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Direct Dating and Identity of Fibre Temper in Pre-Contact Bushman (Basarwa) Pottery

Charles. A. Bollong[a,b], John C. Vogel[c], Leon Jacobson[d], Willem A. van der Westhuizen[e], and C. Garth Sampson[b]

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Several ^{14}C dates have been obtained from the fibre temper in cooking bowls made by the forbears of the Zeekoe River Bushmen (Basarwa), South Africa. Although the temper appears to be burned grass, the $\delta^{13}C$ values do not match those of local C_4 grasses or even those for the montane C_3 grasses from adjacent ranges. Instead, the $\delta^{13}C$ values are typical for local springbok bone. XRF analysis of whole sherds show unusually high Ca and P values which support the proposition that crushed bone was added to the grass. However, SEM and other chemical studies distinguish clearly between bone-tempered sherds and the Zeekoe valley ware. While the source of Ca is identified as caliche inclusions in the temper, the high P values may be from select clays, ashed grass, or absorbed blood. Visual characteristics rule out the possibility of animal dung temper. Blood and fat residues absorbed by grass temper could be the combined cause of anomalous $\delta^{13}C$ and high P values.

Keywords: CERAMICS, FIBRE TEMPER, BONE TEMPER, CARBON ISOTOPES, RADIOCARBON, SCANNING ELECTRON MICROSCOPY, X-RAY FLUORESCENCE.

Introduction

In the ethnographic past, fibre-tempered pottery was more frequently associated with mobile pastoralists and/or foragers than with sedentary groups. Experiments show that fibre-tempered vessels not only weigh less than equivalent pots tempered with sand or crushed minerals, but they also require less time and care to make. Although both types can withstand about the same amount of repeated heating, the fibre-tempered vessel will abrade more rapidly and it transfers heat more slowly to the food or liquid within (Skibo *et al.*, 1989). For nomadic potters and users who carried their domestic equipment with

[a] Laboratory of Traditional Technology, Department of Anthropology, University of Arizona, Tucson, Arizona 85721, U.S.A.
[b] Department of Anthropology, Southern Methodist University, Dallas, Texas 75275, U.S.A.
[c] Quarternary Dating Research Unit, c/o Ematek, C.S.I.R. Box 395, Pretoria 0001, Republic of South Africa.
[d] McGregor Museum, Box 316, Kimberly 8300, Republic of South Africa.
[e] Geology Department University of the Orange Free State, Box 339, Bloemfontein, 9300 Republic of South Africa.

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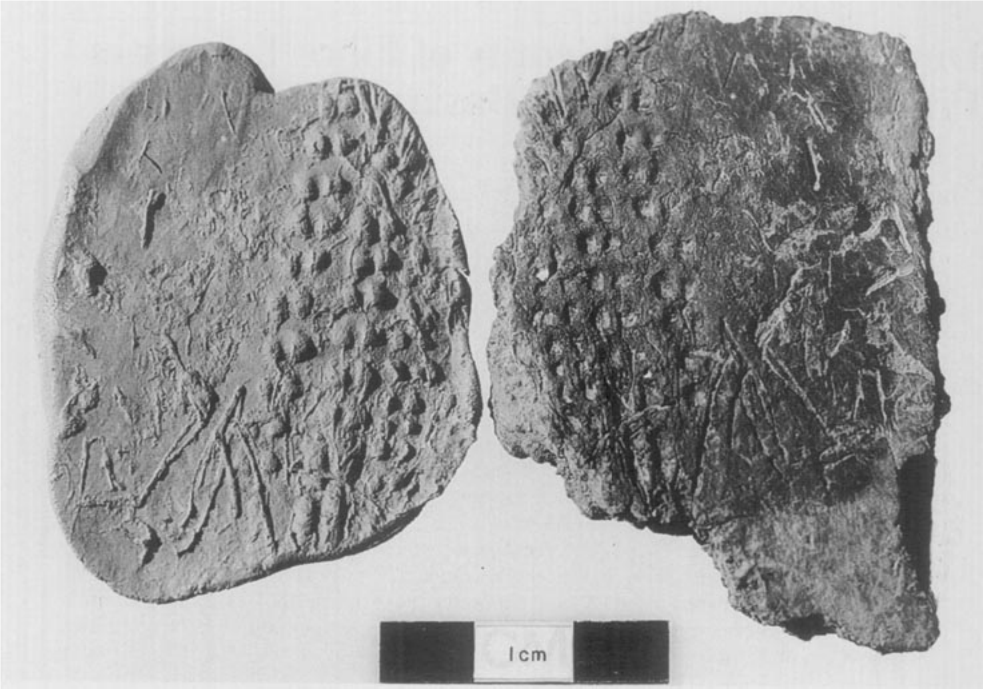

Figure 1. Outer surface (right) and its impression (left) of a typical fibre-tempered sherd from the upper Seacow valley, South Africa. Clusters of fibre impressions, assumed to be grass and stem fragments, overlap the stamp-impressed row of double punctate decoration.

them, these shortcomings were outweighed by the advantages of a lightweight vessel that could be quickly replaced without much effort.

The Bushman (Basarwa) foragers of the semi-arid central plateau of South Africa offer a typical example of this ceramic adaptation. Although there is abundant archaeological evidence to show that fibre-tempered ceramics were used throughout most of the central plateau, we have only one informant's account of Bushwomen making pottery (Bleek & Lloyd, 1911). This states clearly that pounded grass was added to the clay as temper. Sherds from archaeological contexts reveal dense carbonized fibres in the freshly broken edge, and imprints of burned fibres on the inner and outer surfaces (Figure 1). Many descriptions of Bushman pottery have accepted without question that the fibre is grass (Laidler, 1929; Schofield 1948; Sampson, 1967), and the recently coined term Grass Tempered Plain Ware or GTPW (Sampson *et al.*, 1989) underscores the interpretation.

GTPW appeared in the Zeekoe (now Seacow or Seekoei) River valley in the upper Karoo portion of the central plateau about one millennium ago. Either it was introduced by nomadic herders and adopted by resident foragers, or the Bushmen adopted and rapidly modified the nomads' pot making techniques to create their own GTPW. Ten rockshelter sequences in the upper valley register its first appearance there (Sampson *et al.*, 1989), together with a typical sand-tempered vessel called Khoi ware (Sampson, 1984), so named because it resembles the pottery used by ethnohistoric Khoi pastoralists (Rudner, 1979). Typical Khoi vessels were storage jars; the fibre-tempered vessels were used mainly as cooking bowls.

Table 1. Radiocarbon dates and related data

Lab No.	Date BP	Error	δ^{13}C	Site	Motif	Sherds	Carbon	%C
Pta-5502	330	+/−60	−18·20‰	Cypherwater 52	double punctate	120·0	1·1	0·9
Pta-5506	240	+/−60	−18·2‰	Hartbeesfontein 179	double punctate	98·6	0·91	0·9
Pta-5362	200	+/−45	−20·5‰	Leopardsvlei 27	double punctate	90·8	1·63	1·8
Pta-5364	350	+/−50	−18·9‰	Niekerksfontein 64	double punctate	90·0	1·17	1·3
Pta-5380	410	+/−50	−20·7‰	Modderfontein 12	?double punctate	54·8	0·82	1·5
Pta-5149	370	+/−50	−18·4‰	Buitensfontein 84	ovoid stab-and-lift	82·0	1·23	1·5
Pta-5148	410	+/−70	−17·9‰	Paardevlei 233	quill, vertical gash	53·0	0·74	1·4
Pta-2843	320	+/−40	−20·6‰	Vinkelfontein 4	double punctate	64·8	0·63	1·0
Pta-2844	440	+/−45	−19·7‰	Middle Mount 100	comb stamp	110·0	1·94	1·8
Pta-2846	580	+/−50	−18·9‰	Middle Mount 100	comb stamp	54·9	1·04	1·9
Pta-3392	320	+/−50	−16·2‰	Zaayfontein	plain	61·5	1·2	2·0
Pta-3393	1050	+/−60	−15·2‰	Zaayfontein	plain	71·3	0·67	0·9
Pta-3401	540	+/−80	−14·8‰	Glen Elliott	plain	69·0	0·56	0·8
Pta-3402/75	1120	+/−70	−19·3‰	Glen Elliott	plain	60·6	0·8	1·3
Pta-350	610	+/−50	−20·8‰	Rose Cottage	plain	ND	ND	ND

About halfway through the ceramic levels of most rockshelters, stamp-impressed decorations (Figure 1) appear on fibre-tempered sherds. At about the same levels, Khoi sherds disappear from the record. Thereafter, at least a dozen different decorative motifs were used on the bowls (Sampson, 1988), some of which have localized distributions in the upper valley (Ridings & Sampson, 1990). However, the chronological sequence of these motifs is unclear: the rockshelter deposits are too compressed, and yield too few sherds, to reveal stratigraphic separations between individual motifs. In the upper levels all these motifs are replaced by rocker-stamp decorations. The change coincides with the appearance of the first European items in the sequence (Sampson *et al.*, 1989).

An absolute chronology of each non-rocker motif from the middle portion of the sequence is essential if we are to understand the outburst of motif variations in the upper valley during the centuries preceding European contact. Because the rockshelter deposits are leached and churned by insects, we lack the visible microstratigraphy needed to assure a tight association between an individual sherd and charcoal fragments nearby. Thus ^{14}C dates acquired for specific sherds from the surrounding charcoal are often in doubt. A more dependable precise chronology is essential if the timetable of motif changes is to be established.

Direct ^{14}C dating of the fibre temper in these sherds offers a viable alternative by which to establish the required timetable. We report here the first evaluation of a pilot dating program, and the questions of fibre identity that arose from these results.

Materials and Methods

Radiocarbon dating

Sherds from 15 vessels were used in the pilot study (Table 1). The method (Taylor & Berger, 1968) was applied first to excavated samples from Glen Elliott and Zayfontein shelters in the adjacent middle Orange River valley and to sherds from Rose Cottage Cave some 250 km to the north-west (Beaumont & Vogel, 1984). The first of these pilot dates (Pta-3392 and Pta-3401) were chosen to cross-check ^{14}C dates from charcoal fragments dispersed in the matrix at the same levels. As these compared favourably, sherds were selected from the base of each ceramic sequence (Pta-3393 and Pta 3402/75) to determine the date for the introduction of fibre-tempered pottery into the area. The other 10 vessels

Table 2. Carbon-13 values for Antidorcas marsupialis

Lab No.	Locality	Tissue	δ^{13}C
B-93a	De Aar	bone	−18·9
B-93b	De Aar	flesh	−21·9
B-121a	Phillipstown	bone	−20·8
B-121b	Phillipstown	flesh	−22·6
2171	Richmond	bone	−18·8
2195	Zoetvlei	bone	−17·0
2059	Richmond	bone	−15·5
2185	Haaskraal	bone*	−20·9
2187	Haaskraal	bone*	−16·3
2186	Haaskraal	bone*	−20·6
2189	Haaskraal	bone*	−18·1
2190	Haaskraal	bone*	−17·9
219?	*Haaskraal*	*bone**	*−18·1*
2177	Haaskraal	bone*	−18·1
2184	Haaskraal	bone*	−16·9
2191	Haaskraal	bone*	−22·7
2192	Haaskraal	bone*	−18·3
B-122a	Keetmanshoop	bone	−16·6
B-122b	Keetmanshoop	flesh	−18·5
B-122c	Keetmanshoop	fat	−25·4

*Archaeological specimen

are from surface sites in the upper Seacow valley, and were selected to test the ages of non-rocker (pre-European) decorative motifs. Five double punctate samples (Figure 1) were selected to verify the age range of this motif, which stratigraphic evidence suggests may be the youngest of the non-rocker designs (Sampson *et al.*, 1989).

Decorated sherds were matched to ascertain that they were from the same vessel. The sherd was broken down in a pestle and mortar and the organic fragments were hand picked with tweezers. Residual organic powder was extracted by flotation and filtering. The density of burned fibres varies from one vessel to another. Table 1 gives the combined sherd weight of each sample together with the weight of recovered organic matter. Fibre yields by weight varied between 0·8–2·0%. Combustion and measurements were made using conventional gas-counting methods. None of the difficulties experienced elsewhere with organic dates from sherds (De Atley, 1980) were encountered here. No calibration procedures were applied because of the well-known ambiguities presented by wiggles in the last millennium, and especially in the last 300 years, of the calibration curve, where ^{14}C dates may have more than one calibrated age (Stuiver & Pearson, 1986).

Stable carbon isotope analysis

δ^{13}C values for the fibre temper were obtained from the same combusted samples used to acquire the ^{14}C dates (Table 1).

To verify that grass was indeed the standard fibre used throughout, values for typical C_3 and C_4 grasses were obtained from a list of 351 species drawn from various South African herbaria (Vogel, Fuls & Ellis, 1978).

To establish if crushed bone was possibly added as temper, δ^{13}C values for springbok (*Antidorcas marsupialis*) bone were obtained from the neighbouring districts of Phillipstown, De Aar (Vogel, 1978 and Richmond (Table 2). Springbok bones occur most frequently in the rockshelter deposits with the sherds, so this species is a logical choice.

Table 3. XRF values for CaO and P_2O_5

Lab. No.	CaO wt %	P_2O_5 wt %	Site	Type/motif	Date
S1	3·92	0·90	Paardevlei 233	quill, gash	410+/−70 bp
S2	4·53	0·26	Vlakplaas 78	quill, gash	
S3	6·17	0·23	Leeufontein 39	notched spatulate	
S4	2·88	0·32	Heydon 2	ovoid stab & lift	
S5	7·56	0·34	Vergelegen 177	spatulate stab & lift	
S6	3·85	0·28	Cypherwater 52	double punctate	350+/−60 bp
S7	6·56	0·45	Haaskraal 799	double punctate	
S8	6·28	0·27	Hartbeesfontein 179	double punctate	240+/−60 bp
S9	4·10	0·48	Niekerksfontein 64	double punctate	350+/−50 bp
S10	5·93	0·19	Haaskraal 925	double punctate	
S11	6·86	0·47	Leopardsvlei 27	double punctate	200+/−45 bp
S14	6·14	0·73	Abbot's Cave	plain	
S15	5·56	0·56	Abbot's Cave	plain	
S16	5·98	0·89	Abbot's Cave	plain	
S19	1·62	2·34	Lame Sheep Shelter	Khoi	
S12	1·36	0·27	Abbot's Cave	Khoi	
S13	1·32	1·84	Abbot's Cave	Khoi	
S17	1·28	1·85	Lame Sheep Shelter	Khoi	
S18	1·14	1·87	Lame Sheep Shelter	Khoi	
S20	1·26	0·30	Kookfontein 69	Khoi	
S21	1·39	0·19	Kookfontein 69	Khoi	
S22	2·47	0·15	Paardevlei 208	Khoi	
S23	1·02	0·20	Paardevlei 208	Khoi	

One modern specimen from within the upper valley (Zoetvlei) is included, plus 10 archaeological specimens (Haaskraal) also from the upper valley, and contemporary with the sherds. One set of values from Keetmanshoop, some 800 km north-west, is quoted because it includes a value for springbok fat.

XRF analysis

Sherds of 14 fibre-tempered vessels from the upper Seacow valley were subjected to XRF analysis (Table 3) so that their chemical composition could be compared with nine Khoi (sand-tempered) specimens from the same region. Vessels were selected from the surface collections (Sampson, 1988) to achieve valley-wide coverage. Large sherds were selected, weighing between 20–80 g, and these are assumed to be representative of within-vessel variations in temper and paste composition. Within the fibre-tempered group, six double punctate specimens were chosen to establish the chemical range within a single motif type. Pieces from five of the dated vessels were included in this study. Also included were three pre-decoration specimens from a sealed context in the Khoi horizon of Abbot's Cave. These values are compared with those for 12 clay samples collected at wide and regularly spaced intervals across the western half of the upper valley (Table 4). They are compared with source rock data for typical Beaufort Series mudrocks (Zawada, 1984) and for Karoo dolerite (Ackermann, 1983).

Standardized procedures were followed using Phillips PW 1404 XRF apparatus according to the technique of Norrish & Hutton (1969). Twelve components were measured. As Na was not analysed in all samples, it was removed from the calculated totals together with the volatiles. Na generally occurs in very small quantities, so that its removal caused no

Table 4. XRF data for clays and bedrock

Lab No.	CaO wt%	P_2O_5 wt%	Farm, Area
HAA D	1·16	0·11	Haaskraal
LEE	2·32	0·23	Leeufontein
MID	2·08	0·15	Middle Mount
NIE 91	2·50	0·13	Niekersfontein
NOO	1·16	0·11	Nooitverwacht
SNE	1·53	0·14	Sneeukuil
TAA	0·95	0·11	Taaibospoort
CZA	1·83	0·13	Zoetvlei
CHWB	2·73	0·19	Haaskraal
CHWA	2·90	0·19	Haaskraal
CBA	1·88	0·16	Buitensfontein
CHA	2·01	0·18	Haaskraal
Dolerite	11·35	0·28	Fauresmith
Beaufort shale	1·91	n.d.	Fauresmith

significant changes to the final percentage values. Thus, the values for CaO and P_2O_5 quoted in Table 4 are percentages by weight of a total of nine elements.

Sourcing of the Ca content

The three potential sources of the relatively high Ca values discovered in these fibre-tempered sherds by XRF, and also by PIXE analysis (Pineda *et al.*, 1990), are bone, shell or caliche inclusions. Wet chemical methods used to distinguish between caliche and shell tempers were extended to bone inclusions also. Fresh samples of each were heated in an electric kiln by 50 °C increments from 300 to 800 °C. This upper limit was deemed appropriate to replicate open firing methods, and also to cover the critical temperature (above 700 °C) at which changes from aragonite to calcite are likely to affect the crystalline microstructure (and visual appearance) of Ca-bearing inclusions (Rice, 1987). At each heating step, samples were systematically observed for colour and texture changes, then treated with 30% and 10% HCl solutions to determine the effects of heating on degree of fizz reaction. They were also treated with Feigel's solution (Ag_2SO_4 combined with $MnSO_4-7H_2O$ in distilled water) which is a proven shell/caliche discriminator.

Following these controlled experiments, fibre-tempered sherds were selected for comparison. Only sherds from vessels already subjected to XRF and PIXE analysis, i.e. sherds with proven high Ca values, were chosen. These were thick-sectioned to produce multiple faces from each sherd. Each face was sequentially polished on a lapidary wheel, then finished with 600 grit. Selected sections were heated to 800 °C and tested with Feigel's solution.

As a third test, residual thick-sections and some burned bone samples were prepared for examination by SEM. Sectioned faces showing obvious calcareous inclusions were selected. Faces were repolished with 1 mm grit and coated with Au-Pd according to standard SEM preparation procedures. A Jeol 840 Scanning Electron Microscope with Tracor Northern software was used and output was subjected to EDAX analysis. Quantitative analysis was not pursued because the relative compositions of pottery inclusions and bone specimens showed such distinct characteristics.

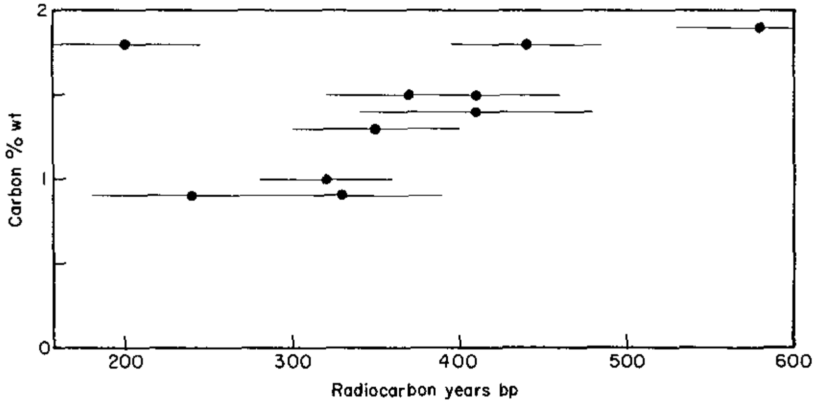

Figure 2. Mean Radiocarbon years, with 1-sigma error bars, plotted against Carbon as a percentage of whole sherd weight, for 10 fibre-tempered sherds from the upper Seacow valley.

Finally, a sample of previously identified prehistoric bone-tempered ware from the Texas coast (Matson, 1935; Campbell, 1961; Hester, 1980) was obtained for treatment. This was heated to 800 °C and treated with Feigel's solution to confirm the response of experimentally burned bone.

Results

Radiocarbon dates from fibres in the 15 vessels are listed in Table 1. Ages range between 1120–200 bp. One-sigma errors range between 45–80 radiocarbon years. The earliest decorated specimen dates to 580 ± 50 bp.

The % weight of carbon in non-Rocker wares apparently declined gradually between 580 bp and about 250 bp, then rose rapidly by 200 bp (Figure 2).

The $\delta^{13}C$ values range from −20·8% to −17·9%. When ^{14}C dates are compared with $\delta^{13}C$ values for each sample there is no relationship between radiocarbon age and stable carbon isotope values. Three of the four samples from Glen Elliott and Zaayfontein in the middle Orange River valley have notably higher $\delta^{13}C$ values than those from the Seacow valley (Table 1). Figure 3 gives the distributions of $\delta^{13}C$ values for 177 C_4 grass species and 174 C_3 grasses from South Africa. Most of the $\delta^{13}C$ values for assumed grass tempers in sherds fall between these two distributions. Fibres from three middle Orange River vessels overlap with the minimum limit for C_4 grasses; four Seacow valley specimens barely overlap with the maximum limit for C_3 grasses. Because the number of grasses found in the upper Seacow is far smaller than the species totals shown in Figure 3, the actual ranges in $\delta^{13}C$ values for grasses also must be narrower than those shown. The overlaps between sherds and grasses are spurious, therefore.

On the face of it, the $\delta^{13}C$ values indicate that the fibres are not grass, but this flatly contradicts the visual evidence (e.g. Figure 1). A viable alternative could be that crushed bone was added to the paste. As springbok was the most frequently procured animal, this would be a logical choice. The range of $\delta^{13}C$ values for local springbok bones squarely overlaps the range obtained for the carbonized tempers (Figure 3), thus there is a case for assuming that crushed bone was added to the grass temper.

If so, then the bulk chemistry of these sherds should reflect their bone content as well as the composition of their clay fabric. A clear chemical signature for the presence of bone is

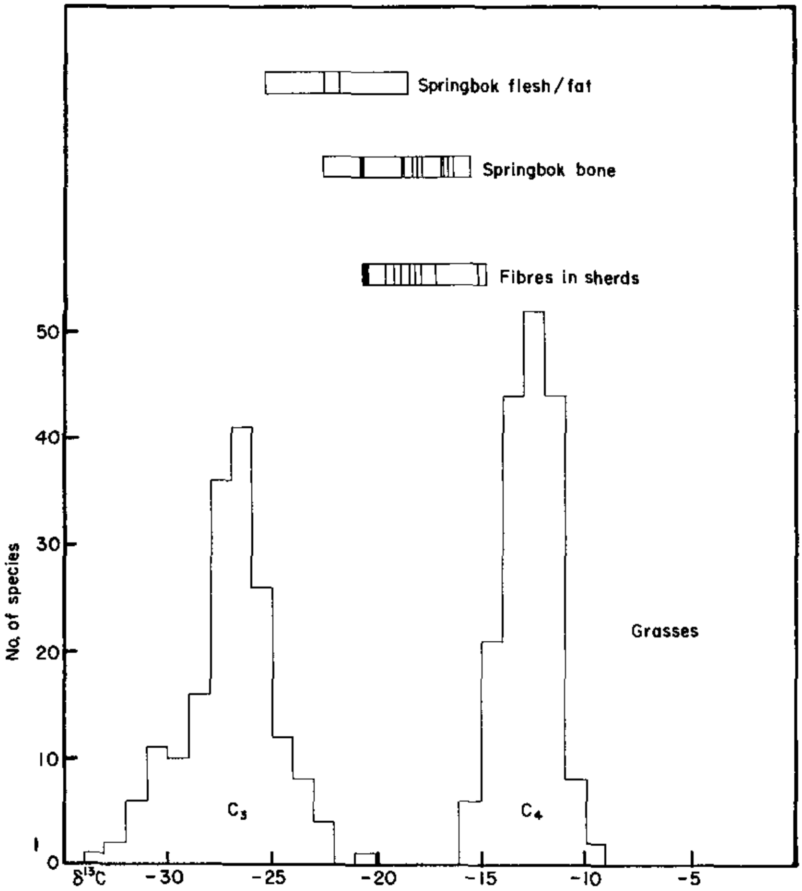

Figure 3. The distributions of $\delta^{13}C$ values for C_3 and C_4 grasses from South Africa show no convincing overlap with the $\delta^{13}C$ values for 10 fibre-tempered sherds from the upper Seacow valley. Instead, the sherds match more closely with the distribution of $\delta^{13}C$ values for local springbok bone, and overlap partly with values for springbok flesh and fat.

provided by the EDAX analysis of a control sample of experimentally burned bone, in which Ca and P peaks are very prominent (Figure 4), reflecting the elemental composition of a typical hydroxyapatite (Worrall, 1986), namely $Ca_5(OH)(PO_4)_3$. The minor Au and Pd peaks result from the sample coating. If bone temper is present, it follows that the parent sherd should yield unusually high proportions of Ca and P.

The XRF values for CaO and P_2O_5 in fibre-tempered sherds are compared with those for sand-tempered (Khoi) sherds and for local clays in Figure 5. The clays are derived mainly from Beaufort shale bedrock sources (Table 4). Clearly, the CaO content of the fibre-tempered specimens is consistently higher than that for Khoi vessels and local clays. The P_2O_5 values of four of the five Khoi sherds from buried contexts are relatively high, but there is overlap between all other groups. The three buried fibre-tempered sherds (all GTPW) are also slightly richer in phosphates than all but one of their counterparts from surface sites. If all buried specimens are omitted from the comparison, then 50% of the

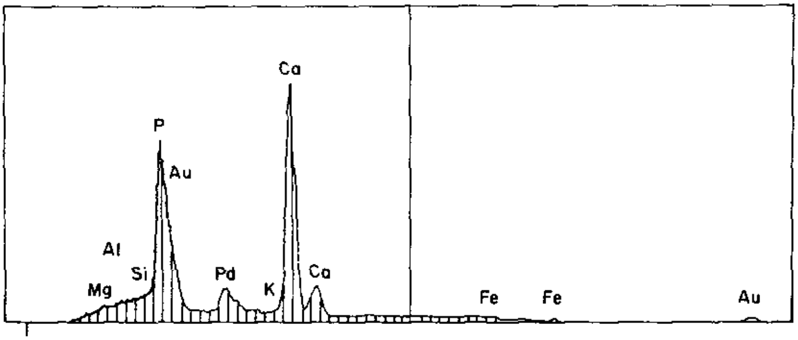

Figure 4. EDAX values for modern burned bone.

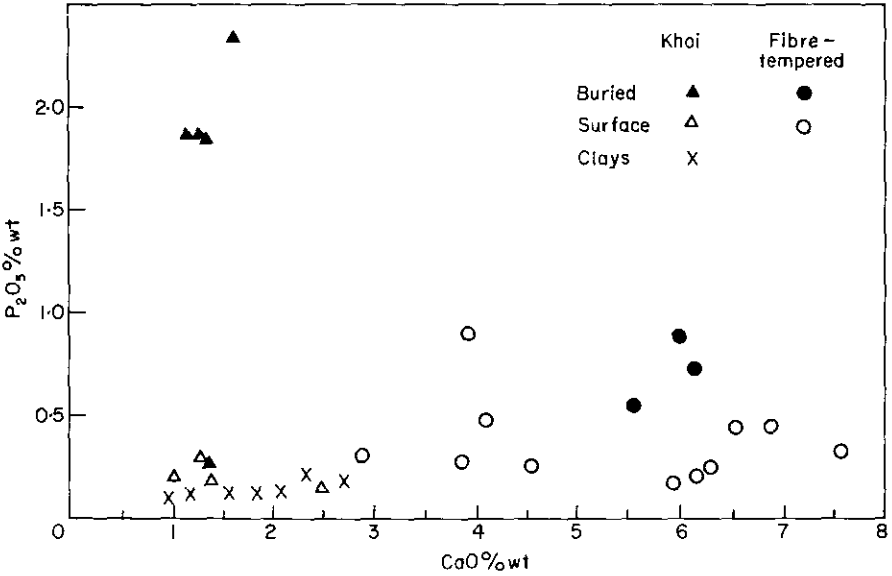

Figure 5. Scattergram of XRF values: CaO as percentage of sherd weight against P_2O_5 for fibre-tempered vessels, Khoi vessels and local clays, all from the upper Seacow valley.

unprotected fibre-tempered sherds contain higher P_2O_5 values than the unprotected Khoi sherds. Thus the XRF data for Ca and P tend to strengthen the proposition that crushed bone was added to the paste.

If so, then bone fragments should be visible in hand specimens. Using the documented Texas specimens as reference material, about 100 Seacow valley sherds were scrutinized for the presence of the characteristic particles, namely small, off-white inclusions with vessel channels clearly visible, especially in larger particles (Figure 6). None was found. The only off-white inclusions present were rounded particles without vessel channels in them (Figure 7). Only fibre channels in the surrounding paste can be seen. Inclusions were isolated under SEM, and their chemical signature, provided by the EDAX analysis, does not match that of bone (Figure 4) in that the P peak is absent and there is a prominent Si

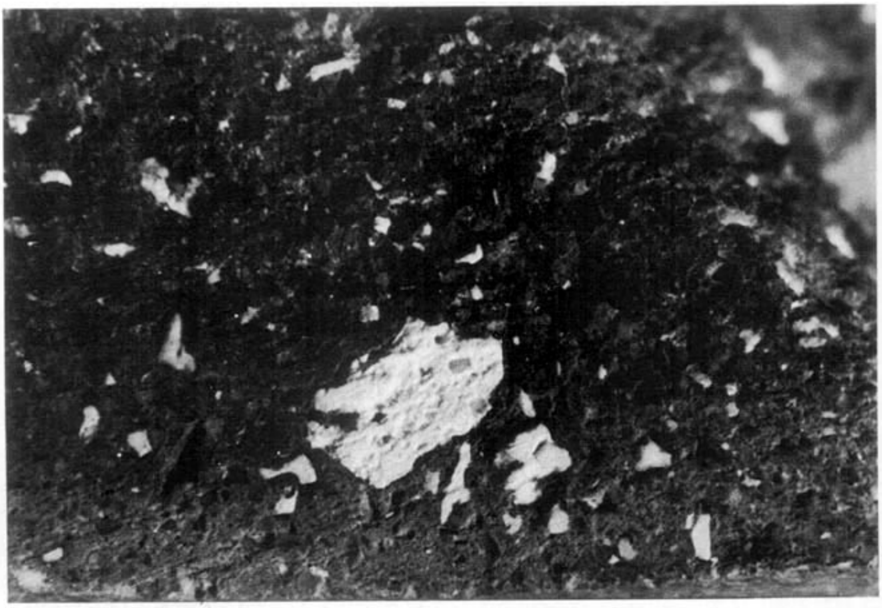

Figure 6. Bone temper fragments in freshly broken sherd section. Note the channel voids in the large inclusion.

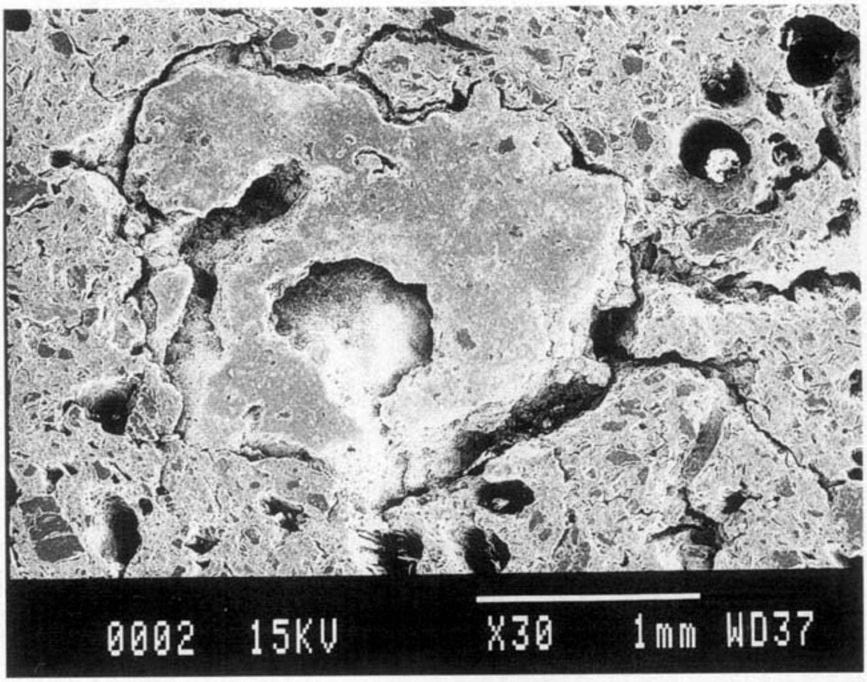

Figure 7. SEM image of a typical off-white, rounded inclusion without channel voids in a freshly broken section of Seacow valley pottery. Note the fibre channels in the fabric surrounding the inclusion.

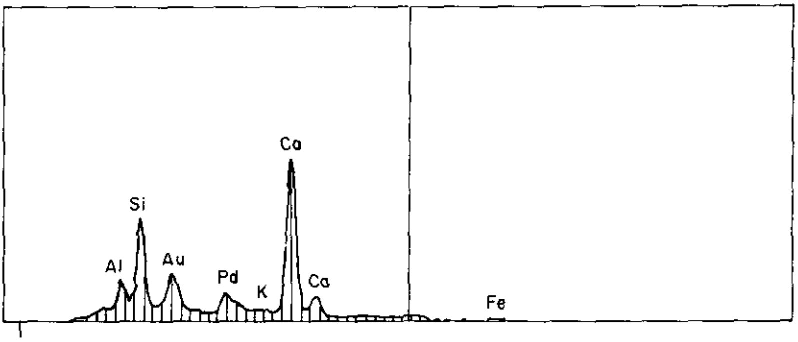

Figure 8. EDAX values for the inclusion shown in Figure 7. Compare with Figure 4.

peak (Figure 8). These results do not support a case for bone tempering by Seacow valley potters, unless the anomalous inclusions were heavily burned bone particles in which channel structure was obliterated and phosphates somehow were lost.

Bone heated to 300 °C begins to brown with blackening edges, and shows no reaction to 30% HCl or Feigel's solution, probably because of retained fats. Between 350–450 °C it becomes carbonized to a sooty black colour; there is a very slight reaction to 30% HCl, but none to Feigel's solution.

Between 500–650 °C the bone loses its dark organic components and begins to shift to lighter pinkish-tan hues. Reaction to acid is still very slight, with none to Feigel's solution. Between 700–800 °C the lightening process continues to the calcined whites seen in Figure 6. There is still only very slight reaction to acid and a very faint response to Feigel's solution. This can produce a tinge of grey-blue stain (Munsell N8/0 to N6/0). Even at this temperature, calcined bone retains numerous characteristic channels within its structure (Figure 6). These results further support the proposition that the off-white inclusions in the Seacow valley pottery are not bone.

To establish if these Ca-rich inclusions are small caliche fragments, control specimens of caliche were step-heated and tested in parallel with the bone. At 300 °C there is slight greying, and no change between 350–450 °C. There is a very slight reaction to 30% HCl, but none to Feigel's solution. Between 500–650 °C there is no change. Reaction to acid is still very slight, with none to Feigel's solution. Between 700–800 °C caliche acquires a pinkish hue and responds immediately to Feigel's solution by staining to a dark grey colour.

Next, sherds from the same fibre-tempered vessels used in the XRF and PIXE analyses were heated to 800 °C, and their polished faces, each showing a calcareous inclusion, were treated with Feigel's solution. In every instance, the calcareous inclusions stained to the distinctive dark greys shown by the control specimens of caliche. As a double check, a sherd of Texas bone-tempered ware was heated to 800 °C and treated with Feigel's solution. There was no stain reaction. This second test confirms, then, that the inclusions are not bone fragments but are small particles of caliche or some other untested source of Ca. As caliche is able to envelop quartz sand particles during formation, this would explain the Si peak visible in the EDAX analysis of an inclusion shown in Figure 8.

Discussion

Because freshwater shell fragments are found on many of the same surface sites that yielded the fibre-tempered sherds (Sampson, 1988), shell also must be eliminated as a potential candidate for the calcareous inclusions. Indeed, control specimens of shell step-heated to 800 °C produced the same dark grey reaction as caliche. However, shell calcines to a brighter white than these inclusions (Porter, 1964), and generates characteristically square albite crystals (Stimmel *et al.*, 1982), definitely not observed in the inclusions (Figure 7). Furthermore, shell fragments are not likely to produce high quartz values like that seen in Figure 8.

If the source of Ca is caliche particles, this raises the question: were they deliberately added to the fibre as part of the tempering process, or were they casually incorporated as grit in the clay fabric? As calcrete is a common component of many surface sediments in the valley, accidental inclusion cannot be ruled out. The single available informant's account of Bushwomen making pots (Bleek & Lloyd, 1911) is not helpful on this subject. After the clay ("earth which is soft") was dry-pounded it was sifted . . . "And they pour down the earth which is hard to be pounded again at another time." Although these harder fragments were not caliche (they are called "glittering particles" elsewhere in the text) it could be inferred that they were retained for use as temper. As calcareous tempers greatly improve the firing performance of a vessel (Rye, 1976), it is not unreasonable to suppose that the Seacow valley potters also deliberately incorporated harder particles in the temper. However, it remains uncertain whether caliche particles were consciously mixed into the clay or survived as impurities after cleaning the clay.

Three other possible sources of elevated calcium levels have yet to be investigated. Firstly, the potters may have sought out small clay bodies derived purely from dolerite bedrock (Table 4) rather than from the country mudstones. Secondly, calcite crystals are commonly present among the lithic debris on Bushman surface sites in the upper valley (Sampson, 1985). As these have no other immediately obvious function, it is not unreasonable to suppose that they were collected (from dolerite outcrops) by potters, to be ground and mixed with the clay. Thirdly, ash may have been added to the clay, with other important consequences discussed below.

Of the potential sources for the elevated P_2O_5 values in the fibre-tempered sherds, animal dung and blood or absorbed fat are the most likely.

Dung often contains seeds that should be sieved out before use (London, 1981) because they may explode during the firing. Dung temper can be readily distinguished from grass temper in hand specimens. Skibo *et al.* (1989) describes fibres in horse manure used in test briquettes as less than 2 mm long. When worked into the clay, the manure fibres became dispersed very evenly throughout the briquette. This created an overall rough surface more susceptible to abrasion. The grass temper used in this test was 2–5 mm long and 1 mm thick. It tended to form clumps of leaf fibres and stem fragments in the clay, and very similar configurations are present in documented ethnographic specimens (Rye, 1981). All the Seacow valley sherds used in this study exhibit the latter pattern (Figure 1). A second search of the entire study collection of 64 000 sherds has yielded only a few dung-tempered specimens, yet to be studied.

This leaves blood and fats absorbed in the fibre temper and fabric pores as the only possible source of the elevated P_2O_5 values. As P is an established marker element for the presence of these substances in fired clay (Duma, 1972; Freestone *et al.*, 1985; Cackette *et al.*, 1987; Dunnell & Hunt, 1990) it is likely that both are present. Indeed, preliminary tests have demonstrated the presence of lipids in these sherds, and the residues show high P values. Further investigations are expected to discriminate between various lipid sources.

The fact that P values are lower in sherds from unprotected surface sites (Figure 5), suggests that P is being lost by weathering. This further implies that a significant proportion of P was lost from the sherd surfaces, and that the observed P values for exposed sherds derive mainly from the interior fabric.

The single ethnohistoric account (Bleek & Lloyd, 1911) describes clearly how the potter anointed her unfired vessel with fat while it was still damp, smeared it with gum after it had dried, then boiled springbok blood in it after it was fired. She ladled the blood out, leaving some to dry on the inside. Both meat and marrow bones were boiled in the pot, and fat was skimmed from the surface of the broth.

Other possible sources of high P values in the fabric, yet to be investigated, include clays derived from dolerite, clays rich in organics and ash added by the potter. The latter is of special interest as Tylecote (1986: 224) has shown that high P_2O_5 values can be obtained from dung ash (2·46%), some wood ashes (4·85%) and especially from leaf ash (7·07%). Significantly, dung ash also yielded 17·56% CaO, while wood ashes produced 22·54–24·96% and leaf ash 49·5%. The latter implies that the grass temper itself, ashed in the firing process, could be the additional source of P and Ca.

Conclusions

Neither crushed bone nor shell was added as fibre temper by the Seacow valley potters, but occasional small caliche fragments may have been mixed with, or inadvertently retained in the paste. Grass was the main tempering additive throughout, only rarely in the form of animal dung. Because the Bushman settlement pattern overlaps with the distribution of C_4 grasses (the C_3-dominated mountain tops were virtually uninhabited), it is likely that C_4 grass was the standard tempering medium. Mixtures of C_3 and C_4 grasses in the paste are unlikely for the same reason. Absorption of springbok blood and (especially) fat by C_4 grass fibre must be responsible for the anomalous $\delta^{13}C$ values obtained. Local springbok flesh has consistently high $\delta^{13}C$ values, equivalent, to a C_3 grass. Springbok fat has even higher values, near the mode of the distribution for C_3 grasses. When these substances are absorbed in the grass fibre, the typical C_4 values become skewed towards the C_3 end of the spectrum, thus placing them in the intermediate zone between the two. Blood and fat also contributed to the elevated P values found in most sherds. Although fats tended to concentrate on the sherd surface, more tended to soak into the fibre temper of cooking bowls than into the fabric of sand-tempered Khoi jars. When exposed, superficial fats were leached from the surfaces of both types, leading to overall decreases in P_2O_5 values.

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