90.2 | 0.648 |
| 4 | 0.213 | 5.9 | 96.1 | 0.419 |
| 5 | 0.128 | 3.5 | 99.6 | 0.336 |
| 6 | 0.013 | 0.4 | 100 | 0.112 |
| 7 | 0.001 | 0 | 100 | 0.034 |

**TABLE 4**. *Multiple discriminant analysis I: standardised canonical discriminant functions.*

| Variables[1] | Functions (as indicated in Table 3) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| g–op | –0.970 | –0.509 | 0.484 | –0.153 | 0.002 | 0.533 | 0.241 |
| eu–eu | 0.593 | –0.336 | –0.407 | 0.295 | 0.409 | 0.163 | 0.564 |
| ba–b | 0.378 | 0.741 | 0.323 | –0.838 | –0.065 | 0.265 | 0.325 |
| b–n | 0.296 | –0.819 | –0.081 | –0.084 | 0.668 | –1.131 | –0.736 |
| b–pr | –0.111 | 0.820 | 0.208 | 0.434 | –0.475 | –0.207 | 0.982 |
| n–pr | 0.384 | –0.086 | 0.593 | 0.526 | –0.257 | 0.334 | –0.522 |
| al–al | –0.104 | 0.530 | –0.164 | 0.217 | 0.767 | 0.284 | –0.295 |

[1]g–op = cranial length, eu–eu = cranial breadth, ba–b = *basion–bregma* height, b–n = *basion–nasion* length, b–pr = *basion–prosthion* length, n–pr = *nasion–prosthion* distance, al–al = nasal breadth.

within-groups sums of squares) help to assess whether the obtained functions are effective in maximising group differences. A good discriminant function is one that has much between-groups variability in comparison to within-groups variability, therefore high 'eigenvalues' are associated with good functions (below 0.1 the function has no efficiency). The first three functions obtained here were the best in the model as they accounted for most of the variance (90.2% in total) (see Table 3). Their canonical correlations above 0.6 showed the high degree of association between the discriminant scores and the groups.

The higher standardised canonical discriminant function coefficients (above 0.6) are used to indicate the importance of the variables involved, whose different combinations result in different functions (see Table 4). For example, cranial length (g–op) in Function 1, and both cranial base length (b–n) and basion–prosthion length (b–pr) in Function 2 corresponded to the key variables responsible for group differentiation.

The classification results of the multiple discriminant Analysis I are summarised with the predicted membership for each individual in Table 5. In total, only 59% of the cases were correctly classified into their group of origin after cross-validation. This again indicated that there is much morphological overlap between the groups as can also be seen by the scatter plot with the 95% confidence ellipses (see Fig. 2). As a high number of comparative groups were used, Africans in particular were pooled into two groups, of Bantu-speakers (Sotho/Tswana, Zulu, Suku and Hutu) and Khoe-San, for better visual assessment of the variation (although the multiple discriminant analysis considered the original groups separately).

Relative to the available comparative samples, the Gladstone individuals were classified as follows: mainly as Zulu (54%), and in decreasing order with the Suku (13.6%), Sotho/Tswana (10.2%), North Africans (10.2%), Khoe-San (5.1%) and Hutu (3.4%), but never with Riet River (Table 5). More than 80% of the Gladstone group fitted rather well into the Bantu-speaking groups (mainly Zulu and a few others), with a relatively more prognathic face. According to the highest posterior probabilities, three cases (GLD N74.8, GLD N38.7, GLD S2.6) were classified as Khoe-San as a result of a flatter face. Six individuals (GLD N31.E, GLD N38.8, GLD N74.1, GLD NOP3, GLD S2.1, GLD S3.2) were grouped with North Africans due to a flatter face and shorter vault, and two (GLD N34.7, GLD N34.1) with Indonesians as a result of a shorter cranial vault.

Tables 6 to 8 show the results of multiple discriminant Analysis II, which compared Gladstone individuals with only the African groups, using all 11 variables. The first three functions obtained accounted for most of the variance (91.1% in total) (see Table 6). Their canonical correlations (above 0.5) also reflected a relatively high degree of association between the discriminant scores and the groups. For the first two functions, the four variables that presented the highest standardised canonical discriminant function coefficients (above 0.6) were basion–nasion length (b–n) and nasal breadth (al–al) for Function 1, and basion–bregma height (ba–b) and basion–prosthion height (ba–pr) for Function 2 (see Table 7).

Finally, the classification results of multiple discriminant Analysis II are summarised in Table 8. In total, 63.4% of the cases were correctly classified into their group of origin after cross-validation. This indicated slightly less overlap between the groups in comparison to Analysis I (see Fig. 3). According to the highest posterior probabilities, the Gladstone unknown individuals were again mainly classified as belonging to Bantu-speaking groups (Sotho/Tswana, Zulu, Suku and Hutu)

**TABLE 5**. *Multiple discriminant analysis I: classifications in counts (and %) for both the unknown group (Gladstone) and known groups. Total correct classification after cross-validation: 59%.*

| Groups under study[1] | Predicted group membership | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | STW | ZUL | KHS | RRV | BAS | BAH | NAFR | IND | *n* |
| GLD | 6 (10.2) | 32 (54.2) | 3 (5.1) | 0 | 8 (13.6) | 2 (3.4) | 6 (10.2) | 2 (3.4) | 59 |
| STW | **1 (3.2)** | 2 (6.5) | 1 (3.2) | 3 (9.7) | 4 (12.9) | 16 (51.6) | 4 (12.9) | 0 | 31 |
| ZUL | 6 (10.9) | **1 (1.8)** | 1 (1.8) | 8 (14.5) | 1 (1.8) | 30 (54.5) | 6 (10.9) | 2 (3.6) | 55 |
| KHS | 0 | 0 | **31 (75.6)** | 0 | 1 (2.4) | 3 (7.3) | 5 (12.2) | 1 (2.4) | 41 |
| RRV | 0 | 1 (5.6) | 7 (38.9) | **2 (11.1)** | 3 (16.7) | 0 | 5 (27.8) | 0 | 18 |
| BAS | 1 (2.3) | 0 | 5 (11.4) | 30 (68.2) | **0** | 5 (11.4) | 2 (4.5) | 1 (2.3) | 44 |
| BAH | 1 (3.8) | 0 | 2 (7.7) | 2 (7.7) | 13 (50.0) | **5 (19.2)** | 2 (7.7) | 1 (3.8) | 26 |
| NAFR | 2 (3.5) | 0 | 1 (1.8) | 0 | 2 (3.5) | 4 (7.0) | **45 (78.9)** | 3 (5.3) | 57 |
| IND | 0 | 0 | 0 | 1 (1.9) | 1 (1.9) | 4 (7.7) | 6 (11.5) | **40 (76.9)** | 52 |

[1]Groups are coded as follows: GLD = Gladstone, STW = Sotho/Tswana, South Africa, ZUL = Zulu, South Africa, KHS = Khoe-San, Southern Africa, RRV = Riet River, South Africa, BAS = Suku, Democratic Republic of Congo, BAH = Hutu, Rwanda, NAFR = Gizeh, Egypt, IND = various Indonesia. *n* = number of individuals investigated.

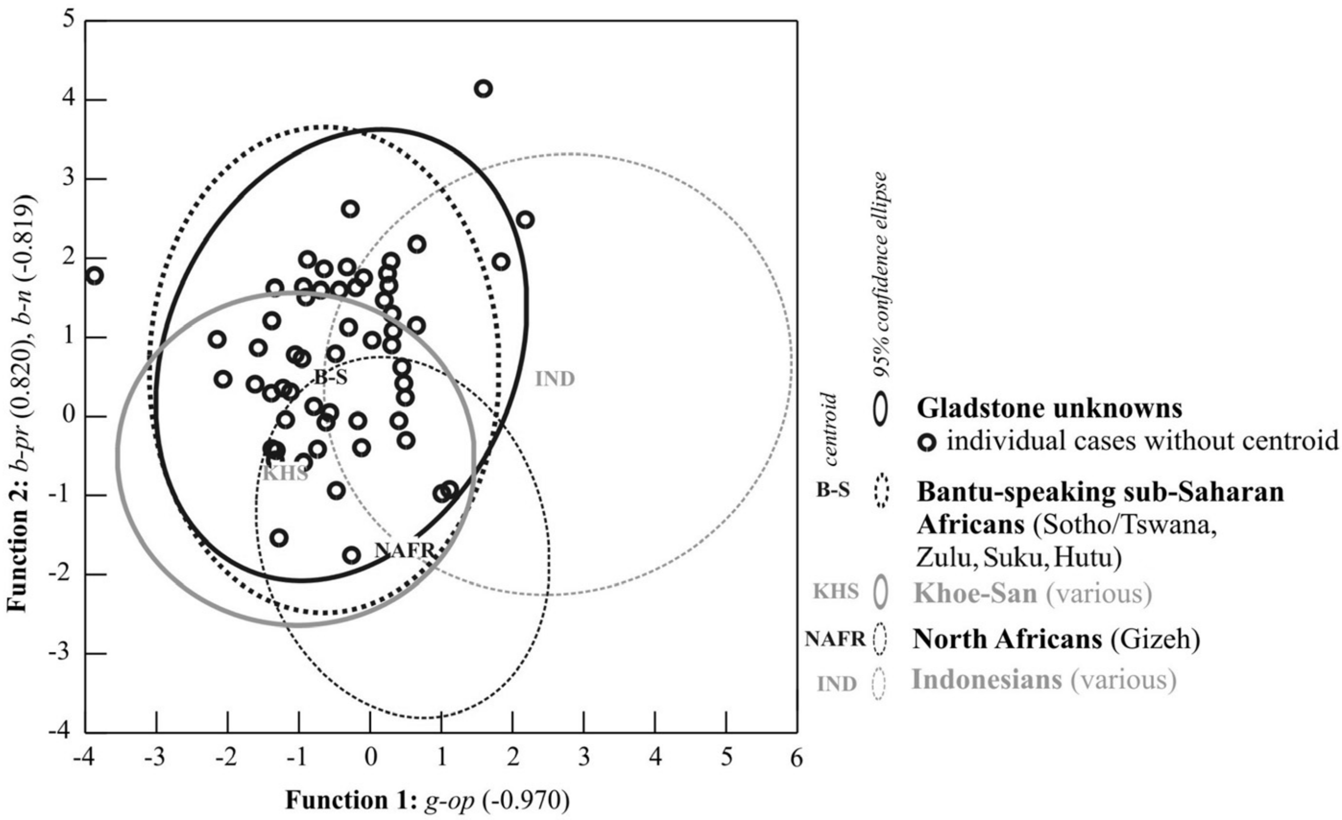


**FIG. 2**. *Discriminant scores plot for analysis I. The two functions account for 70.3% of the total variance. The 95% confidence ellipse with its centroid is shown for each group (for Gladstone individual cases are shown instead of the centroid). Highest standardised discriminant function coefficients are put into brackets for each function.*

(85.9%), owing to a relatively high vault and prognathic face, with the majority again being classified as having greatest affinity with the Zulu comparative sample (52.6%). Slightly more individuals were classified as having a possible Khoe-San and Riet River ancestry (5.3%) owing to a lower vault and flatter face, but less were classified as being of possible North African descent (8.8%) as characterised by a narrower nose.

## DISCUSSION

The possible ancestry of the unknown individuals excavated from alongside the fenced Gladstone Cemetery, based on the craniometric results, should be discussed with caution, as morphological similarities, even in probabilistic terms, do not

**TABLE 6.** *Multiple discriminant analysis II: eigenvalues for the discriminant functions.*

| Function | Eigenvalue | % of variance | Cumulative % | Canonical correlation |
|---|---|---|---|---|
| 1 | 1.896 | 50.1 | 50.1 | 0.809 |
| 2 | 1.036 | 27.4 | 77.5 | 0.713 |
| 3 | 0.515 | 13.6 | 91.1 | 0.583 |
| 4 | 0.178 | 4.7 | 95.8 | 0.388 |
| 5 | 0.118 | 3.1 | 98.9 | 0.325 |
| 6 | 0.041 | 1.1 | 100.0 | 0.198 |

**TABLE 7**. *Multiple discriminant analysis II: standardised canonical discriminant functions.*

| Variables[1] | Functions (as indicated in Table 6) | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| g–op | 0.037 | –0.034 | 0.334 | 0.633 | –0.378 | –0.900 |
| eu–eu | 0.382 | –0.372 | –0.006 | 0.064 | 0.145 | 0.682 |
| ba–b | –0.050 | 0.791 | –0.775 | –0.108 | –0.283 | –0.110 |
| b–n | 0.642 | –0.499 | 0.112 | 0.489 | 0.239 | 0.492 |
| b–pr | –0.529 | 0.635 | –0.030 | –0.497 | 0.201 | 0.396 |
| n–pr | –0.370 | 0.032 | 0.897 | 0.155 | –1.152 | 0.477 |
| n–ns | 1.050 | 0.306 | –0.683 | –0.275 | 0.926 | –0.179 |
| al–al | –0.625 | –0.040 | –0.184 | 0.647 | 0.201 | 0.319 |
| obh | –0.368 | 0.327 | 0.096 | –0.179 | 0.271 | –0.172 |
| zy–zy | –0.125 | 0.033 | 0.637 | –0.190 | 0.327 | –0.490 |

[1]g–op = cranial length or glabella-opistocranion, eu–eu = cranial breadth or euryon–euryon, ba–b = basion–bregma height, b–n = basion–nasion length, b–pr = basion–prosthion length, n–pr = nasion–prosthion distance, n–ns = nasal height or naso–spinale, al–al = nasal breadth or alare–alare, obh = orbital height, zy–zy = bizygomatic breadth or zygion–zygion.

**TABLE 8**. *Multiple discriminant analysis II: classifications in counts (and %) for both the unknown group (Gladstone) and known groups. Total correct classification after cross-validation: 63.4%.*

| Groups under study[1] | Predicted group membership | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | STW | ZUL | KHS | RRV | BAS | BAH | NAFR | *n* |
| GLD | 11 (19.3) | 30 (52.6) | 1 (1.8) | 2 (3.5) | 6 (10.5) | 2 (3.5) | 5 (8.8) | 57 |
| STW | **7 (22.6)** | 12 (38.7) | 1 (3.2) | 3 (9.7) | 3 (9.7) | 3 (9.7) | 2 (6.5) | 31 |
| ZUL | 8 (14.5) | **33 (60)** | 1 (1.8) | 0 | 8 (14.5) | 1 (1.8) | 4 (7.3) | 55 |
| KHS | 3 (7.3) | 1 (2.4) | **30 (73.2)** | 3 (7.3) | 2 (4.9) | 2 (4.9) | 0 | 41 |
| RRV | 2 (13.3) | 0 | 6 (40.0) | **3 (20)** | 2 (13.3) | 1 (6.7) | 1 (6.7) | 15 |
| BAS | 1 (2.3) | 8 (18.2) | 4 (9.1) | 1 (2.3) | **28 (63.6)** | 1 (2.3) | 1 (2.3) | 44 |
| BAH | 1 (4.5) | 1 (4.5) | 2 (9.1) | 0 | 2 (9.1) | **14 (63.6)** | 2 (9.1) | 22 |
| NAFR | 0 | 3 (5.3) | 1 (1.8) | 0 | 0 | 0 | **53 (93.0)** | 57 |

[1]Groups are coded as follows: **GLD** = Gladstone, **STW** = Sotho/Tswana, South Africa, **ZUL** = Zulu, South Africa, **KHS** = Khoe-San, Southern Africa, **RRV** = Riet River, South Africa, **BAS** = Suku, Democratic Republic of Congo, **BAH** = Hutu, Rwanda, **NAFR** = Gizeh, Egypt. n = number of individuals investigated.

necessarily equate directly with biological affinity. In fact, morphological similarities should always be interpreted in relation to the present worldwide variation (clinal in nature with low inter-population differences) in association with historical records for the population under study. However, it is clear that considerable morphological variation is present within the Gladstone sample.

According to the general manager of De Beers, "nowhere else on the face of the earth [could be found] an assemblage of workers of such varied types of race, nationality, and colouring as [on] the South African Diamond Fields" (Williams 1902: 407). Contemporary documentation indicates that "native Africans [came] from the Transvaal, Basutoland, and Bechuanaland, from districts far north of the Limpopo and the Zambesi, from the Cape Colony , Delgoa Bay and countries along the coast of the Indian Ocean from Damaraland and Namaqualand" to pursue opportunities for wage labour on the mines. The workers often travelled thousands of kilometres to the Diamond Fields, mainly on foot, and those coming from far off were often weak and emaciated by the time they arrived (Williams 1902: 413).

A government official, the 'Registrar of Natives', kept records of black labourers arriving at the mines (Smalberger 1976; Williams 1902), noting their identity as "Hottentots, Basutos, Soshaganas (Zulus from North of Delagoa), Mahawa (the Pedi or Secocoeni Basuto), Colonials, Kaffrarians, Mantatees, Batlapin, Swazis, Coolies, Baralongs, Griquas and Mozambique" (Turrell 1987). While many of the labourers were not registered, the records hence incomplete, the documentation nevertheless clearly shows that the majority of black labourers were of Pedi, Tsonga (also known as the Shangaan), Sotho and Zulu speakers. In contrast to what one might expect,

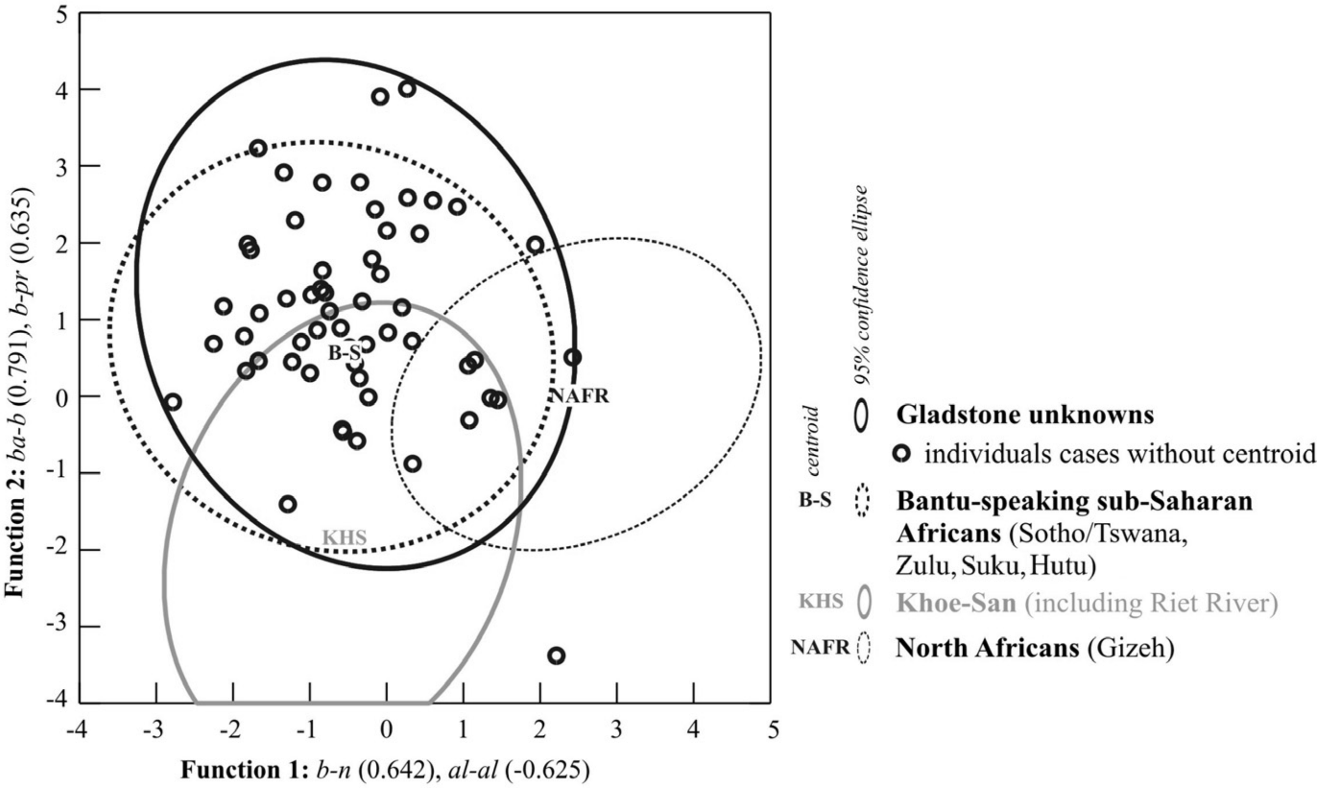


**FIG. 3**. *Discriminant scores plot for analysis II. The two functions account for 77.5% of the total variance. 95% confidence ellipse with its centroid is shown for each group (for Gladstone individual cases are shown instead of the centroid). Highest standardised discriminant function coefficients are put into brackets for each function.*

**TABLE 9.** *Descriptive data for the male sample under study: Gladstone population, including the eight comparative groups.*

| Variables[1] | Gladstone | | Sotho/Tswana South Africa | | Zulu South Africa | | Khoe-San Southern Africa | | Riet River South Africa | | Suku DRC | | Hutu Rwanda | | Gizeh Egypt | | Indonesia | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. |
| g–op | 185.65 | 7.09 | 187.66 | 5.74 | 185.13 | 5.92 | 178.37 | 6.23 | 179.89 | 8.25 | 177.97 | 5.22 | 184.10 | 6.07 | 185.63 | 6.20 | 171.53 | 8.80 |
| eu–eu | 133.16 | 5.71 | 133.82 | 5.80 | 134.11 | 5.09 | 133.59 | 5.12 | 134.83 | 5.40 | 128.84 | 4.88 | 135.27 | 4.45 | 139.28 | 5.00 | 141.49 | 6.33 |
| ba–b | 135.56 | 6.45 | 133.69 | 5.41 | 133.67 | 5.95 | 122.54 | 4.71 | 127.61 | 6.38 | 130.86 | 5.05 | 125.64 | 6.33 | 133.74 | 5.20 | 135.00 | 6.01 |
| b–n | 103.45 | 4.40 | 101.11 | 4.39 | 102.00 | 5.00 | 94.76 | 4.84 | 97.47 | 6.72 | 96.82 | 3.15 | 99.44 | 3.96 | 101.51 | 3.67 | 98.40 | 4.28 |
| b–pr | 104.25 | 5.69 | 101.24 | 4.35 | 102.38 | 6.10 | 93.66 | 5.28 | 97.00 | 7.16 | 99.61 | 5.71 | 101.91 | 6.32 | 96.60 | 3.76 | 96.59 | 4.55 |
| n–pr | 67.58 | 6.18 | 67.71 | 4.71 | 67.33 | 4.07 | 57.51 | 5.32 | 63.72 | 6.23 | 63.31 | 5.20 | 69.10 | 5.16 | 68.54 | 2.90 | 69.28 | 3.87 |
| n–ns | 48.85 | 3.11 | 48.65 | 3.39 | 50.00 | 2.56 | 43.76 | 2.94 | 45.53 | 3.91 | 46.53 | 3.10 | 49.00 | 3.24 | 51.81 | 2.67 | – | – |
| al–al | 28.13 | 1.91 | 28.13 | 2.63 | 28.66 | 1.93 | 27.17 | 2.27 | 25.75 | 2.74 | 27.65 | 2.36 | 27.09 | 1.68 | 24.86 | 1.68 | 26.39 | 1.56 |
| obb | 40.42 | 4.41 | 39.84 | 2.30 | 40.44 | 1.91 | 39.27 | 1.86 | 38.47 | 2.09 | 39.04 | 1.72 | 40.44 | 1.80 | 39.54 | 1.76 | – | – |
| obh | 32.97 | 2.92 | 33.24 | 2.36 | 33.76 | 1.76 | 30.83 | 2.41 | 31.75 | 2.26 | 33.18 | 2.16 | 34.97 | 1.74 | 32.98 | 2.04 | – | – |
| zy–zy | 129.78 | 5.71 | 129.19 | 5.45 | 129.95 | 4.08 | 129.19 | 5.45 | 124.73 | 6.86 | 125.96 | 4.91 | 133.55 | 5.83 | 128.90 | 4.23 | – | – |

[1]g–op = cranial length or glabella–opistocranion, eu–eu = cranial breadth or euryon–euryon, ba–b = basion–bregma height, b–n = basion–nasion length, b–pr = basion–prosthion length, n–pr = nasion–prosthion distance, n–ns = nasal height or naso–spinale, al–al = nasal breadth or alare–alare, obb = orbital breadth, obh = orbital height, zy–zy = bizygomatic breadth or zygion–zygion. S.D = Standard Deviation.

African communities closest to the mines (including the Rolong, Tlhaping, Griqua and Koranna) contributed least to the workforce (Kallaway 1981; Worger 1987; Turrell 1987).

The craniometrical results obtained in this study for both the worldwide (Analysis I) and African (Analysis II) comparisons, largely concur with historical information available for this population sample. Looking at the morphological variation in a broad perspective, the majority of individuals in this sample population was most probably of (Bantu-speaking) sub-Saharan African descent (at least 80%), and especially of southern African origin correlating with the Zulu (at least 50%) and Sotho/Tswana (at least 10%) samples. As corroborated by the historical information cited above, the composition of the mine worker population represented by the Gladstone skeletons clearly reflects a particular southern African context with a high rate of inter-regional migration in the form of migrant labour. In fact, the observed morphologies do not resemble the geographically closest population (including Khoe-San) but rather the more distant Zulu sample. While there is a great degree of overlap between the Bantu-speaking sub-Saharan African groups, other possible origins, such as Central African (Suku: at least 10%) or even to a lesser degree East African (Hutu: at least 3%), cannot be excluded. Only a small percentage (1–5%) of individuals buried in the Gladstone Cemetery were of possible Khoe-San descent.

In some cases possible ancestry could not be specified as the specimens in question presented with a combination of traits reflecting various possible population affinities (perhaps owing to gene flow between various regions). The fact that six Gladstone individuals fell within the range of variability of North Africans (GLD N31.E, GLD N38.8, GLD NOP3, GLD S2.1) and/or Indonesians (GLD N34.7, GLD N34.1) does not necessarily mean that individuals from those regions were present in the sample. It might suggest a wider range of possible origin and/or mixed ancestry in relation to more northern and eastern parts of the world (in addition to sub-Saharan Africa). For example, the morphological similarities observed between the Khoe-San and North African populations (often related to gracility) do not reflect a common origin (Morris & Ribot 2006). It therefore remains difficult to systematically specify the origin of an individual on morphological grounds alone. However, as suggested above, it can indicate some possible gene admixture within the Gladstone population, involving possibly a minimal number of Khoe-San individuals.

Although there are some obvious limitations regarding the assessment of ancestry through metric analysis of skeletal remains, owing to the inherent nature of human variation (which is highest within a 'population'), this study has indicated that the interpretation of craniometric data can be of great value, particularly in the light of contextual data available for a historical 'unknown' group.

While the inter-group variation is highly overlapping on different geographical scales, all results are in accord with historical documentation describing the cosmopolitan nature of the workforce on the diamond mines of Kimberley. High wages were initially one of the main reasons for individuals to travel up to thousands of kilometres from within southern Africa to Kimberley to work on the mines (previously, many had exploited work opportunities in the Cape and Natal Colonies and the Free State). Attempts by the mining companies to lower the wages resulted in the almost immediate exodus of workers (Worger 1987). Their earnings supported and began to transform rural economies in a variety of ways. Some migrant workers (such as the Tsonga) came to Kimberley mainly in order to earn cash for bride-wealth, some to buy farming equipment, for example ploughs and wagons, while others (especially the Pedi and South Sotho) worked in order to obtain a firearm, which was readily available in Kimberley during the early mining years, but forbidden to be sold to Africans from 1877 (Turrell 1987; Worger 1987). Much of this activity, at the start, was subject to chiefly control and other existing social obligations. Thus, for instance, young men returning from the mines would often owe a tribute or a tax from their earnings to the chief (Turrell 1987). This relatively easy chiefly income came at a high price, however, since migrant labour in return also provided labourers with a window of opportunity to challenge chiefly control and to accumulate wealth independently (Turrell 1987). Slowly but surely sterling began to displace cattle as payment for brides, leading to bride-prices being increased to above migrant labour wages, resulting in heightened social and political dissatisfaction within rural societies (Worger 1987; Turrell 1987).

The Gladstone burials relate to a later period, however, when rural autonomy had been considerably eroded throughout much of southern Africa. The loss of land and the imposition of hut taxes were amongst factors that compelled men from rural areas to seek wage labour. Those obtaining work on the mines were recruited for longer periods and at a lower wage (Worger 1987; Pakenham 1992).

Economic factors were the main reason why local populations around Kimberley, such as the Griqua, Kora and Tlhaping, did not generally participate in work on the mines, although small numbers did sell their labour in this way. Instead, they had the means, initially at least, to retain relative independence by selling firewood and fresh produce such as milk, meat and vegetables to the mines and the towns that grew up around them (Kallaway 1981; Turrell 1987; Worger 1987). Here it should be mentioned that very little in the way of vegetables and other fresh produce reached the labouring classes on the mines, since scurvy was a major problem among them, with historical sources indicating that labourers in the compounds were fed mostly with maize and occasional coarse meat (Cape of Good Hope Votes and Proceedings of Parliament 1899; Harries 1994).

With time, however, the depletion of resources (or denial of access to them) forced individuals from these groups increasingly to sell their labour, on farms, in towns or indeed on the mines, albeit in low numbers in proportion to migrant workers recruited from further away. The coming of the railway to Kimberley in 1885 brought in cheaper grain, coal and other products which undercut still further the local trade in fresh produce and firewood (Worger 1987).

Thus, although the Kimberley mines brought new opportunities to the area it is obvious that, just as was observed in the communities providing migrant labour from further afield, it also resulted in social and political changes for the communities in the region around Kimberley itself. The Griqua and the local Khoe-San peoples benefited least of all from the discovery of diamonds in their proximity, and it appears that relatively few of them were taken up in the workforce.

In conclusion it can be said that the craniometric study on the 59 adult males excavated from alongside the Gladstone Cemetery has given substance to the historical records concerning migrant labourers coming to work in the Kimberley mines. They indicate that the greater proportion of labour at the Kimberley mine was provided by migrant workers from beyond Kimberley's immediate hinterland and that the local African communities (including Khoe-San) contributed much less to the labour force in the mines. Many of the labourers came from elsewhere in southern Africa (the relatively high correlation with the Zulu comparative sample suggests the northeastern side of South Africa as one region of origin), even as far afield as the east coast of Africa (possibly even as far as Asia). The relatively heterogeneous nature of the Gladstone sample (as seen in the high degree of morphological diversity) probably reflects the varied geographical origins of the workforce in Kimberley as well as some possible genetic admixture. Owing to the considerable overlap, as can be seen in Figs 2 and 3, however, it remains difficult to specify possible regions of origin more precisely. Nevertheless, this study reiterates the value of craniometric analyses as a tool to determine the probability of biological affinity of unknown individuals when viewed in the light of contextual historical information.

Further research combining both the morphometrical approach and ancient DNA analysis could expand on these results and provide more precise data on the ancestry of the people buried in these unmarked graves.

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