Southern African Field Archaeology 3:82-93. 1994.

THE METALLURGICAL ANALYSIS OF ARTEFACTS FROM JAKKALSBERG, RICHTERSVELD, NORTHERN CAPE*

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*Accepted for publication August 1994

ABSTRACT

Jakkalsberg, an open site on the banks of the Orange River, has been dated to between the 7th and 8th centuries AD. There are a number of indicators suggesting that this is a pastoralist site. The faunal sample is dominated by caprines, the pottery is typical Cape Coastal Ware, and the informal lithic artefact assemblage and the mean size of the ostrich eggshell beads is consistent with local pastoralist sites. A number of corroded iron fragments from the site were subjected to metallurgical analysis. The microstructure, composition, and fabrication techniques indicate that they are likely to be of indigenous manufacture. The absence of any evidence for the smelting of iron on site may point to trade with Iron Age communities further north.

INTRODUCTION

The sites of Jakkalsberg A and B (28.10.50S; 16.53.15E) are located on the southern bank of the Orange River within the Richtersveld Rural Area and about 5 km from the boundary of the Richtersveld National Park (Fig. 1). A local herder alerted the Parks Board to the presence of these sites when he noted a burial being exposed by the wind. The human remains were collected from the edge of the large surface site termed Jakkalsberg A in June 1992. The bone remains and hearths were in danger of rapid disintegration, so a grid was set out and exposed stone artefacts, bone, pottery and ostrich eggshell beads collected. A further concentration of material was noted some 40 m to the southwest of Jakkalsberg A. This second site, Jakkalsberg B, lies partially buried under a small hill and offered the potential of sampling *in situ* material. The Parks Board provided the financial assistance necessary for a thorough investigation of these sites in November 1992 (Webley 1993).

The sites are situated on the edge of a dry river-bed, a tributary of the Orange River which flows some 200-300 m to the north (Fig. 2). The bed of the tributary lies 10 m below the level of the sites, suggesting that it accommodated a considerable flow of water in the past. A number of tree types such as *Euclea pseudebenus, Rhus viminalis, Ziziphus mucronata, Acacia karoo, Tamarix usneoides* and reeds such as *Phragmites communis* are found in a broad band along the Orange River (Van Jaarsveld 1981). There are a number of dead tree-stumps on Jakkalsberg A which may be contemporary with the occupation of the site. Topographically, the area along the river consists of low sand-dunes with occasional outcrops of shale. The area is dominated by the Jakkalsberg mountains, several kilometres to the west, after which the sites are named. The sites are only one kilometre downstream of Skate's Drift, a natural drift across the river.

EXCAVATION STRATEGY

During the initial two-day rescue operation at the site the burial was removed and a total of 81 square metres of material from Jakkalsberg A was sampled. During follow-up work in November 1992 material from a further 18 square metres was collected from the surface of site A, while 26 square metres (called SS or sub-surface) were excavated to archaeologically sterile

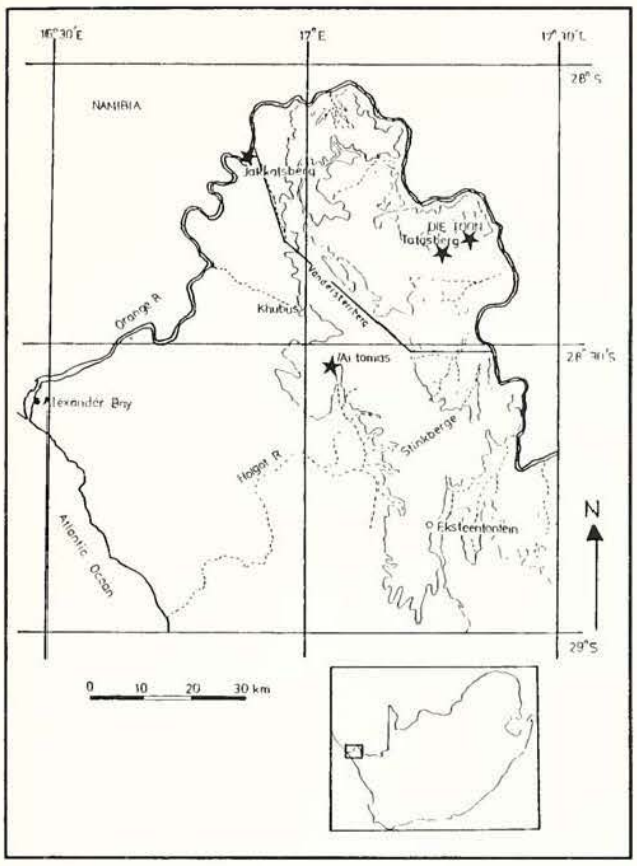

Fig. 1. Map of the Richtersveld, indicating borders of the National Park and the location of Jakkalsberg as well as other archaeological sites investigated in this area.

soils. The division between surface and sub-surface material is quite arbitrary as there is no stratigraphic layering, which would suggest that we are dealing with successive occupation horizons at the A site. Four hearths were identified, plotted and charcoal removed for radiocarbon dating. All the material was excavated, sieved and removed for analysis at the Albany Museum. This material has been studied and a preliminary report is available (Webley 1993).

With respect to site B, this concentration of artefactual material is bounded to the north by a small hill and to west and south by the dry river bed. Material from 38 square metres was collected and excavations concentrated on rows K, J and I (Fig. 2) which abut the hill and contain the greatest depth of deposit. Hearths in these rows were stratified one above the other indicating that re-occupation of the site occurred in the past.

DATING

Hearth 1 from Jakkalsberg A was dated to 1330 ± 60 BP (Pta-5958), which calibrates to AD 664(691)783. Hearth 2 dates to 1300 ± 25 BP (Pta-6100), calibrated to AD 691(762)777 (J. Vogel pers. comm.). Both dates are from hearths only 4 m apart suggesting an occupation during the 8th century AD. At Jakkalsberg B, Hearth 1 in square K11 which was partially wedged into the side of the hill, produced a date of 1420 ± 25 BP (Pta-6122), calibrated to AD 640(652)660. Hearth 2, situated between squares J13-14 in the first occupation unit (MOU) has been dated to 1380 ± 50 BP (Pta-6101), calibrated to AD 648(668)691 (J. Vogel pers. comm.). The fact that some of the hearths, such as in square K12, were superimposed one above the other suggests that this site was occupied on a number of occasions over a relatively short period. Sites A and B are separate but contemporary sites and this is borne out by the analysis of their cultural material.

METAL FRAGMENTS

While excavating in squares J13 and J14 at Jakkalsberg B a badly corroded fragment of iron some 20 mm in length was recovered within the same unit (MOU 2) and only 50 mm from Hearth 2 subsequently dated to 1380 ± 50 BP. It was clearly *in situ*, there being no indication of a pit or burrow to suggest that it had been introduced from above. Subsequently, sorting through the surface material a number of iron fragments as well as an iron bead and a copper percussion cap were recovered. The iron fragments recovered from Jakkalsberg A were concentrated on the northern portion of the site and were not associated with any formal stone artefacts or worked bone implements (Fig. 3). With respect to the spatial distribution of metal items at the B site, a very small area was sampled making it difficult to observe any clear patterning. Nevertheless, the majority of the fragments were found outside the area of densest stone artefact scatter.

The percussion cap and gunflint recovered on the outer edges of the artefact concentration at Jakkalsberg A cast doubts on the integrity of the assemblage and a metallurgical analysis suggested a means by which the nature and possible origins of the metal artefacts could be determined.

ANALYTICAL METHODS

The remains of eight iron artefacts, the one brass percussion cap, and three nodules of possible slag were submitted for analysis to the Materials Laboratory, Department of Archaeology, University of Cape Town (Table 1). All the specimens were photographed, weighed, sketched, measured, and their visual appearance described. Selected samples were sectioned with a water-cooled rotary diamond saw. A polished thick section was prepared for each sample. The sections were mounted in acrylic resin under vacuum to remove air bubbles and ground and polished on rotary laps, with a final ¼ -micron diamond polish.

All the sections were studied with a Reichert-Jung Polyvar dual metallographic/petrographic microscope, using plane polarised light and Nomarski differential interference contrast (Snyman 1989) where appropriate. Grain size was established by visual comparison with standard charts (ASTM 1981; Scott 1991:52-53). Microhardness determinations were made with a

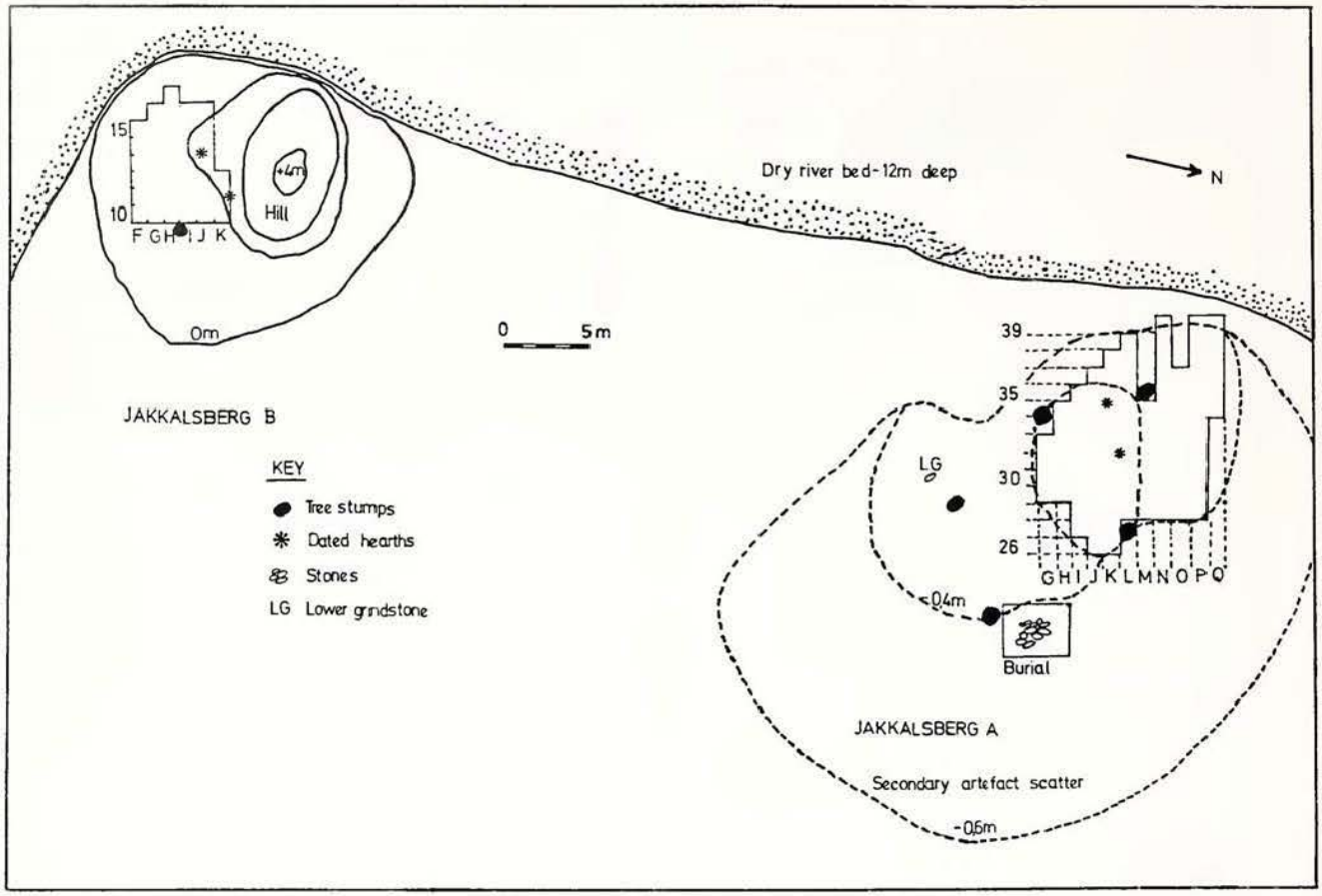

Fig. 2. Map of the location of Jakkalsberg A and B on the banks of a dry river bed, some 300 m to the south of the Orange River.

Table 1. Metal and slag samples submitted for analysis.

Number	Site	Location	Object	Material	Mass (g)
JAK1	Jakkalsberg B	J15 S1	rod	iron	2,38
JAK2	Jakkalsberg B	J15 S1	cap	brass	0,23
JAK3	Jakkalsberg B	J14 Mouz	bar	iron	3,75
JAK4	Jakkalsberg B	F14	bar	iron	0,80
JAK5	Jakkalsberg B	G14	bead	iron	0,10
JAK6	Jakkalsberg	Surface	3 nodules	"slag"	23,5
JAK7	Jakkalsberg A	I32, S5	spatula	iron	1,67
JAK8	Jakkalsberg B	G12, S	strip	iron	0,26
JAK9	Jakkalsberg B	G14, S	strip	iron	1,70
JAK10	Jakkalsberg B	G15, S	3 fragments	iron	0,71
JAK11	Jakkalsberg B	J12, S	strip	iron	0,61

Shimadzu microhardness tester fitted with a Knoop indenter. The Vickers indenter on the available instrument was damaged, necessitating the use of the Knoop indenter, which is not standard for archaeometallurgy. This means that the microhardness measurements quoted here are suitable only for internal comparison[1]. The Knoop indenter is sensitive to anisotropy, both microstructural and crystalline, so measurements were taken in various orientations on the specimens in order to minimise this effect.

The chemical analyses were carried on a Cambridge S200 scanning electron microscope with a KEVEX energy dispersive X-ray fluorescence micro-analysis system (EDS). Analyses were done in spot mode with an analytical volume approximately 1 micron in diameter and in raster mode where appropriate for the determination of bulk compositions. Software ZAF corrections were applied to the analytical results to produce semi-quantitative analyses expressed as elemental or oxide percent, normalised automatically to 100 percent. This system has a precision of about 1 percent for the detectable elements, in this case those with atomic weights heavier than sodium. The lower limit of detection is about 0,1 percent under optimal conditions and values below 1 percent only represent presence or absence information.

DESCRIPTIONS AND ANALYTICAL RESULTS

The metallographic descriptions are presented below and the results of the EDS analyses are listed in Tables 2 and 3. The phases and components were identified primarily on the basis of their optical properties in reflected light as described in standard texts (Samuels 1980; Craig & Vaughan 1981). Where necessary the identifications were confirmed by X-ray fluorescence micro-analysis.

Table 2. Results of energy dispersive X-ray fluorescence analyses of non-oxide phases. The values are significant only to the first decimal place. (r = raster, s = spot).

SAMPLE			ELEMENTS WT. %							
			Al	Si	Cl	Fe	Cu	Zn	Pb	Th
2a	bulk	(r)	-	-	-	-	64,79	35,21	-	-
2b	incl.	(s)	-	0,15	0,14	-	64,44	35,02	0,25	-
2c	incl.	(s)	0,70	0,99	0,83	-	12,35	7,68	77,45	-
2d	incl.	(s)	-	0,66	10,00	-	40,34	12,72	36,27	-
2e	incl.	(s)	0,67	0,38	-	-	38,06	15,52	49,70	0,28
2f	incl.	(s)	0,94	0,45	-	-	40,85	15,08	47,44	-
5a	bulk	(r)	-	0,36	-	99,64	-	-	-	-
5b	bulk	(r)	-	0,30	-	99,70	-	-	-	-
7a	bulk	(r)	-	-	-	99,30	0,70	-	-	-
7b	bulk	(r)	-	-	-	98,78	1,22	-	-	-
7c	ferrite	(s)	-	-	-	100	-	-	-	-
7d	ferrite	(s)	-	-	-	100	-	-	-	-
7e	ferrite	(s)	-	-	-	100	-	-	-	-

Table 3. Results of energy dispersive X-ray fluorescence analyses of oxide phases. The values are significant only to the first decimal place. (r = raster, s = spot).

SAMPLE			OXIDES WT. %								
			Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	MnO	FeO	Fe_3O_4
5c	incl	(s)	-	-	0,61	27,16	-	1,19	-	-	71,03	-
5d	incl.	(s)	-	-	0,49	21,76	-	1,79	-	-	75,97	-
5e	incl.	(s)	-	-	0,50	26,32	-	0,91	-	-	72,26	-
6Aa	bulk	(r)	2,39	2,82	12,17	63,74	1,43	4,99	1,02	-	11,44	-
6Ab	glass	(s)	3,77	-	25,58	57,30	0,40	11,64	-	-	1,31	-
6Ac	glass	(s)	-	18,11	1,61	52,48	-	7,35	0,74	-	19,72	-
6Ad	glass	(s)	4,49	-	29,10	52,32	0,20	13,56	-	-	0,34	-
6Ae	glass	(s)	-	17,49	0,60	50,71	-	14,61	0,76	0,46	15,37	-
6Af	stl	(s)	-	-	1,13	3,13	0,39	0,68	0,88	1,05	-	92,74
6Ba	bulk	(r)	-	2,65	14,08	62,36	1,38	4,97	1,03	0,41	13,13	-
6Bb	glass	(s)	4,27	-	28,00	53,43	0,23	12,99	-	-	1,09	-
6Bc	glass	(s)	-	18,74	0,31	52,90	-	16,64	0,50	-	10,91	-
6Bd	glass	(s)	5,16	0,08	19,55	60,01	1,11	7,46	0,74	-	5,90	-
6Be	stl	(s)	-	13,05	4,14	9,18	-	0,95	2,47	-	-	70,22
6Ca	bulk	(r)	-	2,52	14,99	60,42	1,71	3,72	1,04	-	15,60	-
6Cb	glass	(s)	-	-	17,94	71,04	6,92	3,15	-	-	0,95	-
6Cc	glass	(s)	6,49	-	21,59	61,68	1,05	6,94	-	-	2,26	-
6Cd	glass	(s)	-	3,01	21,78	56,02	1,76	2,59	1,18	-	13,64	-
6Ce	glass	(s)	-	3,80	15,56	61,85	1,46	4,02	1,34	-	11,97	-
7f	incl.	(s)	-	-	0,20	82,12	0,51	-	-	-	17,17	-
7g	incl.	(s)	-	-	5,14	71,71	1,65	6,20	0,68	2,38	12,43	-
7h	incl.	(s)	-	-	6,79	70,76	1,10	7,41	0,67	2,68	10,58	-
7i	incl	(s)	-	-	6,38	75,99	1,37	7,70	0,73	2,29	5,54	-

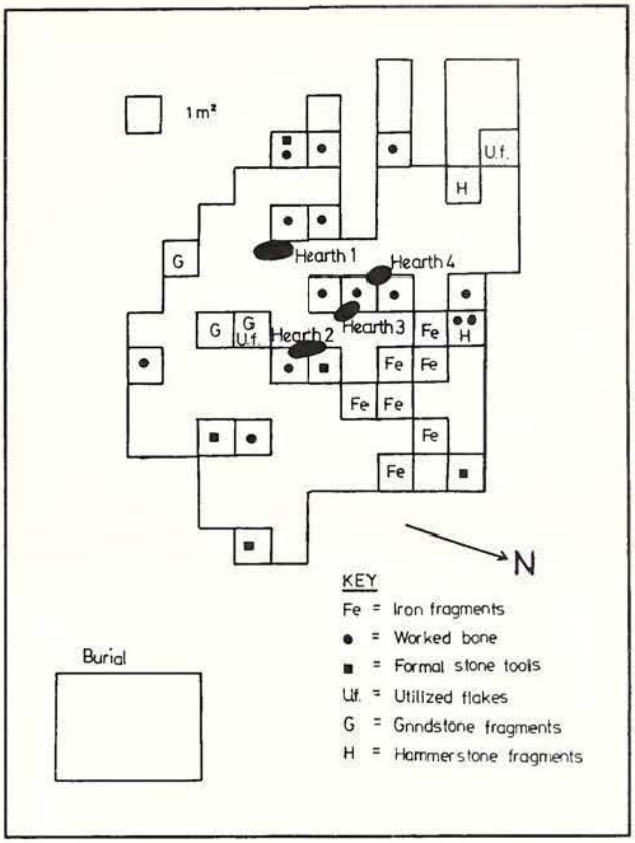

Fig. 3. Plot of the distribution of iron fragments, worked bone as well as formal and utilized stone artefacts at Jakkalsberg A.

Sample JAK 1: Jakkalsberg B J15 S1, iron rod

This was a fragment of corroded iron rod (Fig. 4), 26,5 mm long and with a square cross-section of about 8 mm. It was dark brown, with adhering sandy corrosion products, had a mass of 2,38 g and was magnetic.

A polished transverse section (Fig. 5) showed that it was almost completely corroded with only tiny traces of the original metal, but with numerous 2-phase inclusions typical of bloomery iron (Samuels 1980; Piaskowski 1992). These inclusions were elongated and convoluted, indicating substantial hot-working of the original metal. The original metal microstructure was not discernible.

The inclusions in this sample, and all the other completely corroded samples, were not analysed chemically because of the impossibility of distinguishing in the SEM between the predominantly oxide inclusions and the surrounding oxide corrosion product.

Sample JAK 2: Jakkalsberg B J15 S, brass percussion cap

This was a brass percussion cap (Fig. 4) in the form of a cylindrical tube, with both ends splayed, and one split raggedly. It was dark brown with bright green corrosion products, had a mass of 0,23 g and was not magnetic.

The polished longitudinal section consisted of yellow brass, with some dezincification along grain boundaries and at the margins where secondary copper had crystallized. The etched longitudinal section showed that the metal was intensely deformed, with characteristic slip bands criss-crossing the original grains (Fig. 6). The average grain size was about 0,15 mm although the size varied considerably. At either end the deformation was particularly severe, with grains flattened and sheared. The Knoop microhardness in the central region was HK = 200 (100 g load, 15 s, range 185-232, n = 5). This is a high value which reflects the extensive cold-working undergone during deformation of the cap. There were numerous small oval inclusions with blue-stained, etched surfaces. At both ends there was extensive intergranular corrosion and corrosion along slip lines in the most severely stressed regions.

The bulk composition was approximately 65:35 Cu/Zn (Table 2:2a). This is about the upper limit of zinc for a soft single phase alpha brass (Scott 1991:19). The inclusions, forming typical small elongated globules on grain boundaries, all contained lead (Table 2:2b-f), up to 77% in one analysis, and also a trace of thorium, which was probably an accidental contaminant of the lead. Lead is a common additive to brass, making the alloy softer and easier to work. In the case of this percussion cap, easy deformation was evidently a desired advantage. This

Fig. 4. Photograph of specimens JAK 1 - 5, from left to right (scale in mm).

Fig. 5. Polished transverse section of iron rod JAK 1, showing the severe corrosion of the iron bar (9 X).

Fig. 6. Etched longitudinal section of brass cap JAK 2, showing slip bands in intensely deformed grains (140 X).

brass object was obviously modern, the product of a mechanised process, and a relatively recent addition to the assemblage at this site.

Sample JAK 3: Jakkalsberg B J14 Mou2, iron bar

This specimen consisted of two fragments of a very corroded iron bar (Fig. 4). The two fragments totalled 46,5 mm in length and the cross-section was approximately 10 mm square. The fragments were dark

Fig. 7. Polished longitudinal section through the tip of iron bar JAK 3, showing the preservation of the original outline (36 X).

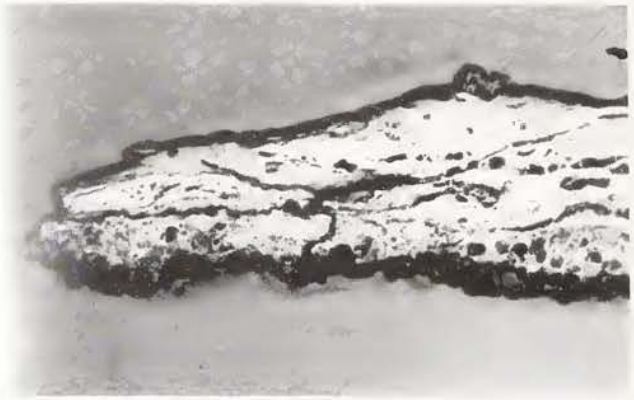

Fig. 8. Polished section of iron bar JAK 4, showing complete corrosion (7 X).

brown, with adhering sandy corrosion products, had a combined mass of 3,75 g and were magnetic.

The polished longitudinal section showed that the original metal was virtually all oxidised with only a few very tiny remnants left. The original outline of the pointed bar was clearly visible in the corrosion products (Fig. 7) but there was no preservation of the original microstructure. Typical 2-phase bloomery inclusions were lacking but there were some glassy stringers that may have represented original inclusions. There was thus no unequivocal evidence that this material represented bloomery iron. The median crack (Fig. 7) may indicate that the object was fabricated by bending a flat bar back over itself during hot-working.

Sample JAK 4: Jakkalsberg B F14, iron bar

This was a very severely corroded iron bar which had disintegrated into a number of fragments. The largest was cigar-shaped, about 15 mm long and 5 mm in maximum diameter (Fig. 4). It was dark brown, magnetic and had a mass of 0,80 g.

The polished longitudinal section showed that the metal was completely corroded and delaminating (Fig. 8). There were strings of very elongated single-phase glassy inclusions and also numerous strings of 2-phase

Fig. 9. Polished section of iron bar JAK 4, showing fractured 2-phase inclusions with light wüstite globules in a darker glass (562 X).

Fig. 11. Etched section of iron bead JAK 5, showing light ferrite with coarse pearlite islands and a dark 2-phase inclusion (280 X).

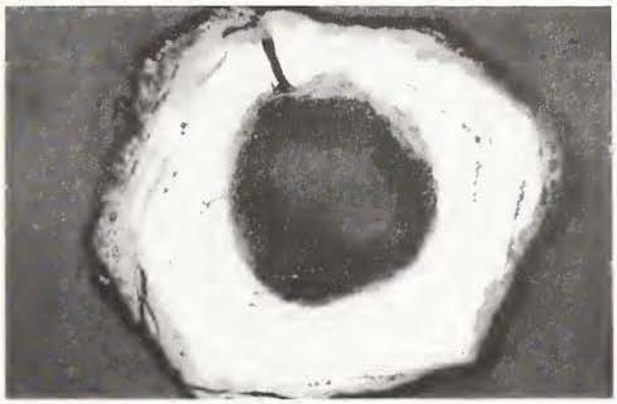

Fig. 10. Polished transverse section of iron bead JAK 5, showing the original hexagonal outline (14 X).

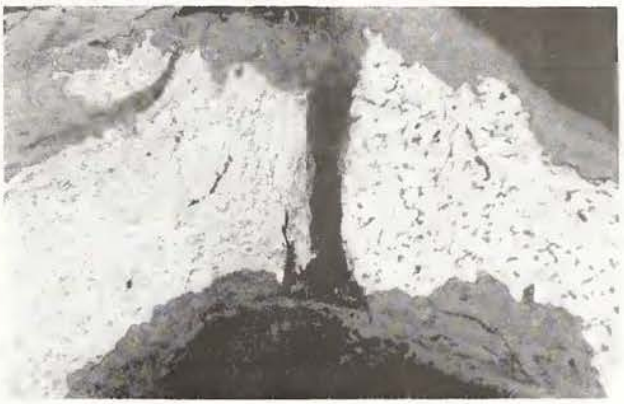

Fig. 12 Etched section of iron bead JAK 5, showing grain deformation at the join (56 X).

inclusions consisting of yellowish-grey blobs of wüstite in a darker glass (Fig. 9). These typical bloomery iron inclusions were elongated and transversely fractured, indicating initial hot-working followed by cold-working below the glass transition temperature of the inclusion matrix. This temperature is strongly composition-dependent but is typically between about 500°C and 700°C (Babcock 1977:26).

Sample JAK 5: Jakkalsberg B G14, iron bead

This was a corroded iron bead, about 4 mm in diameter, 2,9 mm thick, and with an approximately 1 mm diameter hole (Fig. 4). It was very dark brown, had a mass of 0,10 g and was magnetic.

A transverse section showed that the bead was corroded both on the outside and around the hole, although the roughly hexagonal original outline was clearly visible (Fig. 10). There was an unwelded join on one side. Corresponding opposite sides were not parallel so the object was not a small nut.

The metal was inhomogeneous, with inclusion banding and chemical segregation banding. The latter was due to inhomogeneity in the carbon distribution, visible after etching for 10 s in nital. Segregation banding is very common in bloomery iron (Miller 1992:149) and is usually caused by inhomogeneity in the distribution of minor amounts of arsenic or phosphorus, which in turn affect the stability of ferrite (Tylecote & Thomsen 1973). The EDS analysis of the metal detected no significant alloying elements other than about 0,3% silicon (Table 2:5a, b)[2]. The overall carbon content was low, about 0,01-0,02% C and the average Knoop microhardness was HK_K = 236 (100 g load, 15 s, range 190-263, n = 65). The range in microhardness reflected the range in carbon composition and associated grain size. The low carbon areas consisted of large ferrite grains (ASTM 5) while the higher carbon areas had much finer grain size (ASTM 9-10)[3]. These areas consisted of ferrite with islands of coarse pearlite and thick cementite envelopes (Fig. 11). This structure implies a slow cool from an anneal at temperatures between about 723°C and about 900°C (Samuels 1980:67).

The bead was annealed before the final cold-working. There is grain deformation at the join and the orientation of the inclusion strings indicated that the metal in the join area had been cut with a chisel before being hammered closed (Fig. 12). The inclusion strings also followed the hexagonal outline (Fig. 10), so the bead had been forged into shape, and not faceted by subsequent grinding. The inner grains had been compressed and the outer grains

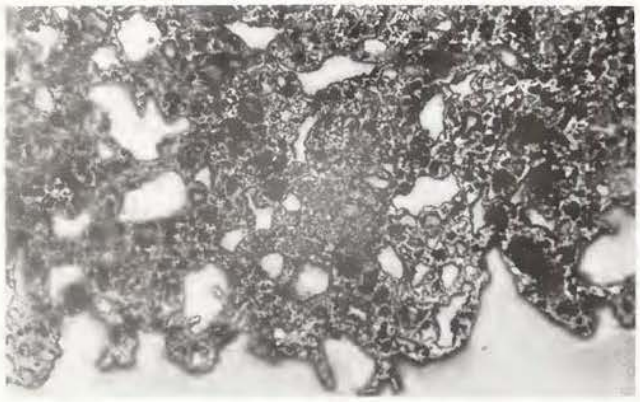

Fig. 13. Polished section of glassy nodule JAK 6B, showing irregular porosity (7 X).

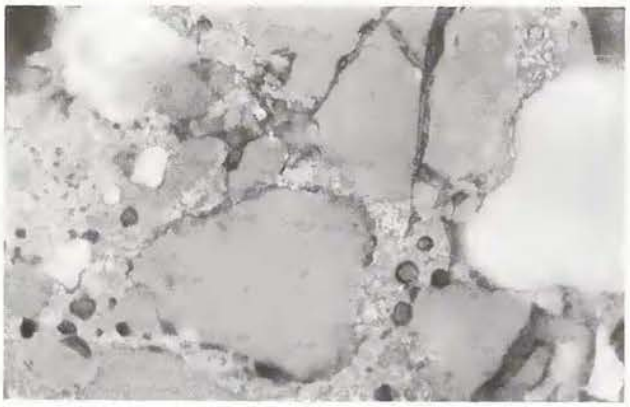

Fig. 14. Polished section of glassy nodule JAK 6B, showing light grey sand grains and bright magnetite dendrites in glass matrix (224 X).

flattened during fabrication. The areas of most intense cold-work, and hence residual strain, have been corroded preferentially.

There were elongated strings of transversely fractured 2-phase inclusions consisting of light blobs of wüstite in a darker material (Fig. 11). The EDS spot analyses of the dark phase showed that it had the composition of fayalite (Fe_2SiO_4) with an insignificant 1% CaO and 0,5% Al_2O_3 (Table 3:5c-e). These are typical bloomery iron inclusions.

This bead was fashioned from a hot-worked strip which had been annealed and cooled before cutting the ends, bending it around, and flattening the sides. The composition and fabrication technique are consistent with its being of indigenous manufacture, although to my knowledge no similarly shaped hexagonal iron beads have been reported from other southern Africa sites.

Sample JAK 6: Jakkalsberg surface, "slag"

This sample consisted of three nodules of what appeared to be some form of slag. They were all three reddish-brown, very vesicular, amorphous and very weakly magnetic. They were designated A, B, and C, and had masses of 11,10 g, 9,35 g and 3,05 g respectively. They were roughly cuboid chucks measuring between 38 mm and 20 mm per side.

The polished sections revealed that they were all very similar. They were very porous, sandy, ferruginous, glassy nodules. A and B had very irregular porosity (Fig. 13) while C had more spherical pores. All three consisted of partly-fused quartz sand grains in a vesicular matrix of glass, which contained areas with lath-like crystallites and scattered patches of small, highly reflective dendrites (Fig. 14).

The bulk compositions, determined by using a large EDS raster size, were all very similar with average values of 62% SiO_2, 14% Al_2O_3, 13% FeO, 4,5% CaO, 3% MgO, 1,5% K_2O as the major elements in common (Table 2:6Aa, 6Ba, 6Ca). The bulk compositions were so similar that these three nodules must be the result of the same process. Raster analyses of the glassy areas themselves showed much greater variability, even within single nodules, because of the local inhomogeneity of the glass and the variable density of inclusions (Table 3:6Ab-e, 6Bb-d, 6Cb-e). The glass was predominantly SiO_2, with very variable amounts of Al_2O_3, CaO, and FeO, but unfortunately the composition gave no clear indication of its origin. Part of the variability in the FeO values of the analyses was due to presence of inhomogeneous distributions of clouds of minute magnetite crystallites and dendrites. Some of these crystals projected into the gas cavities forming the porosity in the glass and could be analysed without too much interference from the surrounding glass. The EDS analysis of such tiny crystals was difficult because they were each only a few microns across but they consisted predominantly of iron oxide (Table 3:6Ae, 6Be). They were identified as magnetite on the basis of their composition, dendritic form, high lustre, and the ability of the samples to attract a sensitive compass needle.

The origin of this glass is discussed below, but it is very doubtful that it is the product of a metallurgical process.

Sample JAK 7: Jakkalsberg A I32 SS, "slag" and iron spatula

This sample consisted of one small piece of "slag" and a very fragmented iron spatula. The apparent slag was a small glassy nodule similar to those of JAK 6, but not appreciably magnetic. It had a mass of 0,07 g. Unfortunately, the sample disintegrated during preparation so there was no opportunity to describe it more fully. The five iron fragments could be reassembled into a small spatulate object (Fig. 15), possibly a small knife blade or adze-like scraper, with a total length of about 45 mm and about 9 mm at its broadest. It varied in thickness from about 1 mm at its pointed end to about 6 mm at the broad rounded end. The total mass of iron was 1,60 g and all the fragments were magnetic.

Two transverse specimens were prepared. Both were severely corroded, but distinctly curved, with the original outlines still visible (Fig. 16). The object had a laminated structure, evident from the orientation of the small areas of original metal. Etched in nital, these had fine grain size (ASTM 8-9) consisting of equiaxed ferrite with

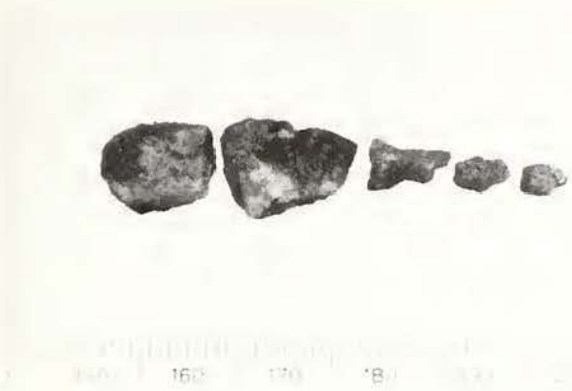

Fig. 15. Photograph of the reconstructed iron spatula JAK 7 (scale in mm).

Fig. 16. Polished transverse section of iron fragment JAK 7, showing curved cross-section (7 X).

Fig. 17. Etched section of metal in JAK 7, showing white ferrite and dark coarse pearlite (280 X).

thick-grain boundary cementite and islands of coarse pearlite (Fig. 17). The overall composition was about 0,3-0,4% C. This microstructure indicated annealing between 723°C and about 900°C, followed by a very slow cool. The bulk composition was determined in two different areas of residual metal and consisted of about 99% iron with 1% copper, although three spot analyses of ferrite grains indicated only iron (Table 2:7a-e).

There were no typical 2-phase bloomery inclusions

Fig. 18. Polished section of iron fragment JAK 7, showing fractured glassy inclusions (450 X).

Fig. 19. Photograph of iron fragments JAK 8 (scale in mm).

but there were elongated and transversely-fractured glassy inclusions (Fig. 18). These consisted predominantly of SiO_2, with subsidiary amounts of FeO, CaO, Al_2O_3, MnO, K_2O, and TiO_2 (Table 3:7f-i). There is nothing special about this glass composition. The CaO and K_2O act as a flux in glass formation, and the Al_2O_3, MnO, and TiO_2 resist reduction at the relatively low temperatures of bloomery iron-smelting and consequently end up in the slag-derived inclusions (Todd & Charles 1978). The inclusion morphology showed that the object had been hot-worked, and then worked below the glass transition temperature (500 - 700°C), before being annealed and cooled. This is typical of temperature cycling in a forge and is a common feature of indigenous bloomery iron objects (Miller 1992).

Sample JAK 8: Jakkalsberg B G12 S, two iron fragments

This specimen consisted of two pieces of very corroded iron. Both were dark brown and magnetic, and had a combined mass of 0,26 g. The smaller fragment was irregular but the larger was in the form of a curved strip (Fig. 19) with overall dimensions of 8 mm by 5 mm by about 4 mm thick. A transverse section was cut from the larger fragment.

The metal was almost completely corroded except for very minute areas of residual iron (Fig. 20). The original

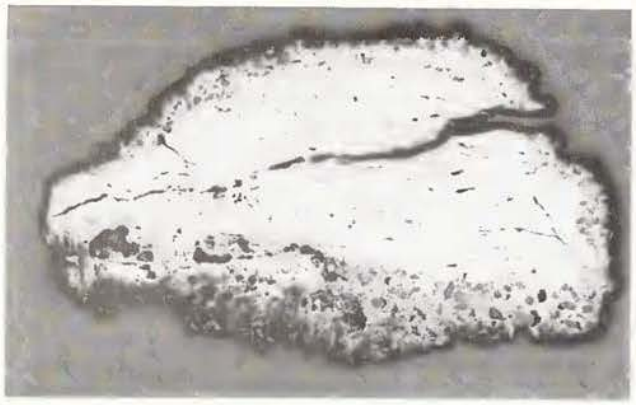

Fig. 20. Polished section of iron fragment JAK 8, showing almost complete corrosion of the metal (14 X).

Fig. 21. Photograph of iron strip JAK 9 (scale in mm).

Fig. 22. Polished section of corroded iron strip JAK 9 (7 X).

microstructure was not discernible but there were elongated, transversely fractured glassy inclusions which indicated cyclical hot- and cold-working.

Sample JAK 9: Jakkalsberg B G14 S, iron strip

This specimen was a piece of heavily corroded iron strip or flattened bar, fractured at both ends (Fig. 21). The length was 22 mm, the breadth 10 mm, and the thickness about 4 mm. It was dark brown, had a mass of 1,70 g and was magnetic.

A transverse section showed that it was virtually

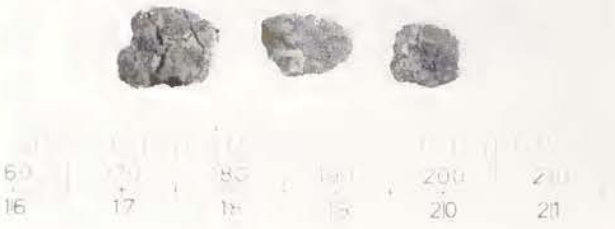

Fig. 23. Photograph of sample JAK 10 (scale in mm).

Fig. 24. Photograph of iron strip JAK 11 (scale in mm).

completely corroded (Fig. 22). There was residual pearlitic structure preserved in places in the corrosion product but the original carbon content could not be determined. The sparse, elongated, transversely-fractured, glassy inclusions were evidence for cyclical hot- and cold-working.

Sample JAK 10: Jakkalsberg B G15 S, three iron fragments

This sample consisted of three flat, irregular iron fragments (Fig. 23). All three were very severely corroded, dark brown and magnetic, with dimensions under 10 mm square and about 4 mm thick. The combined mass was 0,71 g. The specimen selected for sectioning disintegrated while being sawn and the friability of the other two precluded their being sectioned.

Sample JAK 11: Jakkalsberg B J12 S, iron strip

This specimen was a fragment of broad iron strip with one side bent up slightly (Fig. 24). It was 12 mm by 11 mm by about 3 mm thick, had a mass of 0,61 g and was magnetic.

In section it was very corroded with a few tiny remnants of iron (Fig. 25). There were some rounded, pinkish globules associated with dark areas, which appeared to be 2-phase inclusions. In places there were ghosts of pearlite structure in the corrosion product, but the overall carbon content could not be estimated.

Fig. 25. Polished section of corroded iron strip JAK 11 (7 X).

DISCUSSION

The Little Namaqua are reported (Godée-Molsbergen 1921) to have worn copper and iron beads on their clothing and around their arms and legs, as well as chains and plates. "Their only industry is working in copper and iron, from which they make very neat beads and chains", reported van Meerhoff in 1661 (Moodie 1960:233). The source of their iron, according to Goodwin (1956:48), is likely to have been the "Briqua" (BaThlaping) but with regard to the copper he refers to Mentzel's (1944) account of a demonstration of copper smelting by the Namaqua dating to 1762. From the description Goodwin suggests that they could have acquired this technology from Iron Age groups.

The Little Namaqua Khoikhoi owned iron spear heads and arrow heads during historical times. Alexander (1967:96) described a group of Namaqua men whom he encountered in the Komaggas area of Namaqualand in 1836 as having assegais or spears "five feet long with a small blade of iron inserted into the upper end, which was bound with leather", while only "occasionally a few of the arrows have barbed heads of iron". These same groups apparently moved to Arris Drift (new spelling: Arriesdrif) some 40 km downstream from Jakkalsberg, along the Orange River, on a seasonal basis.

With respect to the presence of metal items pre-dating the 17th century, a number of iron fragments and copper beads and ear-rings have been recovered from archaeological sites which confirm their use by people with a stone tool technology. Four copper beads were recovered from a unit in the Numas Entrance Shelter in the Brandberg dated to 870 ± 100 BP (SR 46) (MacCalman 1965); a single copper bead from Bambata Cave immediately postdates 2140 ± 60 BP (Pta-3072) (Walker 1983) and a copper bead from the top of DGL at Boomplaas Cave is associated with a date of 1630 ± 50 BP (UW-337) (Deacon *et al.* 1978). A single copper or brass bead from Byneskranskop 1 was recovered from a unit dated to 255 ± 50 BP (Schweitzer & Wilson 1982). Conical copper ear-rings have been found associated with two Riet River burials, one dated to 110 ± 50 BP (Pta-247) and the other to 890 ± 50 BP (Pta-2898) (Morris 1992:33). These were very similar in form to two others from a burial at De Hoop in the Kimberley District, but these appear to have had iron cones (Miller, Morris & Evans 1993). Iron fragments have been found in a 1230 ± 80 BP (Pta-4592) spit at Wildebeest Kuil 2 (Beaumont & Vogel 1989) and are also reported from the Swartkop sites which date between 400 BP and 700 BP (Morris & Beaumont 1991).

Although brief mention is made in the historical literature of the Little Namaqua's ability to smelt metal, no archaeological evidence has yet been recovered from Namaqualand to support the claim that they actually mined copper or iron. It seems more likely that they obtained their metal items from Iron Age groups such as the Tswana.

The brass percussion cap is obviously not of indigenous manufacture and is a historical import, unrelated to the radiocarbon date of 1330 ± 60 BP (Pta-5958) obtained from a hearth on this site (Webley 1993). Similar-looking artefacts (which in some instances have been identified as clothing fittings rather than percussion caps) have been found in Late Iron Age contexts at the Tsodilo Hills (Miller 1992:217) and in the Waterberg (M. Küsel pers. comm.).

The glassy "slag" is problematic. The presence of magnetite indicates that the glass had formed under oxidising conditions, such as may obtain at a forge. But it lacks the fayalite one would expect to see in forging slag; and if forging were done on the site there should be far more evidence for it. It is not fulgarite, or natural glass formed by lightning strikes, because it is incompletely fused, and fulgarite is essentially fused silica. The Jakkalsberg glass has a relatively high CaO content probably derived from plant ash, which can act as a flux and considerably lower the melting-point of a silicate glassy phase. We suspect that these nodules are an accidental product formed in a fire made with wood with a high alkaline earth content.

The iron bead is very intriguing. It is made of low-carbon bloomery iron, using fairly simple fabrication techniques which do not differ in any significant way from those employed indigenously in the fabrication of numerous iron beads. The hammered hexagonal shape is unusual, though, and the possibility cannot be excluded that this bead was imported, or was a fairly recent addition to the deposit.

Nevertheless, when considering the iron materials as a whole the impression is that these are no different in composition or structure from numerous examples of indigenous metal working. They were formed into simple shapes; the metal was characteristically inhomogeneous and banded; there is nothing unusual about the carbon contents or the grain sizes; the inclusions are typical transversely-fractured glassy stringers and elongated 2-phase slag globules; and they almost all show evidence of cyclical hot- and cold-working typical of fabrication in an open forge reaching about 900°C. There is nothing to distinguish the bulk of this material from iron found at other Early Iron Age sites like Divuyu (Miller 1992) and

it may well relate to the associated Jakkalsberg radiocarbon dates of circa AD 690.

CONCLUSION

Although the percussion cap and the gunflint date to the mid-19th century or earlier, the analysis of the iron artefacts indicates that they are probably of indigenous origin and therefore possibly contemporary with the rest of the cultural assemblage. The gunflint and percussion cap may have been dropped by a traveller passing through the area, subsequently becoming incorporated within the assemblage because of the deflation of the intervening soil horizon. These sites would appear to have been covered by wind-blown sands soon after being abandoned around 1300 years ago and were initially protected from the action of the wind by trees. They have only recently become exposed again, as is evident from the preserved bone and hearths.

The significance of the iron fragments may be determined from an examination of the composition of the rest of the cultural assemblage. The almost total absence of any formal stone artefacts in a toolkit numbering in excess of 9000 stone artefacts suggests that iron may well have been used for certain artefacts such as adzes and arrow tips. Iron and copper items have been recovered from numerous stone age contexts and the results presented above would indicate that they featured in the cultural assemblage of stone age pastoralist groups some 1300 years ago.

ACKNOWLEDGEMENTS

The excavation phase of this project was undertaken with the financial assistance of the National Parks Board. We thank Mr N. Geldenhuys of the National Parks Board as well as Mr H. Braack, the warden of the Richtersveld National Park, for supporting the application for further research. We also wish to thank the Richtersveld Rural Community for their permission to excavate on community lands. Members of the Richtersveld National Park and of the community were extremely helpful and hospitable and LW would like to thank everyone who facilitated the fieldwork during June and November 1992. We are also grateful to the manager of the Reuning Mine, Mr H. Dippenaar, for granting permission to work in a restricted area. The assistants in the field were: N. & W. Cloete, D. Moos, P. Rahloa, M. Joseph and R. Saal and they are thanked for their diligent work under difficult conditions. Dr J. Vogel (CSIR) kindly provided the radiocarbon dates and Ms Fiona Archer provided much of the logistical support in the field.

DM wishes to thank the director of the Electron Microscope Unit, UCT, for providing access to the scanning electron microscope, and to Professor A. Ball, Department of Materials Engineering, UCT, for access to the microhardness tester. The Department of Archaeology, UCT, provided research facilities and administrative support under the auspices of Professor N.J. van der Merwe. Financial support from the University of Cape Town, the Foundation for Research Development (CSIR), Anglo-American De Beers Chairman's Fund Educational Trust, and the Albany Museum is acknowledged with gratitude.

Notes

1. Although Knoop microhardness is not standard for archaeometallurgical purposes values can be compared approximately with Vickers microhardness values by dividing by 1,087. Knoop hardness numbers are expressed as mean indentation pressure values according to the equation K.H.N. = 14,23 W/l^2, where W = load (g) and l = indentation length (microns). Vickers hardness numbers are expressed as load divided by pyramidal surface areas of indentation according to the equation V.H.N. = 1,854 W/d^2, where W = load (g) and d = mean indentation diameter (microns). The mean pressure PM = $2W/d^2$, so V.H.N. can be expressed in terms of mean pressure values by multiplying by a factor of 1,087 (Ross 1985:5). It should be noted that microhardness values determined at different loads are not strictly comparable because the apparant hardness rises steeply with diminishing load, but this effect is more pronounced in harder materials than the soft alloys described here.

2. Segregation banding can develop with concentrations of alloying elements too low to detect with the KEVEX.

3. The higher the number, the finer the grain size.

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