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THE ANALYSIS OF LATE STONE AGE HAFTING CEMENTS FROM THE CAPE PROVINCE, SOUTH AFRICA.

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INTRODUCTION

In recent years it has become increasingly apparent that an important aspect of southern African late Stone Age technology was the use of glues or adhesives to haft implements, and this correlates largely with the viability of microlithic industries. The number of sites yielding evidence of hafting has increased considerably since excavators have become aware of its presence. For the most part, the remains consist of odd lumps or traces on implements, but there are about a dozen fairly complete moulded pieces that allow some comment to be made as to the hafting strategy, and this technique is considered.

To date, no success has been registered in identifying the actual ingredients used, and the main objective of this paper is to indicate that thin layer chromatography can be used to this end.

<u>Terminology</u>. A number of different terms have been used to refer to these glues or cements - for example, traap (van der Stel 1685), /kuai (Jantje in Lloyd 1889), mastic (van Riet Lowe 1954, Clark 1958, 1959) resin (Hewitt 1919), gum-cement (Peringuey 1911,), wax (Goodwin 1945), and gum - but ~~it is~~ unfortunately ~~that~~ each term implies a specific substance, which may not be justified, as a wide variety of ingredients may have been used. For the moment therefore, the more general and non-definitive terms cement and glue will be used, and their suitability should become apparent.

ive as a cutting tool (Hewitt, 1922). He then raises the equally improbable suggestion that both tools were actually fire-flints, the chalcedony serving as a flint with the inflammable resin as a torch, to which Peringuey duly replied that his opinion was still the better (Peringuey, 1925). Clark (1959) identified it as a crescent-adze flake.

A further hafted artefact (Fig. 6 a) comes from a cave near Plettenberg Bay. Hewitt (1922) states that it was the same cave as the previous, but there is no evidence for this (Deacon, 1966). It is a bone handle with an incised pattern similar to a decorated piece of bone illustrated by Peringuey (1911; Fig. 194,2), which also comes from the Plettenberg Bay area (Hewitt, 1912), but with a lump of cement at one end, which actually covers some of the markings. One suggestion was that the decoration consisting of five rows of incised lines, three of cross-hatched and two of spaced horizontal lines, was a tally, with a lump of resin serving as a handle (J.Henning in Hewitt, 1912).Hewitt feels that the decoration is probably purely ornamental. He further compares the ornamentation to decoration on Bantu pottery, but implies no more, while later he also mentions the presence of a fragment of stone situated laterally in the cement, and pursuing his enlightened speculation, suggests a fire-flint function as well, calling it an 'aboriginal match'! (Hewitt, 1922). This has more recently been identified as quartzite by Deacon, who noted that the artefact was originally painted in red ochre (Deacon, 1966). This is also in the Albany Museum.

In addition, Hewitt mentions a 'cylindrical-ovoid lump' of resin originally mounted on a stick, about 5x2 cm, from Woest Hill near Grahamstown (Fig. 5). The haft has since disintegrated, although decayed wood is still present, while there is no evidence of it having had a stone tool mounted in the other end (Hewitt, 1922). (At present in the Albany Museum).

It is known that there was considerable ransacking of the Southern ive as a cutting tool (Hewitt, 1922). He then raises the equally improbable suggestion that both tools were actually fire-flints, the chalcedony serving as a flint with the inflammable resin as a torch, to which Peringuey duly replied that his opinion was still the better (Peringuey, 1925). Clark (1959) identified it as a crescent-adze flake.

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It is known that there was considerable ransacking of the Southern

Cape Caves in the late 19th and early 20th Centuries, and it is probable that other mounted tools were unearthed in a non-scientific manner. Clark (1959) illustrates a mounted pebble flake of slate from a cave near Knysna, that was possibly used as a scraper or adze (Fig. 3). This was given by Mr. J. Henkel to the South African Museum in 1912.A curious item in the S.A.Museum comes from a cave on Robberg, Plettenberg Bay, but thereis no detail on it.Its regular shape, and the glossypink colour raise doubt of authenticity, but it is included (Fig. 6 d).Chalcedony, a piece of mollusc shell, and a hair are embedded on the surface.

Two further implements of unknown origin are in the possession of the University of Cape Town Archaeolog~~ical~~ Department. They were donated by a Mr. Marais (since deceased) in 1963. The one is an adze mounted in cement (Fig. 7d), while the second is an oblate cylinder of cement, with a socket from the haft passing right through, with one end clearly broken across and so it is impossible to guess what the working end might have been (Fig, 7a). A thick scraper which came with the artefacts and has traces of cement may well have served as the actual mounted tool (Inskeep, p.c.). F.Malan handed in a mounted tool from a cave in the Porterville area to the S.A.Museum, but the actual site is not known (Fig. 6b). It shows similarities to the decorated artefact from Plettenberg Bay. Unfortunately both this and the [illegible] artefact are on display and so it was impossible to study them closely.

Wilton Cave has implements with traces of cement (Deacon and Deacon 1963), while a grave from Oakhurst yielded a piece of cement with the impression of a flake in it, and some cement in one end of an oval bored stone (Goodwin 1938).

Further evidence of hafting and the use of cement has come from Matjies River where a lump of black gum was found by Meiring, who suggestedthat it may have been a constituent of paint.(Clark 1959, Meiring 1953). Further east at Melkhoutboom, numerous Late Stone Age tools have shown traces of glues (Hewitt 1931, Clark 1958, 1959, Deacon 1969), including small convex scrapers, a segment, bones and two adzes as well as apparently unretouched flakes. In the latest excavation, lumps of resin were also found, including a flattened piece attached to a twig (Deacon 1969, p.c.). De Hangen cave in the Western Cape has yielded traces of cement (Parkington and Poggenpoel 1971), while Goodwin may well have been referring to cement when he said that there were 'still indications of fats, resins and other organic substances' on some implements from a site near Bredasdorp (Grobbelaar and Goodwin, 1952). One of the more noteworthy contributions from recent research into the Late Stone Age has been the discovery of mounted tools in proven context in areas further afield than the Southern Cape Coastal. At Boomplaas Cave near Oudtshoorn, numerous lumps of cement and a partially mounted microlithic scraper have been recovered (dated about 2500 B.P.) (Deacon p.c.). From Die Kelders Cave have beenrecovered traces of cement on a small scraper (possibly about 2000 B.P.), and an interesting moulded tool, possibly an arrow head (dated about 1600 B.P.) (Fig. 2c) (F. Schweitzer 1970, p.c.). Elands Bay Cave has produced further finds (J Parkington, unpublished). The most interesting piece from Elands Bay (dated about 3500 BP.) is apparently that of a handle with a narrow socket at the short end, probably for a bone or wooden implement (Fig. 8a). A further unusual piece of worked cement from the same level has a soft core, with a darker well bound rim, with a variable thickness (Fig. 8b). The one end is broken while there is no evidence of any implement having been fixed in the other, and it is feasible that it is not even a tool, but possibly merely a lump ready for use. A further small lump has a segment partially embedded in it, but as the working edge showing utilisation is partially obscured by cement which would make it non-functional, the association is probably fortuitous. This artefact was found associated with a concentration of stone flakes and a bone point in a burial dated to more than 9600 B.P. (Fig. 8b).

The use of cement can be inferred in Rhodesia, where seven artefacts have been recently found in the Lowveld at Mtanye Shelter (Walker 1972) showing traces of probable cementing. Simons (1968) found evidence of hafting on three small scrapers at Hillside, Bulawayo. Furthermore, Paterson (1940, 1949) mentions several Wilton microliths having 'clay resin' handles from Cyrene rock shelter, near Bulawayo. Unfortunately, they have not been relocated. The presence of hafting with cement has also recently been established from a number of sites in South West Africa (Wendt 1972). Small scrapers and microlithic tools showing possible remnants have been found, in addition to lumps at five sites.

Finally, the sealing of a hole in an earthen pot and another in an ostrich egg with limpet shells held fast with cement were noted by Peringuey (1911), and so cements may have served as domestic aids and repair kits as well.

The various occurrences have been listed in Table 1, where they have been provisionally classified. There are three basic categories:-

Lumps - various irregular globules of cement, often rather like stones, or 'dollops' of clay, which is possibly why they have not been recognised in earlier excavations.

Traces - numerous microlithic artefacts - scrapers, segments, borers, etc. and also adzes, utilised pieces and so-called waste show thin encrustations of cement. Possibly organic artefacts will also show up traces of cement in the future.

Moulded pieces - show moulded or regular, relatively smooth, shaped cement, often symmetrical in contour, and usually with an indentation left by hafted implement(s), if not with the actual piece(s) still in place. Some of the moulded cement or mounted artefacts have either been described in insufficient detail, or are too fragmentary for more comprehensive description.

It must be realised that, based on so few artefacts, this is only a provisional classification of cement mould types, and is far from complete. The distribution of the sites is indicated in the map in Fig. 1.

Table 1.

TYPES	THE ITEMS	ORIGINS	and CONTEXT	COMMENT
A	Adze-scraper	Touw river, south Cape	burial in cave	probably L.S.A.
	Adze flake	Plettenberg Bay	" " " 'Strandloper'	" "
	Adze-scraper	cave near Knysna	?	
	Adze	?		
B	Small scraper	Boomplaas cave, near Oudtshoorn	L.S.A.	
C	?	Plettenberg Bay cave.	Typical coastal pottery	" "
	?	Porterville	cave	
D	Handle ?	Elands Bay Cave	L.S.A.	
E	Blunt arrow ?	Woest hill	(~~Apparently this item was~~) found in the open.	
F	Pronged arrow head ?	Die Kelders cave	L.S.A.	
G	Bilateral stone tipped arrowheads	unknown or Cape Bushmen		numerous references
?	cylinder of cement	Unknown	?	broken (type A?)
?	moulded piece	Elands Bay cave	L.S.A.	" (type D?)

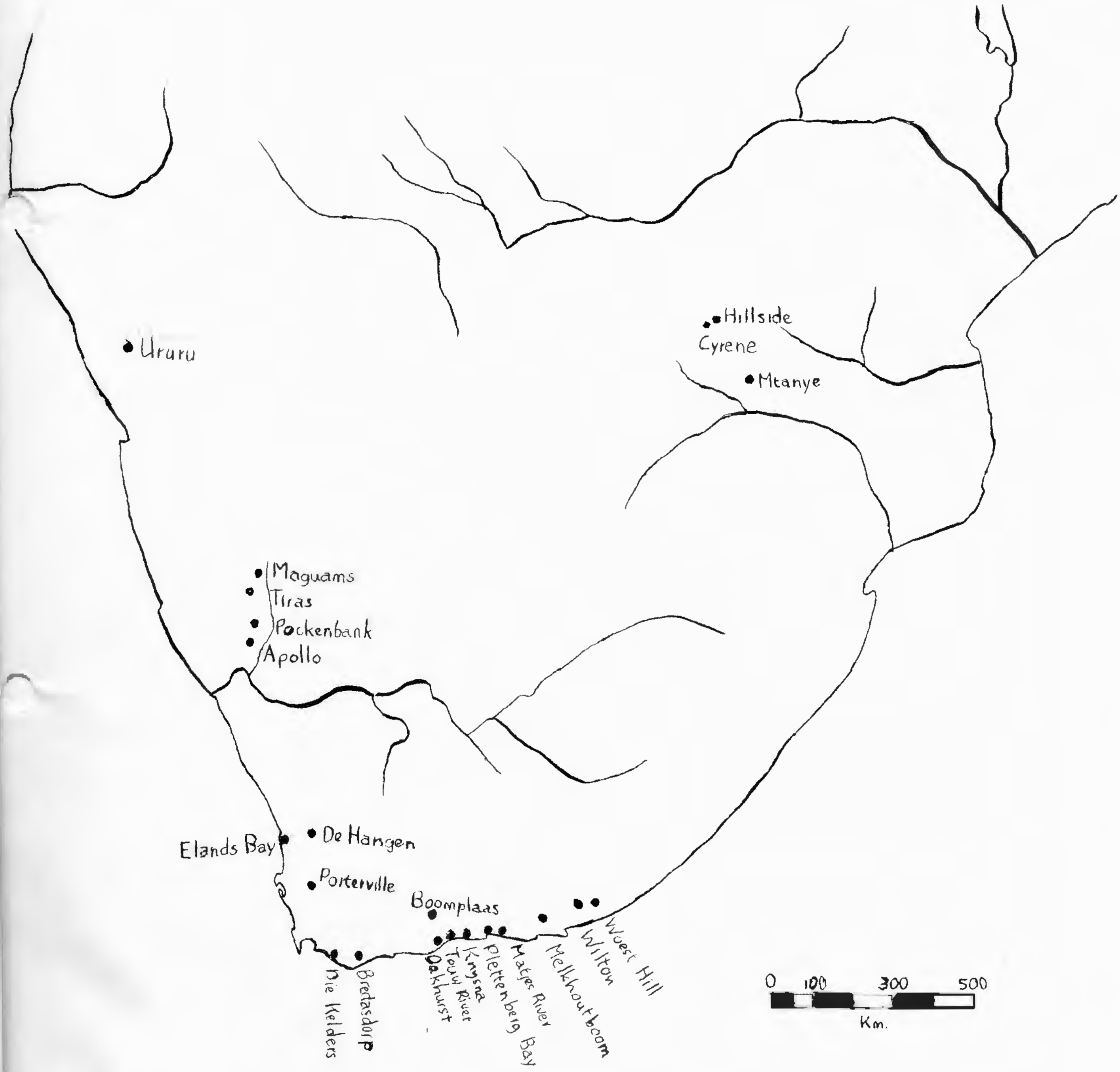


Fig.1. Distribution map of sites showing evidence of cement.

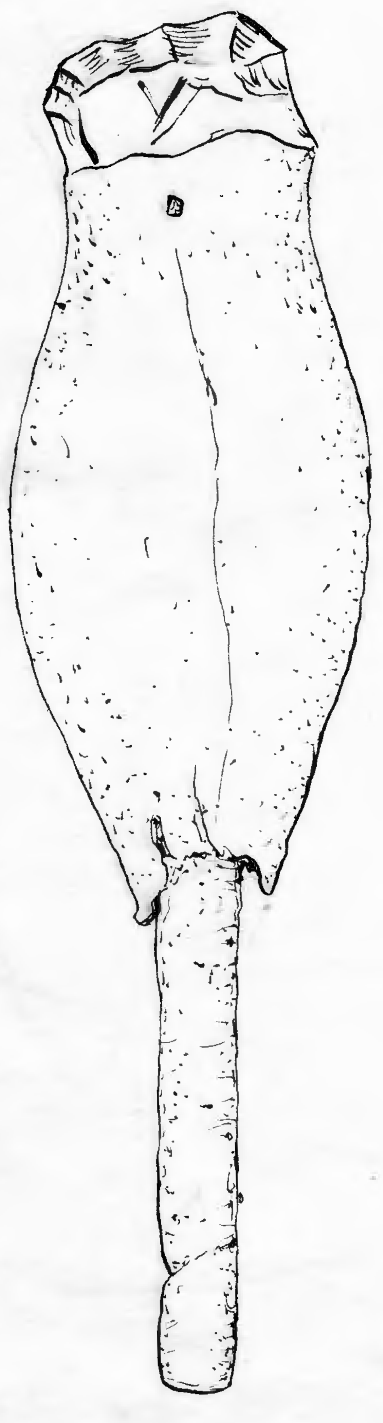


Fig.2. The Touw river Adze-scraper. (not to scale: after Peringuey 1911)

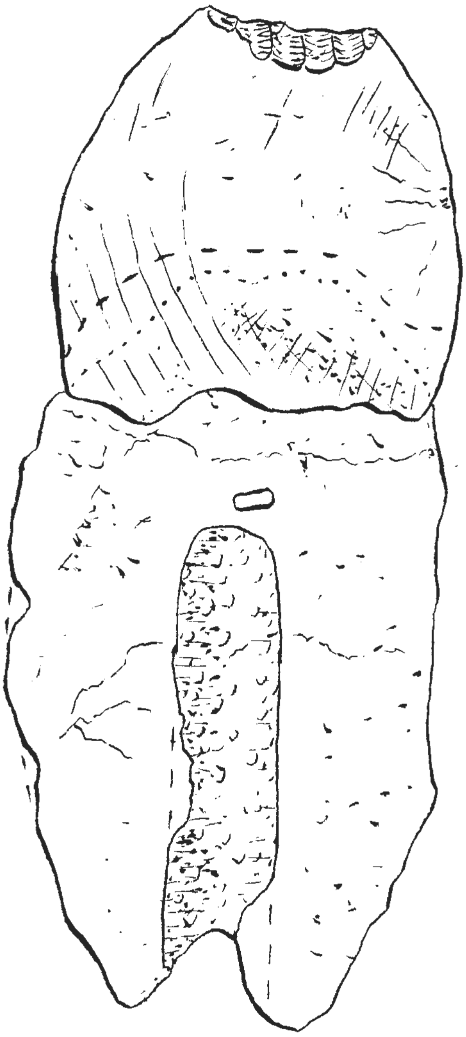
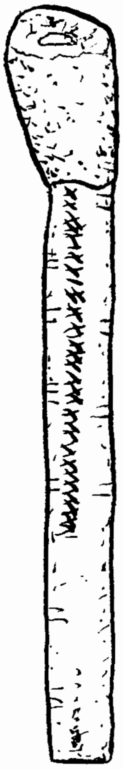


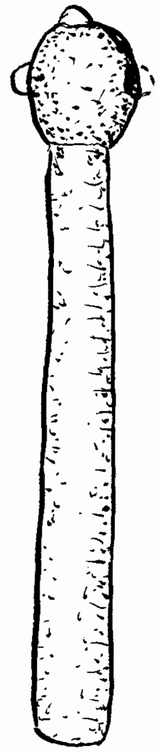
Fig. 3. Adze from the K[illegible] cave. ([illegible] scale x1)

Fig. 4. The Plettenberg Bay adze-flake. (photo by H.C.Woodhouse)

Fig. 5. The Woest hill implement.   (photo by H.C.Woodhouse)



A. From the Plettenberg Bay area. (not to scale)

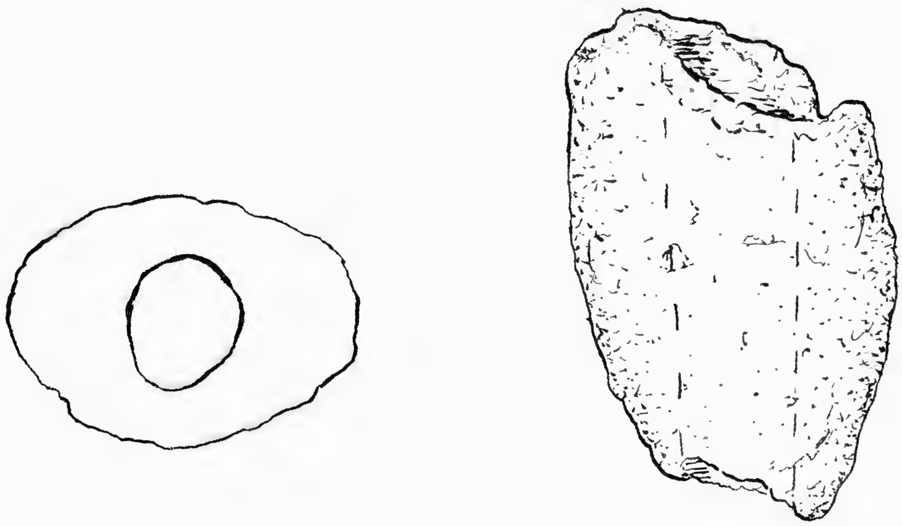


B. From the Porterville area (not to scale)

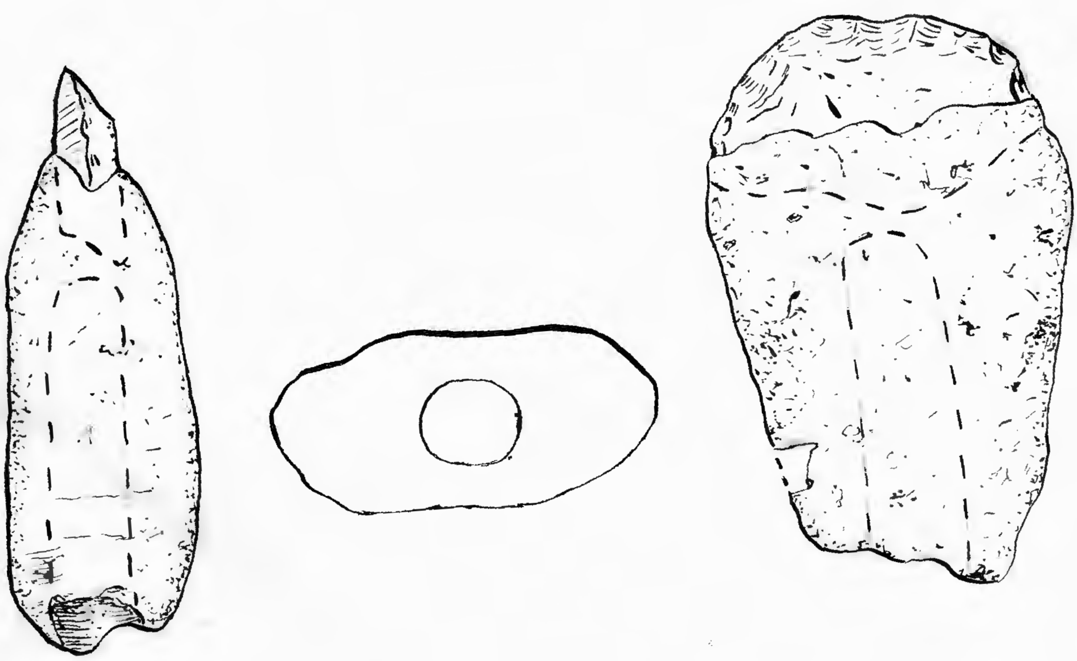
C. Transverse section of the Die Kelders tool. (not to scale)

D. An enigmatical object from Robberg, Plettenberg Bay (to scale x1) or 1:1?

Fig.6. Various items.

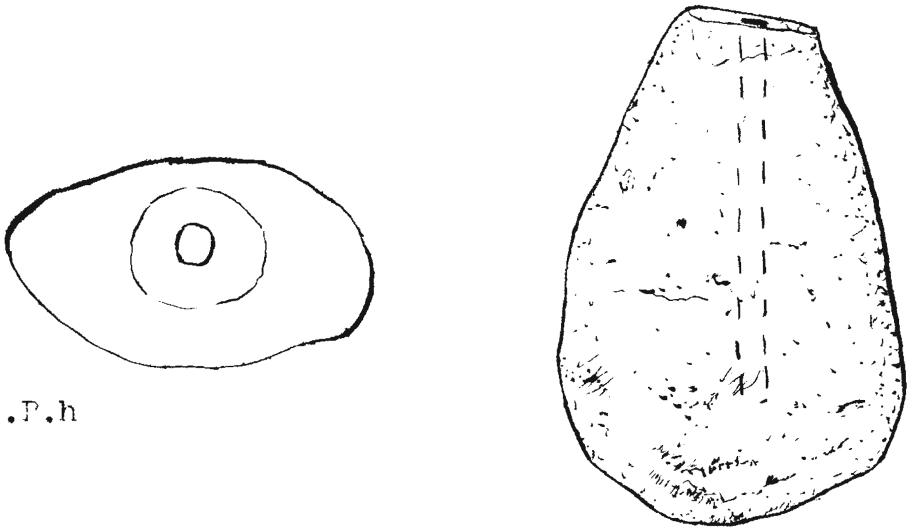


A. U.c



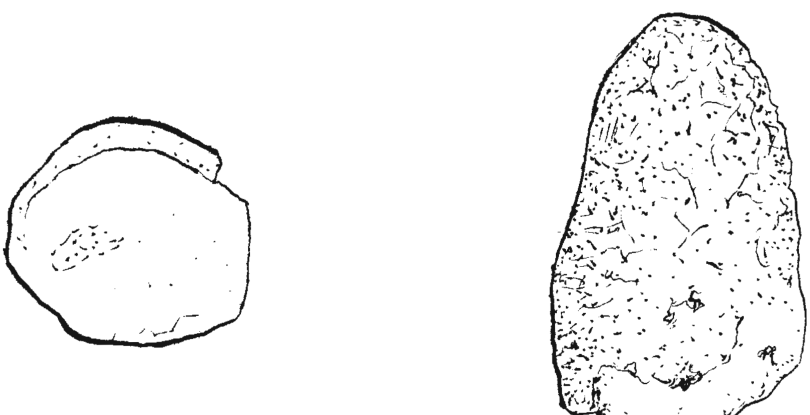
B. U.d

Fig. 7. Artefacts from unknown origins. (to scale x1)



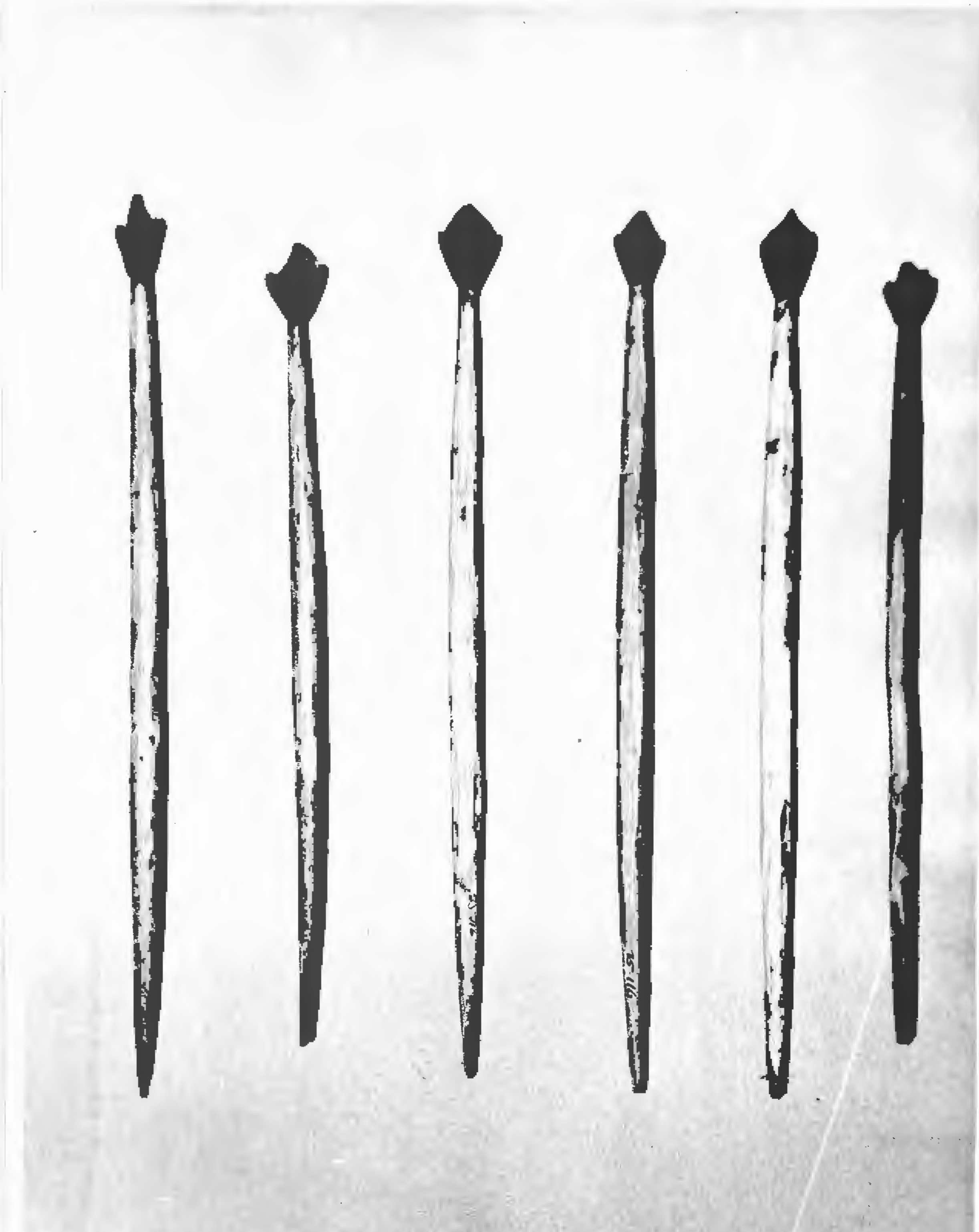
A. E.P.h

B.



C. E.B.s

Fig. 8. The Elands Bay specimens.(to scale x1)



Fig, 9. Jantjes arrows. (photo by J.E.Parkington)

It can be seen that the inland plateau region of South Africa is not represented, although the southern Cape Coastal Belt, South West Africa and south west Rhodesia are. The sample is too small to indicate different bulk cement hafting strategies for different areas. The fact that the three adzes of known context do come from the south-east Cape may relate to a relatively higher adze population in this area.

<u>Ethnographic parallels.</u>

No known collections of comparable artefacts were made by the early travellers and settlers, and so there is little information as to how these artefacts were made, used, or by whom, unlike the situation in Australia. There are some valuable references that show that the Cape and other Bushmen used to haft stone arrow heads (Bowker 1872, Peringuey 1911, Dornan 1917, Hewitt 1922, van Riet Lowe in Goodwin and van Riet Lowe 1929, Maingard 1935), and even some information as to how it was done, in addition to the use of bone and metal tipped arrow heads (van Riet Lowe 1954, Burchell 1824). Paterson (1789) noted the use of 'flint' for harpoons by the Hottentots.

Peringuey (1907, 1911) makes a few important references to arrows, but there are no details about their origins. Some reed shafts from a cave floor had traces of the original fletching cement, an interesting pointer to the use of feather flights, although this was a more common procedure among many Bushman groups than is generally recognised (Schapera 1927). Three others had lozenge shaped lumps of cement on the end of the bone foreshafts into which were fixed small milky quartz 'chips' in the one case, and glass ones in the others. Although some have fallen out, it is clear that these are identical to some described by Goodwin (Goodwin 1945). There are five glass or quartz tipped arrows in the S.A.Museum and three in the Pitt Rivers from South African sites (Clark 1959). One was from the Kimberley area.

Feilden noted that Bushmen had visited Col. Bowker's camps to make arrow heads from discarded soda water bottles (Feilden 1883), Frere (1881) in addition to noting the use of stone arrow heads, also has the interesting observation to make on preference of glass to stone for Bushman arrows, and how values for materials change. He mentions how a Damaraland trader, when enquiring about a sudden demand for a small cheap bottle of perfume, learned that the thick glass intended to hold less perfume was ideal for striking off arrow tip flakes, while the scent was used for its alcoholic affect!

The ones referred to by Goodwin (1945) were made by /xam or Cape Bushmen for the Bleeks in the late 19th Century (Lloyd 1889). It is not certain who actually made them, but a Bushman called Jantje from the Carnarvon area in the Karroo, described the method of manufacture and probably was responsible. The important point is that he could describe them, and so it is reasonable to assume that these were some of the arrows used by /xam Bushmen. Wooden (for hunting birds), metal and glass tipped foreshafts are also present in the collection. The cement (called /kuai), the arrow head and foreshaft are all first warmed over a fire. It seems that the head is first inserted into the cement before placed on the shaft, but this is rather obscure, and Goodwin suggests the description is of placing a metal tip in place. Jantje further describes binding it in place with a piece of sinew, and only the metal ones have been bound with string as well. This procedure then does not apparently apply to stone tipped arrows.

The glass tipped foreshaft consists of two blades of glass complete with bulb of percussion, embedded in an 'ivy-leaf-shaped mass' of cement, on either side of the leading tip of the foreshaft, in such a way that their sharp ends converge and meet in a point. In most cases they do not touch the foreshaft, and are fixed rather precariously and in use would certainly have fallen away from the wax, and have lodged themselves in the skin of the animal. Jantje also describes the fletching process.

Dunn (1880, 1931) learnt from a Bushman woman in Bushmanland, the art of making arrows, and this clearly applies to the above arrows. The bevelled point of the shaft is coated with 'resin', softened by heat, and two small triangular flakes detached previously from a core are pressed into the cement on opposite sides, care being taken to bring the two sharper points together to form a leading point. Often a porcupine quill barb was affixed behind the tip, and this seems to have been more common with the Cape Bushman than others (Schapera 1927).

Stow (1905) mentions stone bladed assegais, and 'well-tempered clay' or the milky sap of a plant used to bind triangular stone arrow heads into a notch on the end of a blunt bone foreshaft with the aid of sinew and a wax-like 'poison'. Schapera describes similar ones of agate and chalcedony (Schapera 1927), while the metal ones in the U.C.T. Arch. Dept. are more recent adaptations of this type to the new metal. Stow further mentions Coates Palgrave as having seen chalcedony and glass arrow heads.

One arrow he described consisted of a small leaf-shaped arrow head of quartz crystal inserted into the end of a reed foreshaft (about three inches long), with the whole composite head, plus horn barb about an inch behind the tip, well embedded in a fine cement which he felt was a clay, and which provided weight as well as adhesion. The whole was covered with poison (Dale 1870 b, Stow 1905). It is not certain whether the arrow head could have been a backed blade tool, for Dale (1870 a) referred to M.S.A. points as arrow heads.

He illustrates some metal and bone heads hafted apparently with cement, complete with barb quills, which Goodwin (1945) felt were characteristic of the Cape Bushmen weaponry only. Some of the modern Hukwe arrow heads are fixed with cement and Cooke illustrates what appears to be a head of solid cement, presumably for stunning birds (Cooke 1969).

A couple of Burchell's (1824) illustrations of iron heads may have been cemented as well. He also collected a quiver with a coating of cement in his travels . It is about two or three mm thick (a piece is in the South African Museum; the rest is in the Pitt Rivers Museum). Paterson (1789) also mentions seeing quivers painted with an " unctuous matter, that grows hard when dry." One suggestion was that this was how the cement was stored (S.A.Museum correspondence), but it seems an unlikely waste of labour, and probably helped preserve the quiver.

All modern Southern African hunter-gatherers rely mainly on binding to haft their arrows, while the use of stone tools in general is now minimal. This is because iron is easy to work and can be bartered from Iron Age Peoples in the North, or Europeans in the south. This latter point probably explains why it is often felt that the use of stone tipped arrows in cement is a feature of the Cape Bushmen, when in actual fact it more probably reflects the longer contact of the northern bands with metal working people. No South African hunter-gatherers use cement in bulk for hafting to-day. However, a glue of some sort is frequently mentioned as being used in addition to sinew or twine for hafting in arrow heads as well (van Riet Lowe 1954, Woodburn 1970, Logie 1935, and Goodwin 1948, see above).

There are references to metal blades, etc. being mounted in wooden handles (Woodburn 1970; on display, Open Air Museum, Pretoria), and these may be evolvements of cement-handled stone tools. Dunn (1931) comments on the use of resin to plug ostrich egg-shell water carriers (see Peringuey 1911, above, for parallel).

The use of a binding medium for painting has long been known, and there are references to the use of fat (Curle 1913, Dornan 1917) plant juices (How 1970) and other materials, like blood (How 1971). Euphorbia juice was apparently coated on pottery by the West Coast Hottentots (Peringuey 1911), or resin boiled in the new pot, possibly to improve the binding of the vessel (Bleek 1911).

One of the Bushmen told the Bleeks how they extracted 'poison' by incising the bark of a certain tree and collecting the juice in a tortoise shell. The juice was heated over a fire and then rolled onto a 'driedoorn' stick (Bleek 1911). Although this seems to be a reference on an aspect of mounting, it may well be providing an insight into how some sticky material was collected, worked and stored.

There are also references to adding sticky material to arrow head poisons and in some cases this would have served as an adhesive, or alternatively as an irritant or intoxicant (Dornan 1917, Shaw 1971). Most studies of the Bushmen and other hunter-gatherers to-day are largely orientated towards social problems, and to a lesser degree economic, while technological and material aspects are usually only briefly or incidentally referred to. Early ethnographers and travellers, on the other hand, do provide some valuable information on technology, but tended to be more obsessed with weapons or spectacular tools (eg. bored stones) than the more menial ones. It is also difficult often to differentiate between conjecture and observation in their writing.

Australian analogies.

Considering the near-total absence of direct observation in later Stone Age communities mounting or hafting stone implements in South Africa there is some value to be gained from a quick perusal of the literature on the Australian Aboriginals, whose activities are considerably better documented than the Southern Cape hunting-gathering peoples. Although there are dangers of inferring too much from analogy, the insights into the role of the hafting media in the technology, and the problems in binding for example, more than compensate for this. One striking point to emerge in fact is that a considerably different range of tools was mounted by different groups. It should be stressed that this is not a comprehensive discussion on Aboriginal technology.

<u>Tools mounted.</u> A wide range of stone tools was mounted with cement usually onto wooden handles or shafts - knives, picks, saw-like implements, daggers, spears, gravers, adzes, choppers, scrapers, spokeshaves, hammers and ground axes (eg. Roth 1897, Spencer and Gillen 1904, Horne and Aiston 1924, Aiston 1928, Thomas 1906, Allchin 1957, Thomson 1964, McCarthy 1967). The classification of these tools is not consistent, which in part reflects poor documentation or classification on the part of the European observer, and in part the fact that different shaped tools could have similar functions and similar shaped implements different uses in different areas (Allchin 1957), while a single tool could be used for a variety of purposes. Adzes for example are sometimes used for chopping, graving, cutting and as a spokeshave (Thomas 1906) or a scraper (Allchin 1957). Varieties of the latter tool, spears and other implements are often recognised by researchers and tool-makers alike, the latter giving them distinctive names. Certain groups like the Bindibu have very few hafted tools (Thomson 1964), while others have a wider range.

In certain cases, a lump of cement is merely added on to the end opposite the working part of the tool itself to serve as a handle, as in the case of knives and scrapers (eg, Gould et al 1971, Allchin 1957). Some knives have a very short flat piece of wood serving as a handle, but being practically completely covered with cement (fig. 10 c i).

More frequently the cement ~~actually~~ serves as a binding medium as in the cases of axes, picks, adzes and spears which require longer handles or shafts. In certain cases the cement ~~actually~~ serves as a hand grip, as in the case of the adze. This is one of the better known hafted tools as it fulfils a very important role in the technology, and frequently dominates assemblages, whereas other categories have been abandoned in favour of European merchandise, or because of the collapse of the ritualistic and warring activities. The adze is often part of a composite tool, and an interesting variety is the wooden spear-thrower /tray, to which it is attached. When used as a spear-thrower, the cement serves as a handle, as it does when used for adzing. A second type, used with both hands has a second 'thumb-grip' of cement at the opposite end (Gould et al 1971). Certain groups mounted adzes of shell for use (Thomas 1906).

Other types of composite tools are barbed spears (Roth 1897) and, from our point of view, a most interesting artefact, the 'taap' knife (Allchin 1957). The latter actually consists of a row of stone flakes or blades, with sharp working edges parallel to the axis of a wooden handle to which they were fixed for part of the length with cement. These flakes are not retouched or backed at all (fig. 10 c 2).

Cement is also used to help bind the spear-thrower hook to the spear thrower, and in one case moulded hooks were used (Spencer and Gillen 1904). Special spear butts also were fixed with resin, while with composite spears the heads were frequently hafted with the aid of cement and twine. Loose heads of course were merely fixed with sinew, and the latter often was used with axes, which were used for robust work.

Fish hooks were also made with the aid of cement, as were ornaments (Spencer & Gillen 1904), the plastic properties no doubt aiding the process.

Finally it should be noted that the Bindibu mend cracks in their trays with spinifex resin (Thomson 1964). A further use of cement as a vice grip is indicated by Aiston (1928) who states that the manufacture of a 'pirrie' point involves fixing it to a handle along one side with cement, before preparing the opposite side, and then reversing the tool and preparing the other edge, before hafting.

Although backed microliths have been found in S.E. Australia, there is no reference to the mounting and use of them (Allchin 1957).

<u>Materials used</u>. Plant glues mentioned are porcupine or Spinifex grass (*Triodia* sp), grass tree (*Xanthorrhoea* sp.), brown cedar, wattle gum,

mindrie root, beefwood (<u>Grevillea striata</u>), and possibly others (Aiston 1928, Thomas 1906, Spencer & Gillen 1904, Roth 1897, Howe & Aiston 1924, and others). A more comprehensive knowledge of Australian botany would have enabled some comment to be made on their distribution, and their relative values and role in the overall economy. There is the distinct problem that some of these plants are perhaps the same species, or have been reclassified since, while it would be useful to know whether the exudation is gum or resin.

In addition, 'beeswax' was sometimes used, and Thomas refers to a 'clay' for mending water vessels (Thomas 1906).

What was used would largely depend upon availability. Thus beeswax was used in the north, because nothing else was available. Amongst the Aboriginals that Aiston (1928) came into contact with, mindrie was the best, and while beefwood glue was easy to work, it was not as durable, especially in hot or damp weather. Spinifex glue was very hard, but could not be used too often, as it became highly inflammable with reuse. In part, a shortage could be overcome by trade, and there is a reference to the importance of cement for bartering (Aiston 1929). This would apply to certain rare stone materials as well, and other desired commodities; items are known to have travelled hundreds of miles. Aiston further states that the various groups would keep the origins of their glue a secret, and this would indicate the importance of the whole hafting technology.

<u>Collection and preparation.</u> It is possible that it was part of the woman's task to collect vegetable glues. This would be in keeping with her gathering role and plant orientation. Thus Aiston (1929) refers to women digging for and collecting mindrie roots, while Thomas's (1964) comment on the contents of women's bags including prepared cakes of 'gum' for making and mending tools is suggestive.

Back at camp, the mindrie roots are either sliced up and placed in the hot ashes of a fire before raking out the exuded hot glue, or the frayed ends held over the fire and scraping off the oozing glue into a bowl until enough had been collected (Howe & Aiston 1924, Aiston 1929). In either case, the lump is then mixed with ash and kangaroo dung, being heated all the while until well mixed. This increases the toughness (Aiston 1929), and the ball, cake or roll of cement is then ready for use or barter,or is stored. It should be noted that whenever the hot sticky soft mass is being worked with the hands, the maker is constantly having to lick his fingers (Aiston 1929), or use perspiration (Thomas 1906) to prevent the glue from sticking to his fingers.

Porcupine or Spinifex grass is also collected in large quantities, which is then pounded and broken up with stone pounders and then rolled on heated flat stones until reduced to a paste which is then allowed to harden (Roth 1897). Aiston refers to the glue being extracted from the roots of Spinifex, but does not describe the process (Aiston 1929).

Elsewhere, portions of the beefwood tree (not detailed) are roasted over a fire, and the molten glue collected on sheets of bark. This is reheated and powdered charcoal is mixed in, before it is ready for use (Roth 1897).

In all cases described, heat is applied to help extract the glue, while in no cases are pure samples collected. Coarse material was either deliberately added, or ash or the original plant fibre became incorporated during the preparation process, which as Aiston correctly states, increases the resilience of the cement.

<u>Tool mounting</u>. Hafting of implements is a relatively simple process and involves exploiting the melting character of the cement, all the while keeping the hands moist with sweat or saliva to prevent them from sticking. The flat or round cake of cement (in one illustration it is the size of a tennis ball) is warmed near a fire, a piece pinched off and stuck on to the end of the handle, the tool inserted, and the cement thickened and finally smoothed, which requires constant reheating over the fire to prevent the glue from setting too quickly (Aiston 1929). Adzes are usually well bedded in the cement to withstand the jarring. From one of the illustrations in Aiston (1929) it seems that the stone tool could also be pre-

heated.

The hafting of the adze (often called a tula) is well known. Apparently the Bindibu take about half an hour to mount an adze, including knapping and selecting the desired flake (Thomson 1964). When the adze flake has set they further prepare the edge by trimming it with their teeth, an unusual flaking technique. Another point mentioned by Thomson, and independently asserted by Aiston (1929) is that the toolsrest directly against the handle base when hafted. This will be discussed again later on.

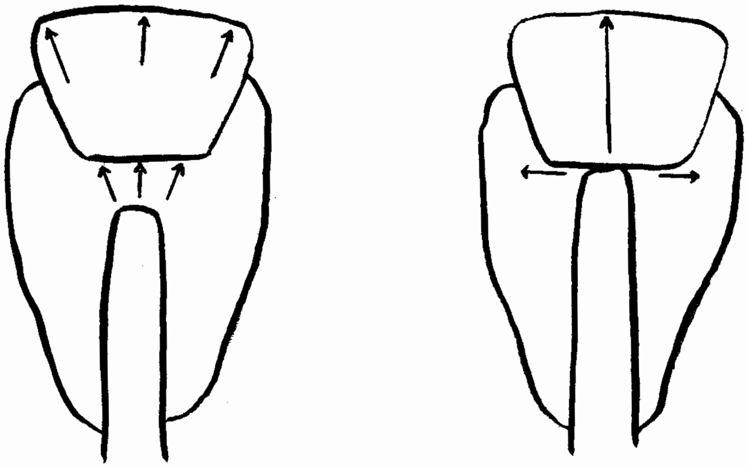
The hafting of the 'pirrie' graver is the same as above (Howe & Aiston 1924). It is interesting to note that this tool is similar to the bifacial points often referred to as spear tips from M.S.A. contexts in South Africa. According to Aiston (1928) they were used for drilling and graving, while their shape would be too unbalanced for projectile needs of any sort , but others refer to them as spear heads. The blunt edges of knives may be chipped, presumably to increase the surface area, and aid the cement to hold fast (Howe & Aiston 1924). If a handle is desired, the knives are then coated with glue into which hair or twigs are wound, both to improve the grip, and to prevent the cement from cracking. A number of the mounted implements show patterns painted on them, especially the cement.

A few other points that may be pertinent are that the manufacture of all tools used to be done by the older men (Thomas 1906) which enabled the younger men and women to concentrate on getting food. Illustrations tend to confirm this. Women's tools tend to be mainly wooden, and stone mainly part of the male's kit (Gould et al , 1971).

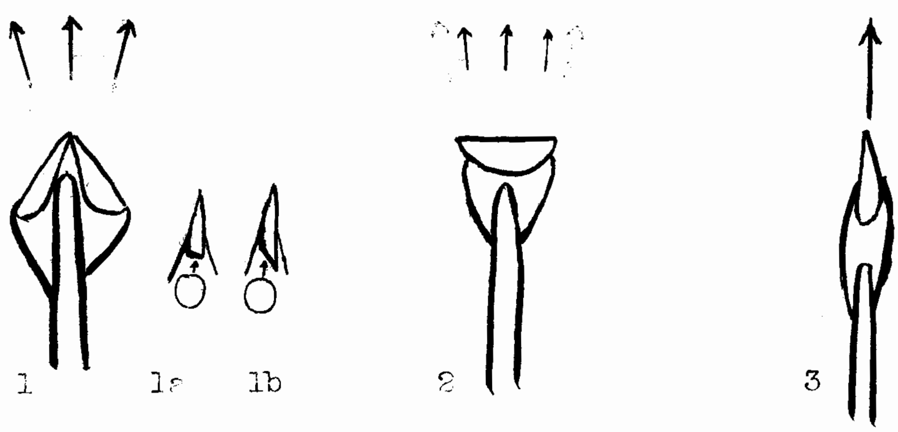
Secondly, it would seem that whether a tool was mounted or not would depend on the amount and type of work anticipated for it (Aiston 1928). Knife flakes might only be mounted if they were of a durable material, for example. If a handle or leverage was essential, the tool would then need to be mounted.

Finally, an advantage of hafting with cement is that it is relatively easy to fix. Should a tool work loose it could be reset merely by heating. It is also a relatively easy manner to replace flakes which have come out, and this would be an advantage in the use of the composite spearthrewer which allows the hunter to carry essential possessions with minimal effort.

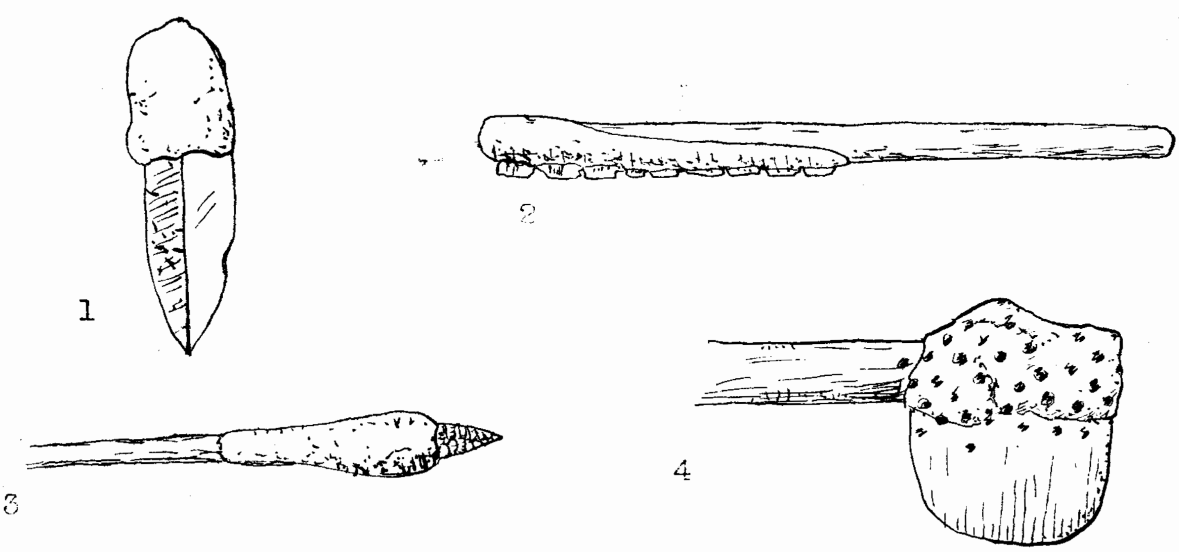
Without the aid of this binding medium, the craftsmen would have to develop methods of tanging which would involve more care and time, although wood and bone would be easier to work than stone in this regard.



A. Adze-scrapers: diagram



B. Arrowheads: diagrams.



C. Some Aboriginal mounted tools. (not to scale) (after Allchin 1957)

Fig. 10.

Ethnological and historical references to possible ingredients used in the Cape cements.

Historical observations as to possible ingredients are as scarce as they are on methods of tool manufacture and cultural correlations for the non-agricultural prehistoric peoples of Southern Africa.

Probably the first mention of hafting was by van der Stel after his 1685 trip to Namaqualand, when he described 'Hottentots' using the 'gum' which they called Traap, of Othonna arbuscula to bind or haft their knives or assegaais, etc. (in Smith, C.A. 1966).

Dunn is tantalisingly vague when he refers to a Bushman woman near the Leek River in Bushmanland using "resin" from "a small pelargonium" softened with heat to haft arrow heads (Dunn 1880).

Pterocelastrus tricuspidatus has been mentioned by various authors (Hewitt 1912, 1922, Clark 1958, 1959, etc. - in the literature they refer to P. variabilis). The resin obtained from the heated roots was used by the Cape Nguni for hafting spears (Smith, A. 1888, and Dr. Schonland in Hewitt 1912) and repairing pottery, and possibly by the Bushmen for hafting arrows - the Europeans in the Eastern Cape called it 'Bushman resin' (Hewitt 1922). Hewitt further mentions that the resin itself was very brittle and had to be mixed with other substances. Tannin extracted from the bark and leaves has been used commercially as well (Sim 1907).

Glue can be got from Hypoxis obliqua by heating the bulb, and was also used by the Xhosa to haft their assegais. The material was allowed to dry before being powdered and thrust into the hole made in the end of the shaft. The heated spear head tang melted the resin when thrust in, and was held firmly on cooling (Smith, A. 1888).

Pappe(1857) mentions that the 'gum' of Euryops multifidus (= E. speciosissimus ?) called 'the resin bush' was used as a substitute for resin in the Olifants River area, presumably by the Europeans, but the purpose is not elaborated. Possibly he is quoting from Burchell (Burchell 1824).

There are references that the gum (gummi acacia) of <u>Acacia karroo</u> (soetdoring) was used for adhesive purposes, 'Cape gum' being exported as late as 1849, (Smith, C.A. 1966) but no direct reference to any of the indigenous inhabitants having used it, as such, except in central Africa (Watt & Breyer-Brandwijk 1962). Possibly this is the Acacia gum used for minor repairs in the eastern Cape (Jimba, p.c.).

<u>Euphorbia triangularis</u> was one of the glues used to haft the metal spear heads into their shafts (Bigalke, pers com.). <u>Virgilia capensis</u> (<u>V. oroboides</u> ?) gum was collected by the Bushmen for use as a starch substitute (Pappe 1857), while the gum of <u>Acacia karroo</u> is also edible. Story (1958) mentions a number of Acacia and other gums eaten by the Bushmen, but again it is not known if they used the adhesive qualities.

There are a number of references to gluey extracts from plants having been used by the Bantu further North (Stow 1905, Watt & Breyer-Brandwijk 1962, Smith, C.A. 1966, Jacot-Guillarmod 1971, Clark 1958, etc.). Some are listed in Table Two, together with probable use. These may have been learnt from the earlier L.S.A. inhabitants. Table 3 is a list of glues used as bird-lime or cohesives. In addition, a number of other plants produce sticky exudations that conceiveably could have been used, and some are given in Table 4. It should be noted that none of these lists is complete or necessarily accurate. In the analysis for ingredients, all these species should be considered, while they should provide indications of related genera and species that should be investigated, and form the basis when research is extended into other areas.

In addition, one of the glue ingredients used by the Northern Sotho is the wax-lined tunnel of a bee that lives underground (Shaw p.c.). This would be a colonial bee, either <u>Apis adensonii</u> or <u>Trigona</u> sp. (mopane bee), for it to produce enough wax to make collection worth while,

TABLE 2

FAMILY	GENUS SPECIES	REF.	DETAIL &	DISTRIBUTION
Amaryllidaceae	Ammocharis coranica	6	for fixing pots in Lesotho	
	Brunsvigia radulosa	6	" " " " "	
	Hypoxis obliqua	15	resin from heated bulb used by Xhosa for hafting	
Anacardiaceae	Heeria paniculosa	18	repairs, by Zulu	Angola, S.W.A Tvl.
	Protorhus longiflora	18	'gum' from bark for hafting, by Zulu	E.Tvl.,Nat.
	Sorindeia sp.	18	adhesive purposes	Mocambique
Apocynaceae	Conopharyngia holstii	18	glue or bird-lime	Tanzania
	Diplorhychus mossambicensis (D. condylocarpon)	3,18	hafting arrowheads fletching, bird-lime used by Luvale	Mal.,Rhod.Tvl Zam.,angola
	Rauvolfia inebrians	(?)18	juice from roots to fix fractures	
Burseraceae	Canarium schweinfurthii	18	hafting arrowheads	W.Afr.
	Commiphora iringensis	18	glue	Tanzania
	C. sp.	3	hafting	mid. Zambezi
Canellaceae	Warburgia ugandensis	18	resin for hafting	Kenya
Cellastraceae	Pterocelastrus tricuspidatus (P.variabilis)	3,13,15 5,19	juice from heated roots for hafting, mending pots by Xhosa	S.W.Cape to E.Cape;N.Tvl & Rhod.?
Compositae	Euryops multifidus (E.trifidus)	2,8	resin substitute	W.Cape
	Othonna arbuscula	16	hafting adhesive	W.Cape
Euphorbiaceae	Euphorbia clavarioides	6	glue & bird-lime by Sotho	
	E. grandidens	18	caulking boats in Mocam.	
	E. triangularis	1	hafting spearheads by Xhosa	
	E. sp.	7	" " " "	
Geraniaceae	Pelargonium sp.	4	hafting arrowheads by Bushmen	Bushmanland
Leguminosae	Acacia catechu	18	adhesive in E.Afr.	N.Tvl. Rhod Mocam.

table 2 cont.

	A. karoo	9	adhesive gum in S.Cape. to Tvl, Nat. S.W.A., Rhod, Malawi	
	A. nilotica	18	edible gum adhesive (lac insect = parasite)	E.Afr., Natal
	A. sieberiana	18	glue	Rhod, Natal, Zam., Malawi
	A. sp.	1,16	mending cracks in sticks	E.Cape
*Liliaceae	Scilla rigidifolia	12	juice from bulb for hafting by Zulu	E.Cape, O.F.S. Botsw. Rhod, Tvl
Malvaceae	Malva parviflora	6	fixing pots in Lesotho.	S.Cape, S.W.
Rubiaceae	Gardenia imperialis	3	mending holes in pots (chew first) in N. Zambia	
Sterculiaceae	Hermannia geniculata	6	repair pots in Lesotho	
	Sterculia foetida	18	good adhesive	
*Leguminosae	Daniellia olivari	18	caulking canoes in Tanzania	

In addition, there are the following references:-

Beeswax	13,14	adhesive	N.Sotho, Hukwe Bushmen
Soot	7	hafting spears	Xhosa

References:-

1 Bigalke, E. p.c.
2 Burchell, W.J. 1824
3 Clark, J.D. 1959, p.c.
4 Dunn, E. 1880
5 Hewitt, J 1912
6 Jacot-Guillarmod, A. 1972
7 Jimba, p.c.
8 Palgrove, O.H.Coates 1957
9 Palmer, F& Pitman, N 1961
10 Pappe, L 1857
11 Riley, 1963
12 Ritter, 1955
13 S.A.museum correspondence
14 Shaw, E.M. p.c.
15 Smith, A. 1888
16 Smith, C.A. 1966
17 Story, R. 1958
18 Watt, J & Breyer-Brandwijk, M. 1962
19 Sim, 1907

There is a reference to the possibility that 'mopane ' bees wax was used by the Hukwe Bushmen (correspondence in the S.A.Museum). Either type would produce propolis, and this is most certainly the sticky agent, as wax, although ideal for moulding, would not retain its binding properties with any amount of work. Propolis is obtained from resin-secreting plants and so the chances of recognising the bee agent are remote, while it could even be possible that a number of plants contributed to the propolis. An outside possibility would also be the lac insects or scales (Lacci - feridae). Gosscardia sp. and Ceroplastes mimosae are probably too waxy, but Tachardina karroo may be stickier (Smit 1964, Imms 1960). These insects would probably show identical resin or gum patterns to the host plant.

Mr. Jimba (African Studies Dept., University of Cape Town, p.c.) informs me that soot was wedged into spear haft sockets previously hollowed in the shaft ends in the Transkei, before a ~~mounted~~ heated spear tang was thrust in. This apparently held firm.

It should be noted that the hafting of spears etc. among the Bantu involves a different strategy to those outlined for the Stone Age above, and this is namely the use of a tang or socket . Glues here are therefore aids to hafting and so glues need not be as resilient as in the case of Stone Age adzes, etc. The reference to a number of plant juices being used as arrow poisons in addition to other ingredients (Schapera 1927, Watt & Breyer-Brandwijk 1962) may be misinterpreting their cohesive role, and so they are probably also fruitful ingredients to consider with regard to glue hafting in general. Gelatine from bone, horns, hoofs, seaweed etc. never really hardens, and would be too jelly-like to have been a good adhesive, but may have been used by the Voortrekkers as a stationery glue.

The artefacts.

Type A. Four of the artefacts are characterised by large, roughly oval pieces of cement with a flake tool at one end, while a haft emerged from the other. The Touws River implement had a wooden haft, as did the Knysna specimen, as can be deduced from the impression left on the cement. Goodwin (Goodwin & van Riet Lowe 1929) noted that a stick was present in a tool from the Knysna area, but may have been referring to the Touws River artefact. (The pimply type of wood used presumably could be identified from the imprint, while the Touws River artefact could also be classified.). The stone tool in all cases was either an adze or adze-scraper, the Touw River and Plettenberg Bay ones apparently being heavily worked, with straight or concave working edges. The maximum length and width dimensions of the tools - excluding bone /wooden handle - are 7,8×4,9 ; 9,8×5,6 ; 10,0×5,7 and 10,6 × 4,8 cm respectively, while they all are roughly oval in cross-section. The adze flake was in all cases orientated more or less along the cylindrical haft axis, with its shape corresponding with the cross section plane. Shaft diameters were about 1,5 cm (Plettenberg Bay), 1,4 cm (Knysna) and 1,3 cm (Unknown) in diameter, and were circular (the Touw River ~~Plettenberg Bay~~ one is not known) [illegible] with a bluntish end. These show a striking similarity to the Australian adzes, referred to earlier.

One of the broken items may also have belonged to this basic category considering the general shape and the hole for the haft, but the mould shows that the haft was clearly thicker than two X-rayed specimens (see below), and showed no evidence of terminating although longer than the same two artefacts, while the cross section was more [illegible] ovoid (size 7,2 x 4,3 x 3,3) and the shape more oblate, suggesting that the original was not much larger. Possibly it served as a hand grip or a handle.

Type B. The mounted implement from Boomplaas is the only microlithic scraper so far found with a reasonable amount of cement still attached. Unfortunately, it is not a complete specimen, but should provide some clues as to their hafting, which included a handle. It would seem that considerably less cement was required than with the adzes, while the stone tool may have been in a slightly different plane to the handle, suggesting a different manner of usage. At Melkhoutboom, practically all of each scraper was covered with cement, excluding the working edge, on the evidence from trace remnants (Clark 1959, Deacon 1969). This would correlate with keeping the implement firmly mounted.

A curious point is that small scrapers are the most common tools that show evidence of hafting (at 7 of the 8 sites showing traces, and about 40% of all scrapers from the 1967 excavation at Melkhoutboom), yet there are no complete mounted specimens. They were the commonest artefact at Melkhoutboom, and so Deacon (1969) deduced from this that the scrapers represented the discarded, worked-out tool, with the cement being reworked possibly by heating, assuming that it retained its adhesive properties.

Type C. The Porterville and the Plettenberg Bay decorated bird-bone artefacts are apparently comparable to each other, although the former one has not been closely studied and the latter is broken. In both cases a blob about two cm in diameter (and therefore originally larger in the Plettenberg implement) covers the end of a handle. The Porterville artefact appears to have had three small pieces of stone placed into the cement - one in front and one on each side, although one of the latter has fallen out. The Plettenberg Bay artefact also had a chip of stone on the side of the cement. It is hard to visualise a purely material function for either of these tools, especially considering the decoration on the one, which is also painted.

Neither of th two Elands Bay moulded pieces shows evidence of having had a stone implement inserted. The one item is curious in that it is not homogeneous, consisting of a thin veneer of red cement over a whiter core of a softer, [illegible] ashey material. It is incomplete and so little more can be said about it. The other (Type D) has a narrow socket (about 5 mm in diameter) in the flat thinner end of a roughly ellipsoid shape.

The dimensions of this tool are 6,9 x 4,9 x 2,8 cm. Judging by the size of the aperture the cement may well have served as a handle to a bone or wooden tool, possibly an awl. An x-ray profile revealed that in side view it was slightly curved, but of constant size. The surface of the tool suggests that it may have been wrapped in leather while still malleable.

Type E. The size of the Woest Hill tool suggests that it is possibly a bit small to be used as a handle (45 x 15 mm), and the fairly regular cylindrical shape suggests that it may have been used as a blunt arrow. In shape and size it is comparable to a wooden tool from Scotts Cave (Deacon & Deacon 1963) (about 5,5 x 1,5 cm), with a similar inferred function. Cooke (1969) illustrates some modern Bushmen arrows including blunt wooden ones and one with apparently a lump of cement on the end, that would be used for stunning birds. There are traces of a wooden shaft emerging from the one end (about 5 mm in diameter).

Type F. The artefact from Die Kelders is probably a form of arrow head. It is roughly about 40 x 15 mm in size, and ellipsoid in shape. From the wide end the shaft would have emerged, while four equally spaced recesses in the more pointed end would probably have supported the bases of short wooden or bone spikes. Again similar pronged arrows are known, and Cooke (1969) illustrates some such Bushmen arrows.

A few adzes, a borer and a segment also showed evidence of cementing amongst the other tools, at Melkhoutboom. The segment had the full edge of the chord exposed when mounted, and the backed part showing the cement, which did not seem to support the concept of it serving as a projectile tip (see below). By contrast, however, the Elands Bay segment (of quartz) shows traces of cement along the utilised edge, but its association with the cement lump is somewhat dubious.

At Die Kelders, one microlithic scraper was recovered with traces of cement (Schweitzer 1970) and three from Hillside (Simons 1968). Mtanye

(Walker 1972) produced one small scraper ([illegible]) with traces of cement. Again at two sites in South West Africa (Apollo 11, Pockenbank) small scrapers showed cement (Wendt 1972).

At Maguaams in South West Africa, some microlithic tools (presumably backed blade tools) showed evidence of hafting (Wendt 1972). Four utilised pieces and two pieces with no apparent working showed traces of cement at Mtanye (Walker 1972). At De Hangen 16 pieces, including possible projectile tips, scrapers and spokeshaves, and unretouched pieces showed it. (Parkington & Poggenpoel 1971 ; Parkington 1972).

It is not possible to describe the hafting of these other tool categories at this stage, while some of the ethnographic references suggest other tool categories, but the arrows already described with two microliths would constitute a further category (Type G), although not from proven archaeological context. These consist of a bone or wooden foreshaft, with a diamond or ivy-leaf shaped mass at the leading end (approx. 1,8 to 2,4cm in size)with the two flakes in position as described. Palgrave (In Stow 1905) probably witnessed yet another arrow type.

Microscopic studies and X-rays.

The two implements from Plettenberg Bay have both been x-rayed and some interesting data has emerged from this (Deacon 1966). Deacon has noted that there is no evidence of their having been first bound on to the haft with sinew, and as there is no apparent modification of the butt ends of the scrapers from Melkhoutboom, it is probable that this was the essential technique for mounting these tools. A further interesting point was that the base of the adze-scraper flake did not rest on the haft, but rides free in the cement.

Similarly with the Knysna adze the adze/flake did not rest against the handle either, as can be deduced visibly, for half of the cement was removed in the 1950's for analysis (see below). It was thus decided to x-ray the other adze (Fig. 11). Once again the flakebutt is separated from the haft cavity by a layer of cement, and so it is evident that this is a deliberate technique, and will be considered below. (The Touws River implement was not available for x-ray).

The Elands Bay solid was also x-rayed. A number of minute pieces of stone are visible, including four of between 2 and 3 mm in size, near the unbroken end. The Elands Bay 'handle' on the other hand has a very fine and homogenous matrix, while the cavity (4 mm wide) is 5,5 cm long.

Microscopic studies were made of the surfaces of the two artefacts in the U.C.T. collection, and the three from Elands Bay. These implements were also selected for provisional glue analysis (by kind permission of Mr. John Parkington), together with a sample from the Knysna tool (by kind permission of the South African Museum); (see below).

Approximately 0,2 g samples were removed from each item, and were washed and cleaned first with water and then an organic solvent, Dimethylformamide. The residue was then given a visual sorting under microscope.

Had there been more time, this latter aspect would have been done more thoroughly. This would have involved washing the material in hydrogen-peroxide (H_2O_2) to remove all organic matter, after a visual check, and then fine sieving to separate the clay content. Weights would have been taken to give approximate composition breakdown.

From the results in Table 5 it is possible to say something about about the composition of each item, although it should be stressed that the treated sample is no more than an approximation, for the original fraction selected may not be representative. Furthermore, the latter was visually divided (ie subjectively) into seven categories - parts of leaf fibre, rootlets or other vegetable strands, quartz pieces over 1 mm, those approximately between 0,5 and 1,0 mm, and those between 0,5 and 0,2 mm in diameter. The remainder was divided into two categories, very fine clay or insoluble organic matter, and quartz less than 2,0 mm in diameter.

fig. 11.

Table.5. Preliminary Visual Study (x25) — Treated Sample Study

Origins	Item	Surface Study: comment	yellow-inclusion	quartz	salt	charcoal	ash	leaf fibre	rootlet	Treated Sample Study: original weight µg	washed weight µg	washed weight %	insoluble C+ H %	inorganic %	quartz 1-2mm	quartz 0,5mm	quartz 0,25mm	leaf fibre	rootlets fibres	comment
Flands Bay	Handle	smooth	✓	few	✓	✓	✓	[illegible]	✓	102,3	8,5	8,3	2,5	5,8	1				5	very little fine material
"	'solid'	brittle outer	✓	few	✓		✓	twig	✓	107,5	10,0	9,3	4,4	4,9		1	1		8	1 hair. very little quartz lot of fine material.
"	"	soft inner		✓			lot		✓	107,3	26,0	24,2	8,8	15,5	1	3	17		9	- - - -
"	segment	v. smooth.	few	few	✓															[illegible] studied
UNknown	Adze	piece of mica, Mollusc shell.		lot	✓	little		✓	✓	104,9	19,8	18,9	4,1 ~~21,7~~	14,8		8	14		16	lot of fine material
"	Cylinder	very pitted		✓	✓	✓	✓	✓	✓	104,5	27,3	26,1	10,2	15,9			28	4	29	- - - -
Knysna	Adze	not studied		✓						100,2	25,0	24,9	5,8	19,2		2	8	1	14	- - - -

The organic (C&H) content of the residual weight was assessed after removing soluble organic matter, and (so) the break down of insoluble organic and inorganic matter is as follows :-

adze	15,5 µg inorganic	4,3 µg insoluble organic
cylinder	16,6	10,7
handle	6,0	2,5
solid outer	5,3	4,7
solid inner	16,6	9,4
Knysha adze	19,2	5,8

From this, we can conclude that the Elands Bay handle is characterised by very little clay, and very little vegetable matter. The Elands Bay solid outer also has very little vegetable fibre, but very little quartz. The inner, however has a high ash and quartz content, but also very little vegetable fibre. It would seem that the Elands Bay segment cement would be very similar to the Elands Bay handle.

The other three artefacts have high quartz and vegetable fibre contents, while the cylinder has a very high ash content, and the Knysna adze a high clay content.

In conclusion between 8 and 26% of the total weights of the implements is provided by vegetable fibre, ash or inorganic matter, particularly quartz or clay. This seems a very high amount to accumulate naturally, and so the possibility that this was deliberate will be considered below. It had been hoped to test for differences between the amount of inorganic and insoluble matter on the surface and from deeper in the artefact in this connection, but this has not been possible yet. Microscopic studies do suggest that there may not be much difference, and that much of this material did not accumulate subsequent to manufacture. The microscopic analysis of the arrow head cement surfaces showed that they were pure and devoid of quartz grains, etc.

The Hafting Strategy.

Hafting types. Tools can be classified into two basic categories - Simple and Composite. Simple types are made from a single piece of raw material, and are used directly in the hand. Composite tools involve the addition of at least one component, usually a handle or lever in Stone Age technology, or two or more working edges. There are six possible methods of hafting:-

1) Wedging the implement into a handle, often with a hole or groove, previously made, usually with the aid of a tang or reduced base (eg. bone arrow heads.).
2) Hammering a pin through an implement into a softer material to transfix it (eg. in Iron Age contexts).
3) The implement can have a natural socket or one specially hollowed out, and be wedged over a handle (eg. bored stones).
4) Binding or sewing with sinew or twine (eg. arrow shaft ends).
5) Using a glue (eg. the artefacts under discussion).
6) A combination of any of the above.

Reconstruction. Since the beginning of the Century, if not earlier, it has been appreciated that hafting could be an important part of the 'pigmy' or Taaibosch culture as the main L.S.A. industrial complex was known (Johnson 1908, Peringuey 1911). There has accordingly been considerable speculation as to how the microlithic artefacts were mounted, and one of the favourite items has been the segment.

Thus Burkitt (1928) illustrated two possible strategies involving a knife and arrow head with the segments being embedded in the handle and haft end respectively. Clark has also reconstructed composite tools (Clark 1959), suggesting how the microliths were fixed in the grooves with cement to form knives and barbed spear heads. The latter is similar to Mesolithic spear heads recovered from Sweden (Clark, G. 1967), and the former to sickle knives from Neolithic sites in the Near East (eg. Oakley 1965). Sickle knife blades however are retouched on the working edge. Clark also illustrates slotted arrow foreshafts with the tips and barbs (Clark, G.

1967). In addition Desmond Clark (1959) illustrates a reconstructed tranchet type arrow, based on the analogy of modern Bantu people in the Congo area using similar but metal bladed arrows. The role of the tranchet arrow is apparently related to thick vegetation country where visibility is poor (Clark 1959). The tool is effective in slicing a wide wound, falling out quickly and so being easily recovered, while at the same time resulting in heavy bleeding thereby weakening the animal and setting up a blood trail that is relatively easily followed. Certainly the symmetrical shape of the segmant is in keeping with the requirements of a balanced tool, while Deacon (1969) noted that the remains of the cement in the segment at Melkhoutboom were on the backed arc and parallel to the sharp chord edge. Mounted stone transverse type arrows have been recovered from the kitchen middens in Europe (Oakley 1965), although these are narrow V-shaped, the apex probably forming a tang. This could reflect the fact that they were hafted by binding (they have been found complete with sinew and haft), and the 'tang' could be dispensed with if one relied on cement. It will be interesting to see if the segment corresponds with reconstructed woodland environment or woodland animals, which would be some confirmation for Clark's hypothesis.

Clark (1959) also reconstructs the mounting of small scrapers, and this corresponds to the known larger mounted adze/scrapers.

Cooke (1958, 1969) illustrates a number of possible ways of mounting backed blade tools either essentially by wedging them into the foreshaft and tightening by means of cement or twine, or by binding them on to the end of the foreshaft with cement.

Most arrows illustrated in the rock art have either simple tapered cylindrical points or are painted too small for it to be able to reconstruct the head. However a fairly large number of arrow heads in the paintings of Rhodesia are large and detailed. It has been suggested that these large examples are probably iron arrow heads (Rudner & Rudner 1970), but as some are the size of the archer's head, it is highly improbable that they are drawn to scale. More likely is that this is an artistic convention, with the painter trying to stress the particular arrow head involved. Indeed the Bushman hunters have a wide variety of arrows for different game and conditions (eg. see Cooke 1958) and so it is probable that the artists felt it important enough in certain cases to distinguish the types. Certainly there is a variety of arrow heads depicted in the art (Cooke 1958). Tranchet or blunt types feature quite prominently, while many are barbed.

With regard to other implements depicted in the rock art, there are many (Cooke 1958 eg.), but it is not easy to identify whether they are composite, let alone hafted, especially when monochrome.

Hafting probably was first used in the M.S.A., and it is generally considered that the well made and balanced bifacial points were tips of spears. Backed pieces and the smaller blades in the succeeding industries may well point to the introduction of the bow. Although no M.S.A. or pre-L.S.A. (i.e. before 'Wilton' complex) artefacts show evidence of the use of cement, a couple of lumps of possible cement have been found in such context (Beaumont , p.c.), but the chances of evidence surviving are of course more slender than the later periods.

That the microlithic L.S.A. industries require the use of cementing has been inferred for a long time on the basis of the small size of a number of the implements. The microlithic scrapers show no definite evidence of having their butts reduced as if for tanging, while it is hard to visualise the backed tools having been bound with sinew or twine tightly into place, for the sharp chord edge would have surely severed it. The rock art does further suggest the hafting of small implements, but as yet one can say no more than that.

<u>Association</u>. The earliest finds with definite traces of cement were in many cases recovered from uncontrolled collecting or digging, or the mode

of classifying and description make it difficult to relate context to the present terminology system. The two implements from Plettenberg Bay were associated with typical coastal pottery and a 'strandlooper' burial respectively (Deacon 1966), while the Touw River specimen also came from a burial and was associated with scrapers and organic matter. The mode of burial is no different to any later Stone Age ones excavated since (Goodwin 1938 eg.). All the adzes and adze-scraperflakes certainly would not be out of context in L.S.A. assemblages, while none of these Southern Cape sites ever fall in the range of the Iron Age distribution.

The more recent and systematic sxcavations have of course undoubtably proved the authenticity of the L.S.A. association with cement from at least a dozen sites, while none of these considered can be shown to have come from an earlier period.

They have been recovered in Rhodesia, South West Africa, and the Southern Cape (Fig. 1) and in all cases where the context is known have come from caves or shelters, excluding the Woest Hill item. The requirement of mineral preservation conditions is thus suggested, but on the other hand very few open sites have been thoroughly investigated.

The absence of any reference to cementing from elsewhere in Southern Africa more probably reflects sampling error than cultural differences, while the Inland Plateau has relatively fewer shelters than the Southern Cape or Rhodesia. Janette Deacon (J. Deacon 1974) has pointed to the shortage of dates from this area for the middle period of the Late Stone Age (about 7000 to 3000 BP). Further The Wilton/Smithfield division of the L.S.A. has now been shown to represent a time orientated trend (Deacon, J. 1972, Sampson 1972), while it would seem from their work that the middle industries with their relatively high concentration of backed blade tools, especially segments, for this region are sparse. However backed tools would not be the only items hafted with cement, while the absence of cement in the more numerous final periods here still cannot be explained. In this regard, Dunn's (1931) and Kannemeyer's (1890) comment that the end scrapers (the size of a 'thumb') of the Bushmen in the Northern Cape and Orange Free State were never hafted but used between the thumb and first finger, suggests that possibly the use of cements was not practised, or that high quality glues were just not available/or economically a worth-while proposition for collecting. Kannemeyer and Dunn of course were witnessing a people whose society was rapidly disintegrating, and considering the increase in scraper sizeat the end of the L.S.A. (eg. Deacon 1972), this direct usage in the hand may reflect technological changes in response to stress induced by greater competition. Nevertheless, the fact that some of the Free State L.S.A. assemblages contain practically all of the rare tanged triangular points in Southern Africa (Clark 1959), while a number of the backed blade tools of this region actually show concave retouch near one end (Sampson 1972), may be significant.

There is thus mounting evidence for the regular use of glue or cement in large quantities in L.S.A. times, if not by all groups, at least in many areas, Small scrapers especially, and backed blade tools - segments, borers, etc. - adzes and large scrapers, and retouched pieces frequently show evidence of having been hafted. It is not impossible that the flat blade core 'chisels' (outils écaillées), and some of the larger tools, like the Rhodesian polished axes will show evidence of cement hafting as well, together with bone and wooden artefacts and ornaments. (4)

General considerations

Where there is evidence of how adzes, scrapers and stone arrow tips or barbs and certain unidentified items were hafted, there is no identification of sinew binding, and the flakes and blades rode free in the cement. In the case of the adzes, the flake in all tested cases so far (admittedly only three) did not rest directly against the haft, suggesting that it was inserted into the cement lump subsequently to the haft (Deacon 1966). Further it is probable that this has added advantages in tool usage, although (in) all Aboriginal instances specified the adze butt was placed directly on the handle. A cement gap would offer two advantages. Onthe one hand the pressure from the shaft does not concentrate in a single area, but instead diffuses outwards, thereby acting on a greater surface of the stone butt. Consequently the work load is spread to the whole of the working edge. This has been pictorially represented in fig.10a. (I am grateful for the help of Dr. G. Garrett of the Material Sciences Dept., U.C.T. in trying to explain certain material problems. It is interesting to note that the Australian shafts as seen from the illustrations, are wider, which may be an alternative way of circumventing this problem of spreading the work load evenly.

Such a large piece of cement for the adze category would not be necessary for pure hafting, and the size and shape is in accordance with a "grip" function. In other words, one would hold the haft in one hand while the other, closer to the working edge, would control the point of impact on the item being prepared.

A second asset is that the 'grip' would act as a sponge and absorb a lot of the pressure ,whereas the vibrations from the continued jarring when in direct contact might help work the stone loose. In addition, the equal pressure from the work end in reverse would set up lateral components that might loosen the shaft, while further, direct shaft/stone contact may result in lateral energy vectors exploiting the glue interface between stone and cement, thereby loosening the stone. It is interesting to suggest from illustrations that the Australian adze flake counterparts are more firmly embedded in the cement than the local ones, and this is a functional development in response to these problems. It should be noted that three of the four South African hafted adzes do not have any wooden or other material left in the sockets made by the hafts, but whether this reflects decomposition, deliberate removal or loosening is not certain.

It is probable that the small scrapers were mounted in similar fashion, but on a smaller scale, while they were apparently more firmly embedded (Clark 1959, Deacon 1969). The striking feature, as noted by Deacon, is the high number of these artefacts showing evidence of cement, yet only the specimen from Boomplaas has a fair amount of it, and even this is incomplete. Deacon has suggested that this may well reflect the re-working of cement. By analogy with the Australian adzes this is highly probable, as is the explanation that the small scrapers with traces of cement represent discarded worked out pieces. Heat would be used to soften the cement when mounting the implements and to remove them, the cement being reused until it either loses its properties or too much dirt is incorporated making it too crumbly. The 'lumps' often recovered probably reflect this, but a few may be lost cakes of prepared cement, but this could be easily tested quantitatively. An interesting feature is that some stone artefacts show evidence of retouch after hafting (Clark 1958). Noting the small size it is just feasible that the mounting in cement initially served as a vice, while they were being prepared, but it could also reflect resharpening.

It should be pointed out in regard to the absence of complete mounted small scrapers that the two adzes from known context came from burials. In other words they were deliberately buried, presumably with the owner, as complete tools. This implies that adzes were important or much cherished implements, and also explains, that in spite of their being rarer and not showing as much evidence of hafting as the small convex and end-scrapers, we know more about their hafting. Further the other two adzes both have convex working edges, and show minimal usage. They have survived complete because they were still potentially usable - ie they had not been deliberately discarded. They may well have been deliberately buried as well.

The methods of mounting the other tool types are considerably less well known, excluding the one arrow type, although there are interesting hypothetical reconstructions and composite microlithic tools from archaeological sites in the Northern Hemisphere. Consistent patterns of cement traces could prove illuminating and one worthy of closer study in the future. The variety of shapes of backed tools suggests that there could be a number of functional types, and possibly the study of remnant cement may help illuminate the debate between the stylistic or functional nature of these types. Certainly the way an object is hafted should provide evidence of how it was used.

The fact that non-retouched pieces were hafted, often as arrow-heads shows how misleading it is to regard non-formal tools as being totally non-functional, but waste debris. Generally however, the elaborately prepared microliths were intended for future planned use, and the care afforded them would indicate that they would not be used for an immediate spontaneous requirement only, so considering their size they probably all were hafted.

The arrow heads described earlier on and possibly made by the Bushman Jantje, are certainly authentic, as identical types have been recovered independently from elsewhere in the Cape, including the Kimberley area, but data on them is frustratingly non-existent. Some of the small blade pieces (length 0,9 to 1,3 cm) have no backing while others show nibbling or fine backing. All characteristically have one acute angle point (approx. 30°), while none could be classified as segments. Some would probably even be included in waste categories of present inventories.

The backing would set up a number of advantages. On the one hand, the increased surface area would facilitate grippage for the cement and the thicker edge would be more firmly held in it, while secondly the pressure transmitted from the shaft should be more easily collected by the cutting pieces (Fig 10B (with)). In these particular arrow heads there are no barb edges, and the whole force is transmitted evenly onto the blades. These are inserted subsequent to the cement being placed on the foreshaft and no direct contact was obvious.

It has been suggested that the arrow tips were intended to work loose from the haft into the flesh on impact, making it difficult to extricate.

If this were intentional, it would be more probable that the blade would not be retouched. The force with which an arrow strikes is dependent on its surface area. The type just described is an intermediate form, and probably a general purpose tool. Using the equation Pressure = Force/Area, by increasing the striking area the striking power is decreased, as in the case of the transverse arrow heads. Conversely, by decreasing the area of contact as in the case of bone points or single full-on stone points, one should increase the penetration. One suspects therefore that the latter type should correspond to big game hunting and it would be interesting to see how they compare with faunal remains.

The small piece of moulded cement from Die Kelders is undoubtedly an arrow head. The small size and regular form are consistent for a projectile head, while the indentations on the end opposite the haft socket are evenly spaced and probably supported the spines. Bident forms of arrow heads have been known to be used by Bushmen, and seem to be represented in the Rhodesian rock art (Cooke 1958), and would be ideal for securing the prey. Stow (1905) refers to Bushmen fishing with spears and arrows on the Orange river, and this tool could be useful in such a role.

The Woest Hill object is not so obviously an arrow head, but the regular form and small size are most suggestive of this role. It was mounted on a wooden foreshaft. Short arrows, used to stun small game and birds while not destroying the skin are used by Bushmen, and may be represented in the rock art (Clark 1959). It is known however that poison and cement were carried on the ends of sticks by Bushmen (Clark 1959), but whether it would be laid on so neatly is debatable.

It is probable that other tool categories will also prove to have been hafted. It is clear further that cement was not solely used as a binding medium for stone or other worked pieces. The items from Elands Bay would seem to be a case in point, although the solid artefact is more enigmatical. The other could quite easily serve as a handle, being too heavy and the shaft too thin to have functioned adequately as a blunt arrow head. In this respect the shape fits the head easily.

It is possible that some of the larger scrapers and blades may ultimately show evidence of having been used in the hand, but set into a cement handle, as in the case of the Australian knives. Little evidence of the composite knife of spear has yet come forth, but Hottentots are known to have used barbed harpoons. No slotted bone or wooden handles comparable with the European Maglemosian spears have been found. A single piece of wood from Melkhoutboom Cave has a slit down one side (Deacon, H. p.c.), but it is hard to differentiate it from splits that occur in aging wood when it shrinks naturally, and so may well be fortuitous. Another possible slotted piece came from Highlands shelter (J. Deacon, p.c.), and interestingly has a thin coating of an unknown substance on it , the analysis of which should be interesting in this respect. If this knife type is to be found, it may well be analagous to the 'taap' knife in Australia, where the flakes are merely fixed in the cement. The absence or rarity of burins in the South African Late Stone Age context may have some bearing on this but they are more normally associated with techniques involving the removal of splinters from relatively soft material like antler by parallel incision. A fine bone knife came from Amadzimba cave (Cooke & Robinson 1954), while Peringuey illustrates some as well (Peringuey 1911), but one would suspect that large or composite stone blade or flake knives would also have been of some importance.

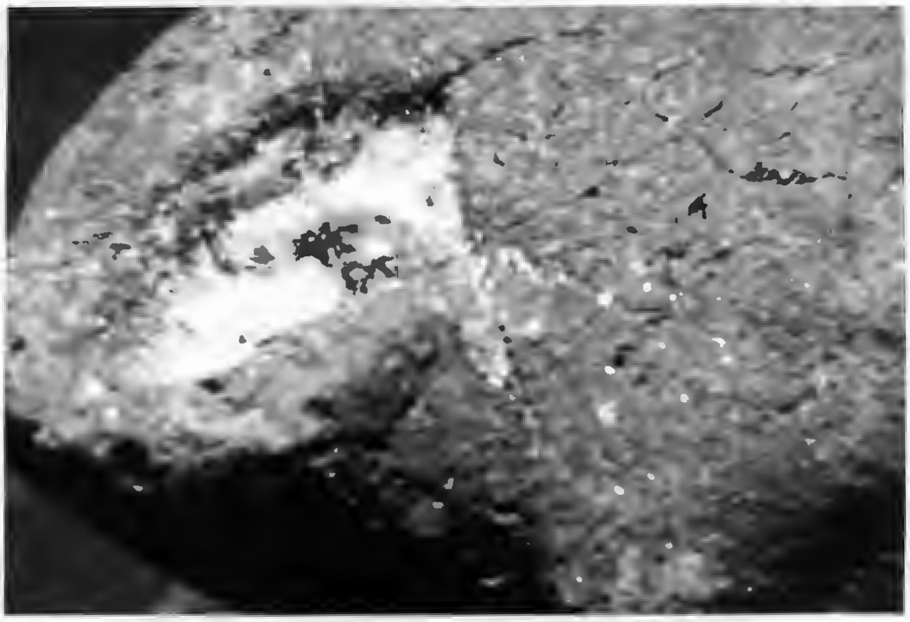
At this stage, the observation made earlier that the artefacts available for more detailed analysis contained a large amount of inorganic matter and vegetable fibre, needs to be elaborated. Deacon (1966) noted a lot of vegetable fibre in the specimens from Plettenberg Bay as well, and so it would seem that this is a characteristic feature. It may well be recalled that Aiston (1929) and Roth (1897) refer to the deliberate introduction of ash, dung or charcoal, or the grinding up of the whole plant to make a gritty mixture. Pure resin in itself is a rather brittle material (note Hewitt's (192-) comment on the brittle nature of 'Pterocelastrus' resin), and the addition of any inorganic matter but especially fibrous vegetable material would certainly strengthen it (Garrett, p.c.). Heat would melt resin and so it would be relatively easy to mix in any material with it. On the other hand it is quite likely that a lot of ash, charcoal, and other matter could have been incorporated accidentally. It seems more probable that the tool makers would have been aware of this fact, especially as the material does seem to be well mixed. The low proportions from the Elands Bay handle and solid outer surface suggest that possibly a stronger adhesive was used on the West coast (see figs 12 to 16).

Another purpose for glue would be for mending or sealing holes and broken objects. Although there is little evidence of it yet for prehistoric times, glue may well have been used in addition to sinew or twine. for hafting. Laidler apparently found sinew on arrows from Ngamakwe Cave (Laidler 19??), and this is the major method for hafting composite arrow and fixing up bows among modern South African hunters. Sewing or weaving would be used in their leather or grass work, while many of these organic items were probably tanned or varnished to help preserve them.

Mention has already been made of the use of binding media in paintings and for arrow poisons. Probably a fat was used to help keep on body paint, and there are references to this effect (Curle 1913). A number of Bantu People today resort to bird lime to help capture small birds, and it is quite likely that the Late Stone Age people, who relied more heavily on non-domesticated animals, resorted to this strategy. Peringuey (1911) mentions that Hottentots from the Port Nolloth area may have used Euphorbia juice to prepare their pots, presumably for greater adhesion.

Binding media therefore fulfil a number of different purposes - bird-lime, arrow poison, cohesive, for body and rock painting, as a preservative, for repairing, for adhesion, for moulding, and for handles. It would seem probable therefore that a number of glues were resorted to at different times, and even similar strategies may have required different glues in differnt contexts. Thus a quick setting glue would be useless as a bird-lime, and a water soluble gum impractical under damp conditions.

This therefore sets up a whole sub-system of supply and demand, - people exploiting the resources in their own area as fully as possible,



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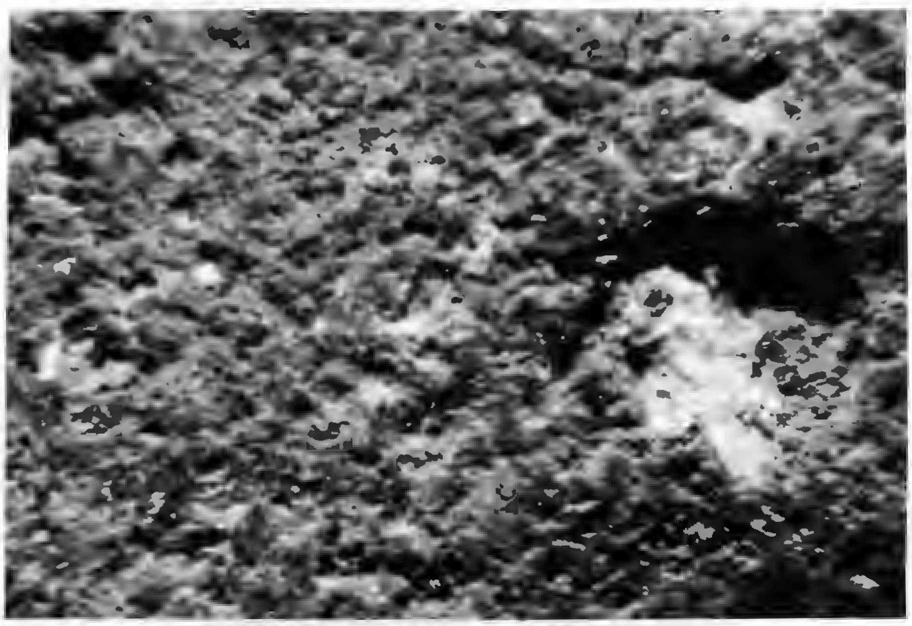
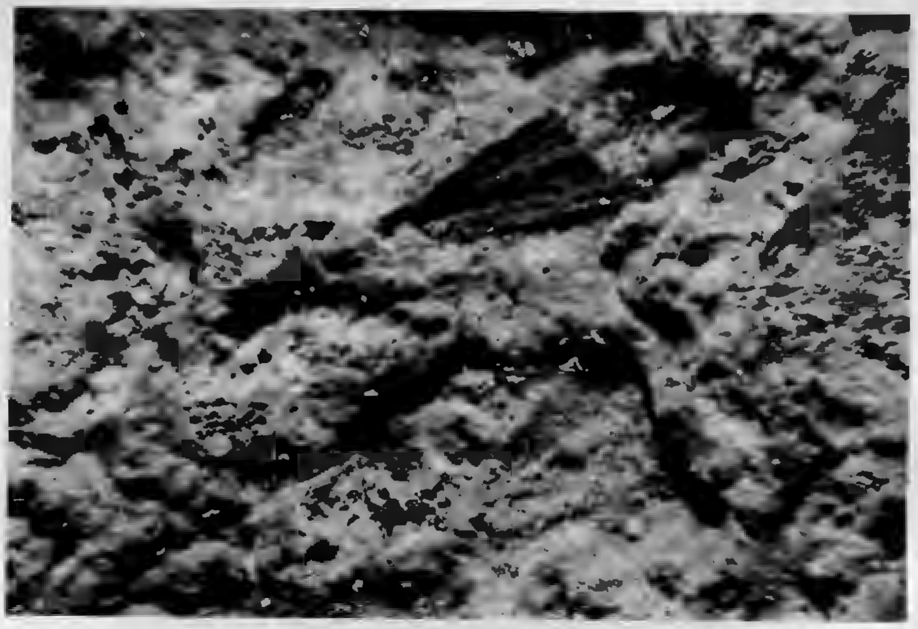


B. Elands Bay 'solid', [illegible] i[illegible] ash in[illegible]sions. (x10)

Fig. 10.



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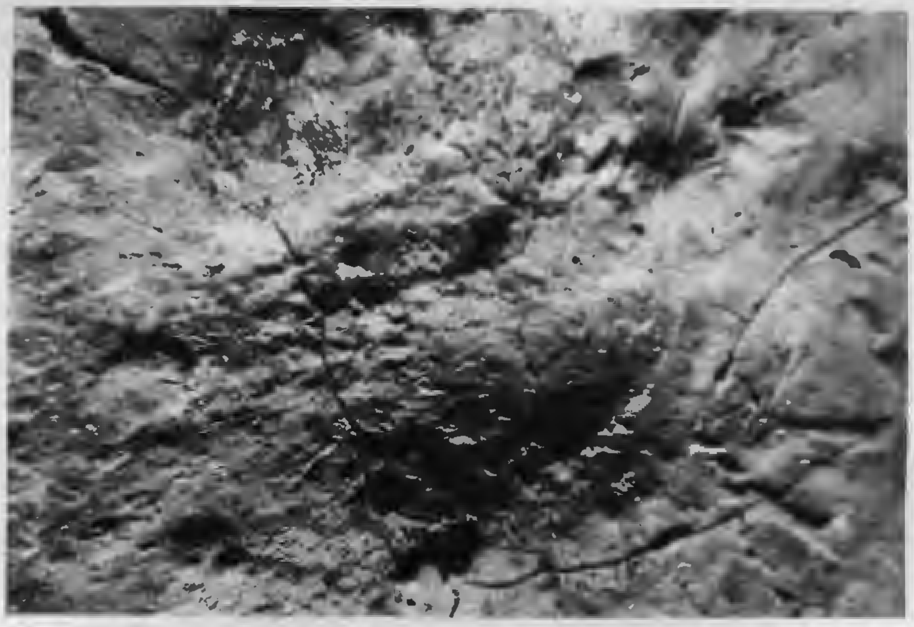

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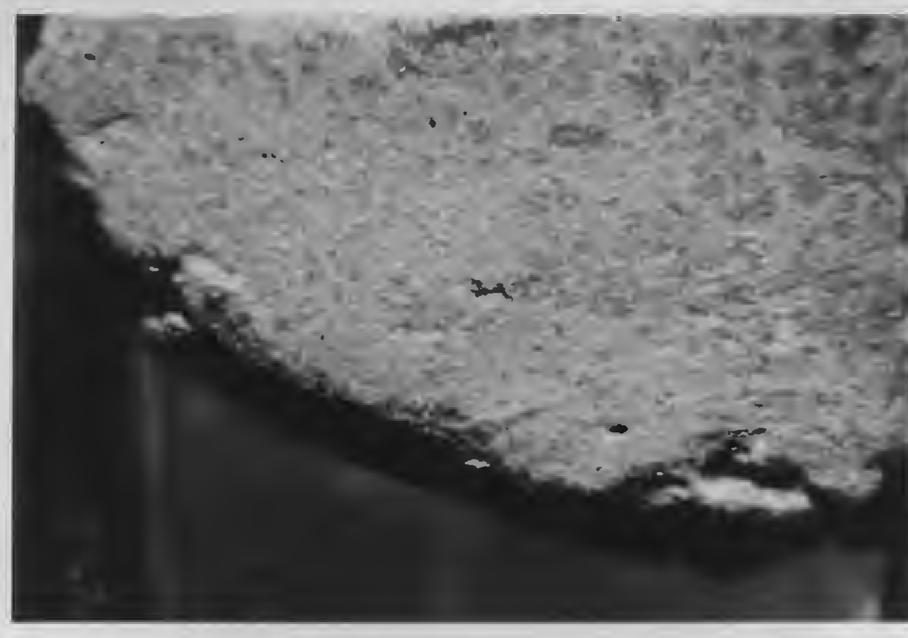
Fig. 14.



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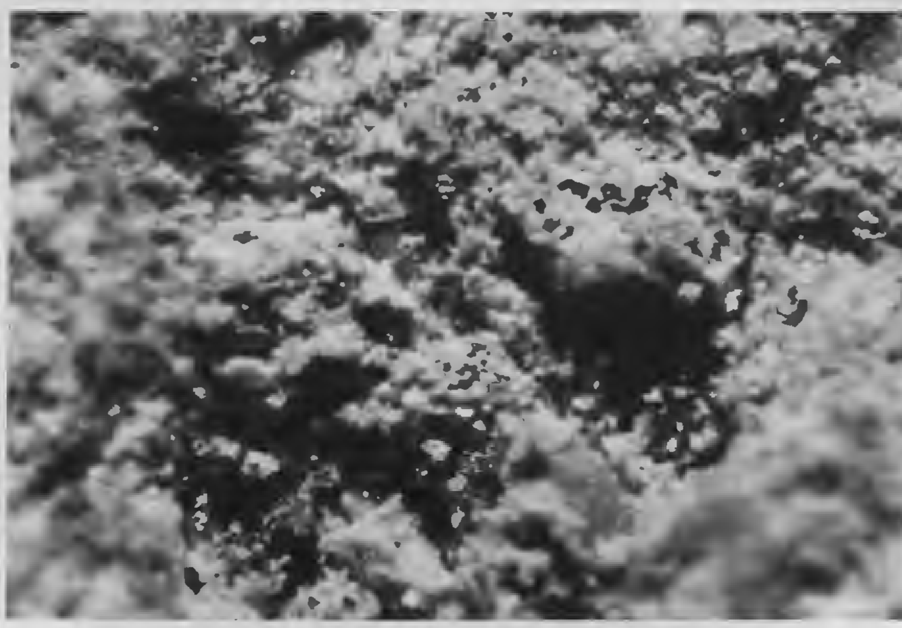

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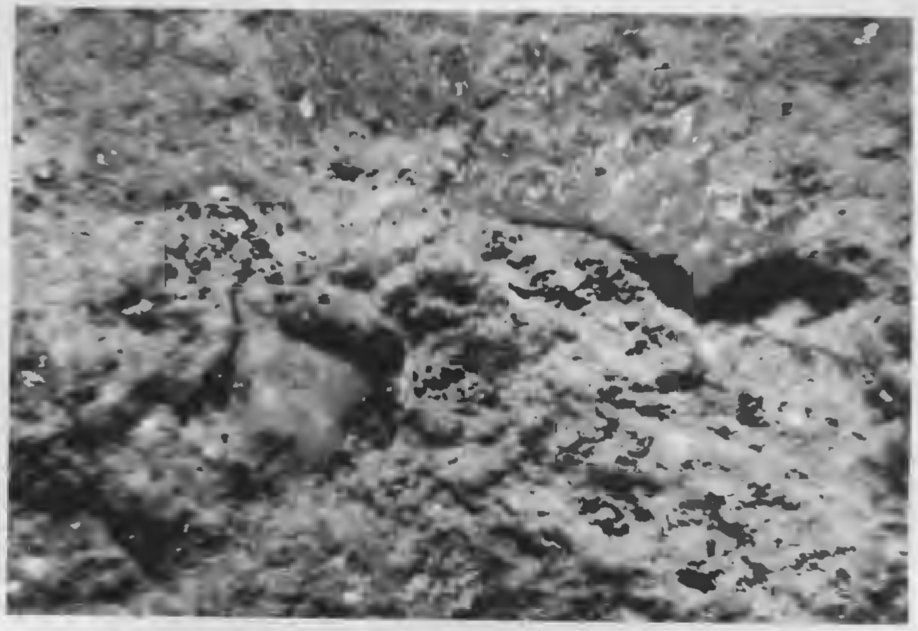

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Material to be tested. 5 samples were initially selected :-

Two from known late Stone Age context in Elands Bay Cave, south western Cape (by permission of J.E.Parkington).

Two from unknown sources. It had been suggested that they might have come from a cave or caves near Plettenberg Bay, an area which was extensively 'prospected' in the early 1900's, but there is no evidence of this (by permission of the U.C.T. Arch. Dept.).

One from an unknown context in a cave in the Knysna area, southern Cape (by permission of the S. A. Museum).

The items have been given names for convenience of reference - E.B.h. (Elands Bay 'handle'), E.B.s. (Elands Bay 'solid'), U.a (Unknown adze), U. c. (Unknown 'cylinder') and K.a. (Knysna adze). Small samples were removed from E.B.h and U.a in the form of a thin section or wedge on one side at right angles to the main axis by means of a diamond edged rotary wire saw, while the other more fragmentary specimens either had loose pieces of material, or the desired amount was scraped off. Two samples of about 100 g each, one from the inner and one from the surface of each item were obtained, but not all were used.

A prediction.

From a review of the literature (see above), it would seem that plant products are almost certainly involved, with an outside chance of insect products, secondarily obtained however from plants. A number of glues would only be effective as an additional aid in tanged, wedged or bound hafting. It is possible that a number of cements were therefore collected, possibly for different function categories. As the hafting technique would be important and a regular part of the technology it would be safe to say that the hunter-gatherers collected the most economical ingredients - i.e. sufficiently durable, sufficiently easy to collect and work, and which accurred in relatively large abundance.

Sticky material can probably be obtained from a wide number of plants but it is unlikely that hunter-gatherers would not be influenced by the relative ease with which a good adhesive substance can be collected.

There are three basic types of sticky plant exudations - resin, gum, and latex or sap, but distinctions are not hard and fast. Resins are insoluble in water, but usually soluble in organic solvents, and soften with heat but harden again on cooling. Gums conversely are water-miscible, and usually insoluble in organic solvents and harden on drying, while latex usually becomes tacky and dries more slowly, but its actual behaviour depends on the constituents in the colloidal suspension.

Resin is therefore easy to work and mould as heat is easy to apply, whereas gum is more difficult to reuse under primitive conditions as the dissolving and evaporating would set up technological problems. Chewing presumably could be efficient but not for reworking large and gritty mounted cement-pieces, while gum would be slower to work and would be useless as an adhesive under damp conditions. It would also be prone to bacterial decay. Furthermore, gums are frequently edible, and so may have been used as a food source.

Latex usually has rubber qualities that may stand against its value as a firm glue, but heat generally softens the dried-out form, although this apparently depends upon the amount of resin present. Resin then has recycling properties, and can be used under damp conditions -eg. sealing water-pots, but could not be used on cooking-vessels

Apart from the advantages outlined above, resin is more likely to be found on Stone Age sites as against gum , because of its greater resistance to bacterial decay and damp conditions. The absence of gum-glues from sites of course need not mean that they were not used.

Thus it is likely that resins will be found to be the basic ingredients. If one knows the resins in the area under study, it is likely that one could predict the ingredients.

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Previous research.

In 1892, Marloth analysed the hafted tool found at the Touw River Cave, and he came to the conclusion that it was probably made of a 'fine resin and chalk'. He also claimed to have found starch grains of 'wheat and rice ... and therefore this cement must have been made after the arrival of the white man in South Africa'. There is no reference as to how he obtained his results, or how justified he was in concluding that the starch grains were of rice and wheat and not other wild plants.

During the 1950's the S.A.Museum tried to get some identification of the plant involved (I am grateful to Miss. E. Shaw for making available certain correspondence). Material from the Knysna artefact and from a small scraper from Melkhoutboom (Hewitt 1931) had been sent overseas to the British Museum and the Colonial Products Laboratory. Correspondence also included the Royal Botanical Gardens, at Kew, the Imperial Institute Kensington, and the C.S.I.R., but the experiments did not achieve very much, due in part to a breakdown in communications, and in part to an inability to remove any sticky material from Pterocelastrus at all, in spite of much effort. The Imperial Institute did however extract 3,5 % of a rubber like material (which lacked elasticity) from some roots of Gymnosporia acuminata which had formerly been known as Celastrus. Benzene and acetone were used after the roots had been ground up with a disintegrator. The only other points of interest are that no wax was identified, that the cement in both cases appeared to be a resin, and that chromotography was suggested as a possible aid.

After this, the next attempt at analysis was in the University of Cape Town Chemistry Department. In 1964, four samples apparently from specimens in the U.C.T. Archaeology Department's collection were tested by thin layer chromotography (Campbell, Tarr and Stephen 1964). They were run off against two commercial resin standards, sandarac and dammar. The standards corresponded fairly well with the expected results, although the slow moving components were rather blurred. Two of the cements were practically identical (correlation in 7 out of 8 visible constituents), while a third was closely related (7out of 11 constituents), and these were more comparable to dammar than sandarac, and also to commercial mastic which was not tested. The other specimen had very few common constituents with the others, and in general showed some similarities with the slower moving sandarac spots. The adze (U.a.) had had a section removed previous to the present experiments, and so was almost certainly one of the samples, but it is not known which. The other items could well be U.c. and the two artefacts in the S.A. Museum, but this is conjecture.

Although no positive results were obtained as local resins had not been considered, the potential value of the method was apparent, hence the current research.

Clark more recently has experimented with infra-red spectrophotometry on Egyptian arrow heads, but has not had much success (Clark J.D., p.c.). It is not known if he used thin layer chromotography at all.

<u>The analysis.</u>

<u>Stage 1; building up a comparative sample of plant glues.</u> As wide a selection of sticky plant products was made as possible, using the literature on potential sources as a guide. This presented greater problems than was initially anticipated, as plant identification proved difficult, and exudation collection was not always possible or easy. In the end thirty-five plant samples were collected, which represents quite a long period in the field. As resins, etc. can vary according to the time of year, locality and possibly in seasons when they are more easy to collect (Howes 1949), it was desirable to be aware of these problems when collecting material, and some samples were duplicated. It was not possible to do this regularly or to collect at different times from the same plants, due to other commitments.

Plants so far encountered can be divided into three categories depending on how the material can be collected. The easiest method is simply to collect globules of resin or gum from the branches or stems were practically identical (correlation in 7 out of 8 visible constituents), while a third was closely related (7out of 11 constituents), and these were more comparable to dammar than sandarac, and also to commercial mastic which was not tested. The other specimen had very few common constituents with the others, and in general showed some similarities with the slower moving sandarac spots. The adze (U.a.) had had a section removed previous to the present experiments, and so was almost certainly one of the samples, but it is not known which. The other items could well be U.c. and the two artefacts in the S.A. Museum, but this is conjecture.

Although no positive results were obtained as local resins had not been considered, the potential value of the method was apparent, hence the current research.

Clark more recently has experimented with infra-red spectrophotometry on Egyptian arrow heads, but has not had much success (Clark J.D., p.c.). It is not known if he used thin layer chromotography at all.

The analysis.

Stage 1; building up a comparative sample of plant glues. As wide a selection of sticky plant products was made as possible, using the literature on potential sources as a guide. This presented greater problems than was initially anticipated, as plant identification proved difficult, and exudation collection was not always possible or easy. In the end thirty-five plant samples were collected, which represents quite a long period in the field. As resins, etc. can vary according to the time of year, locality and possibly in seasons when they are more easy to collect (Howes 1949), it was desirable to be aware of these problems when collecting material, and some samples were duplicated. It was not possible to do this regularly or to collect at different times from the same plants, due to other commitments.

Plants so far encountered can be divided into three categories depending on how the material can be collected. The easiest method is simply to collect globules of resin or gum from the branches or stems

Table 6

(Type?)

Family; Genus	Species	No. of constit. key T.C.C.	Type	Collec	Occur	Date	Distribution	Hist. ref.
[Leg]uminosae Mimosaceae	Acacia karroo	(–)	G.	W K	C.	8/4 24/4	Widespread outside of W. Prov. and... all coastal ...	Yes. 'Cape Gum'. Resin used as adhesive.
Papilionaceae	Virgilia oroboides	(–)	G.	K	C.	2/4	Cape Pen. ... (R.C.)	No. edible: Pappe; Smith
	V. divaricata	(–)	G	W	C.	8/4	Cape Pen. to Pt. ...	No
[Zam]iaceae	Encephalartos caffra	(–)	G	W	C.	8/4	E. Cape.	No. edible?
[Lili]aceae	Aloe karasbergensis	(1)	S?	W	T	8/4	Bushmanland. Karroo, SWA	No.
	A. ferox	(1)	S?	W	T	8/4	Karroo S & E. Cape.	No. medicinal.
[An]acardiaceae	Rhus viminalis	(1)	G	K	C.	24/4.	In S.W.A. W. Cape, Namaqualand	No.
[Irid]aceae	Watsonia sp.	(–)	G?	M K	D	30/3 24/4	Cape penins.	No. edible.
[Celas]traceae	Pterocelastrus rostratus	5)	(R?) T	B	D	6/5	Swartberg, ... Bettys Bay (S. Cape)	No.
	P. tricuspidatus	(5)	(R?) T	C.B.	D	12/5	Cape Coastal (R.C.) Malmes - E. Cape.	Used by E. Cape Nguni & Bushmen. Yes. see Clarke, Hewitt ...
[Hyd]noraceae	Hydnora africana	(4)	(R?) T	W	D	8/4	Malmes, Cape - B...(R.C.) see E. mauritanica	No.
[Ger]aniaceae	Pelargonium sp. (geranium)	–		C	D	6/5	E. caput-medusae (...) Bushmanland	Yes. Bushmen ... Dunn refs. to small ...
[Cu]pressaceae	Widdringtonia nodiflora	(2	R	K	C.	24/4	Cape.	No.
	W. schwarzii	(2)	R	K	C.	24/4	Baviaans Kloof ...	No.
[Com]positae	Euryops othonnoides	(4)	R	K.B.	C.	28/4.	Cedarberg to ... & Witteberg. ...	No.
	E. spathaceus	(3)	R	K.	C.	24/4	Karroid ... SE. Cape. (...) Langeberg to E.L.)	No.
	E. speciosissimus	(3)	R	K	C.	3/4	SW Cape (Cedarberg ...) esp. Piketberg, ...	Burchell in ... Pappe (E. multifidus). ?
	Othonna arbuscula	(3-4)	R.	K W	C.	3/4 8/4.	Namaqualand ... Bushmanland ... (O. ...?)	Yes. Smith 1966 - Tramp used by Hots. as adhesive.
	O. barkerae	(3)	R	K	C.	25/4	Zwartkops ... EE.	No
	O. zeyheri	(3)	R	K	C.	25/4	Cape.	No.
	O. sp. 5/53	(3)	R	K	C.	25/4	Richtersveld.	No.
	Hertia sp. othonnoides?	(4	R	K	C.	25/4	Cape.	No.
[Aizo]aceae	Sarcocaulon burmannii	(–)	(R?) ?	K	C.	25/4	SWA, N. Cape Namaqualand	No
[Mor]aceae	Ficus capensis	(–	L	K	T	24/4	E. (Kaapse, trop. Afr. EE Widespr. - Forests.	No.
[Ascle]piadaceae?	Gomphocarpus fruticosus	(–	L	K	T	24/4	SWA. Cape Pr... Widespread ...	No.
	Sarcostemma viminale		L	W	T	8/4	Karroo, ... Clanwilliam to Up. Nile	No
[Eup]horbiaceae	Euphorbia burmannii		L	W K	T.	8/4 24/4	Namaqualand, Cape Pen, EE W. Cape. Robertson	No
	E. coerulescens		L	W	T.	8/4	E. Cape. Somerset. EE.	No
	E. ledienii		L	K.	T	24/4	S.E. Cape.	No. Hots. used as ... birdlime ... Little
	E. mauritanica	(2+3)	L	W	T	8/4	Sandy & karoid areas. all ... (K&C. 1950) Namaqualand ...	No. Burchell uses as bird lime & ...

Euphorbia sekukuniensis (1)	L	K	24/4	T.	E. Cape to E. Tvl. G.E.	No
E. tetragona. (1)	L	K	24/4	T	E. Cape.	No. clear gum. W & B.B.
E. triangularis. (1)	L	W	8/4	T	E. Cape to Nat.	No.

* W. cupressoides	R.	K	/8	C	E. Cape coastal ? and rainfall mts from Sn Cape to Malawi.	No
*1 E. tenuissimus	R	Bp	/7	C	Oudtshoorn.	No.

of bushes and trees. Occasionally, the resin exudes on its own accord, but normally gum or resin collects in wounds, and so it is possible that the collector can induce flowing, although if the plants are numerous, it is unlikely that this would be necessary. Gum exudation may be the result of disease (Howes 1949) and if so, certain healthy trees may not be productive, no matter how much effort was made to extract it.

A further category is that those with subterranean roots or tubers, etc. that have to be dug up. Trees like Pterocelastrus are relatively easy to find, but others like the underground parasite Hydnora require knowledge of veld craft. If cutting did not induce flowing, these sources would then require a further extraction process, by heat or a solvent.

The final category are those that can be induced to 'bleed', like the Euphorbias. Certain species produce an abundant latex and can either be sliced, or snapped off and allowed to drain. Aloe sap which is sticky can be collected in this way, or alternatively collected dry from wounds after it has hardened.

Table 5 is a list of all the plants collected from, with data on when collected, where from, etc. Some of the material has not been run yet, as it was collected too recently.

A Geranium sp. rootstock could not be induced to yield any exudation at all, while the roots of the two Pterocelastrus species and the Hydnora plant presented problems of extraction. The final solution was eventually to cut up the root and underground organ into small pieces and heat in a test tube over a bunsen at high temperature. A dark liquid was given off, and this was collected. It seemed to have a high tannin content in all 3 cases and did not appear to be sticky, but it was decided to experiment with it nevertheless. It should be noted though that the references to Pterocelastrus tricuspidatus came from the Eastern Cape, and possibly it is easier to collect in that region, or that it can only be extracted at certain times, as is suggested in an unconfirmed statement in the S.A.Museum correspondence, which notes that the resin only rises 'during certain seasons'. Previous attempts failed to extract any material from this plant in the Cape peninsula (S.A.Museum correspondence), and there is a possibility that another species is involved.

Some preliminary experiments were conducted with the material in order to classify it broadly. Those marked 'G' were highly soluble in water, and probably are gums. Virgilia oroboides, V. divaricata, Acacia karoo and some dried Aloe karasbergensis sap (collected dry from the plant) were tested for water-soluble carbohydrates (approximately 0,1g in 10 ml water), and yielded 71%, 46%, 43% and 63% respectively with the phenol H_2SO_4 method, using a colourimeter. This gives some idea of the quantity of water-soluble carbohydrates present in gums. Acacia karoo charred when placed over a bunsen flame in a test tube, but did not melt.

By contrast, those marked 'R' were not soluble in water, and all melted when heated. Some of these were subjected to high temperatures to see if strong heat could break them down(see below).

It should be noted thatthis is not a satisfactory method for classifying resins -which most of the previous group are - and gums, as the distinction is not so simple and gum-resins or intermediate forms occur, but it is adequate for our requirements.

The Euphorbia latex 'L',after being dried, behaved closer to the resins, not being obviously water soluble, while it became tacky with heat on cooling; however, it had a rubbery consistency. The Euphorbias have a high resin content (Watt & Brever-Brandwijk 1962), and the other latex types may not be equivalent. Not all ingredients were tested thoroughly, and neither resins nor latexes were tested quantitatively for water soluble carbohydrates.

2. Testing the cement for water soluble carbohydrates. Two samples of approximately 100μg from the inside and outside of the Elands Bay solid and one each from the other four samples were mixed with 10 ml of distilled water, after being finely crushed, by means of a magnetic stirrer at room temperature. The insoluble matter was separated by centrifuging

and removing with capillary pipettes.

The solute was then forwarded to Dr. Churms for water soluble carbohydrate analysis, also using the phenol H_2SO_4 method and colourimeter set at 490nm wavelength, using a control for the natural colour.

The results are as follows :-

U.a	adze	0,25%
U.c	cylinder	0,14
E.B.h	'handle'	0,00
E.B.s	solid	0,30
Knysna	adze	0,18

When compared with the gums above, it is clear that no gums could be involved primarily as the adhesive agent, and the small counts can be attributed to contamination in manufacture or use, or trace elements in the main ingredients. Considering the small size of the samples available, it was decided not to assess for the actual carbohydrates, but this could be done by hydrolysis and paper chromatography.

3. Thin layer chromatography. The procedure followed was essentially that described by Stahl (1965) but was based on the experience gained in the 1964 experiments. Vegetable samples of approximate 100µg were warmed and centrifuged in 5 ml D.M.F. (dimethylformamide) which was found to be a very suitable solvent. By means of a micropipette, 5 microlitres (5x 10^{-6}) of each were spotted on silica gel plates (F254), which have a special built-in fluorescent indicator (the aluminium back fluoresces under ultra-violet light, unless there is some material overlying it). The plates were dried by means of a hairdryer, while it was found that it was advisable to leave them for half an hour before running, otherwise they might run unpredictably if still wet.

These plates were then run in a 20;1 benzene-methanol solvent mixture. From previous experience it was decided to run each plate twice, as this shows the spots up more strongly. This of course rules out the value of trying to establish a Rf chart, but it was found that spots tended to run at differential speeds. This was in part due to the impossibility of keeping the environments constant, while it became apparent that the solvent mixture behaved unpredictably. Fresh solutions should be used at all times.

In the end 6 plates were developed (Figs, 17 to 22), four of them of plant extracts, and two of them with the half a dozen cement samples being run against controls, including some commercial ones. In all cases a single plant, Euryops othannoides was used as a cross reference.

Plates I and II are mainly of resins, (Euryops and Othonna spp, Hertia and Widdringtonia spp) and tannins (Hydnora and Pterocelastrus spp.), and most show up three or more clear and therefore proportionately dense constituents. Plate 1 shows that there is little difference in the visible spots between fresh and old E. othannoides material, and with material heated strongly. Plate II shows the other Compositae are similar to Euryops, except for O. arbuscula, in that there is a prominent leading spot.The slowest spot is identical in all cases, but the position of the intermediate ones vary.An interesting point is that two samples of O. arbusculawere identical although from plants in different regions.Pterocelastrus and Hydnora were vrey similar.

Plates 111 and 1V show that by contrast, the gums do not show any solvent soluble constituents, excluding Rhus with one. Only the Euphorbias of the latexes show up constituents (usually one), while the aloe saps display single spots.

Thus the resins, tannins and Euphorbia mauritanica have complex solvent soluble structures, and from the 1964 experiments, were therefore more likely candidates, as complex structures were indicated.

Plates V and Vl show the relationship between the six cement samples and some of the more prominent controls, plus the commercial gums/-resins sandarac, dammar, mastic and tragacanth. Plate Vl is a particularly good chromatograph.

Plate 1

a

Euryops othannoides(fresh)

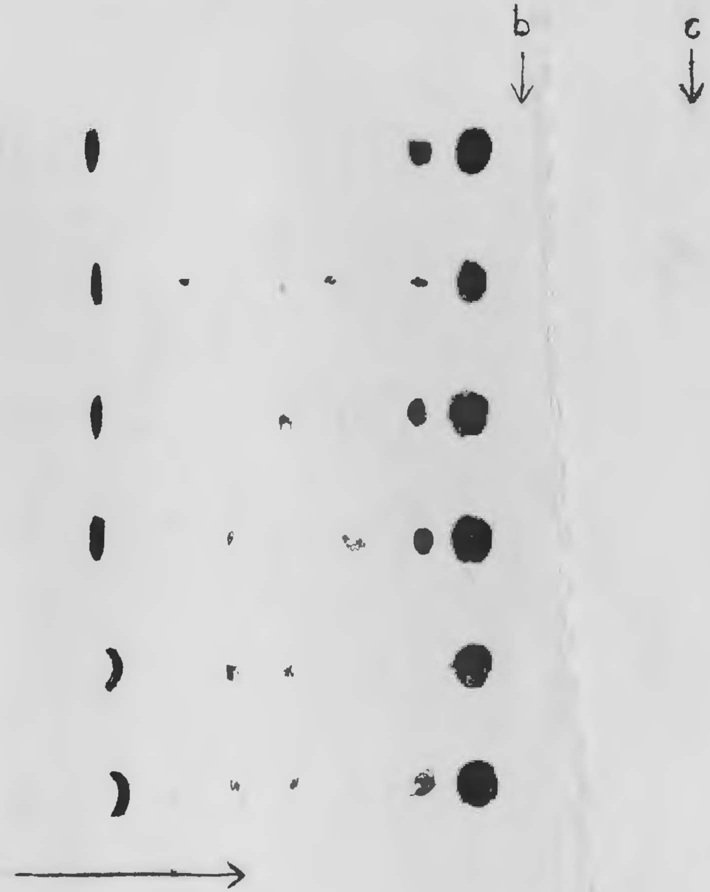
E. o. (old)

E. o. (100°)

E. o. strong heat

E. spaciossisimus

E. spathaceus



a = starting line

b = point where leading spot shows up, often as a line almost

C = leading front

Fig 17

Plate 11

Hertia sp.

Othonna barkerae

O. arbuscula (Kirstenb.)

O. a. (Worcest.)

O. zeyheri

O. sp.

Hydnora africana

Pterocelastrus rostratus

P. tricuspidatus

Euryops othannoides

note that the crescent is an 'artefact' and represents a 'wet' spot - one that had not dried before developing. Consequently it has run too quickly.

Fig. 18

Plate 111

Widdringtonia schwarzii

W. naudifolia

Euryops othannoides

beeswax

Euphorbia sekukuniensis

E. tetragona

Ficus capensis

Gomphocarpus fruticosus

Watsonia sp.

Aloe ferox

Virgilia oroboides

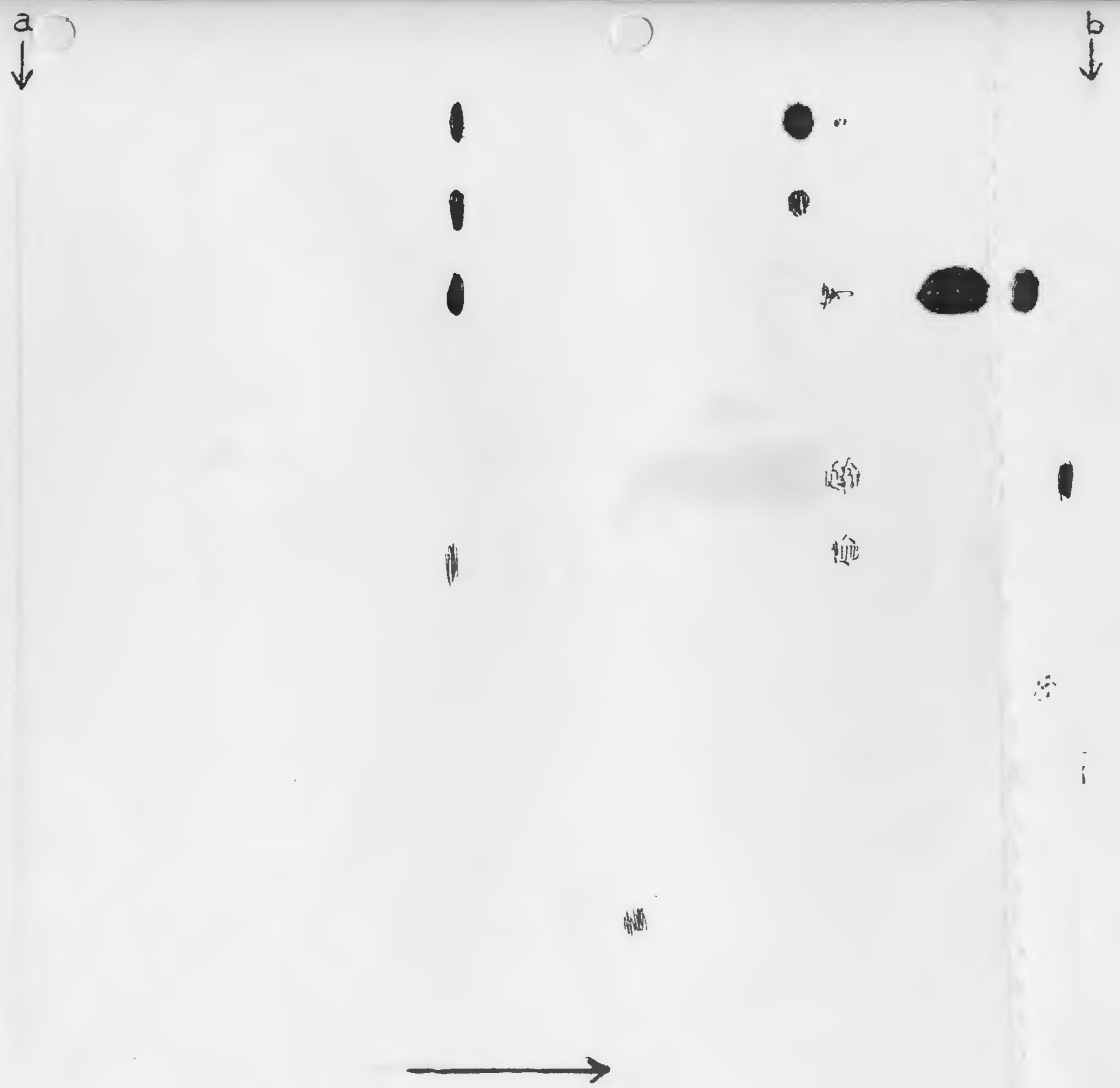


fig. 19

Plate IV

Euphorbia triangularis

E. mauritanica

Virgilia divaricata

Acacia karoo

Enceph alartos caffra

Aloe karasbergensis

Rhus viminalis

Sarcocaulon burmannii

Euryops othannoides

Othonna arbuscula (W) heated

Widdringtonia schwarzii "

Elemi (commercial gum)

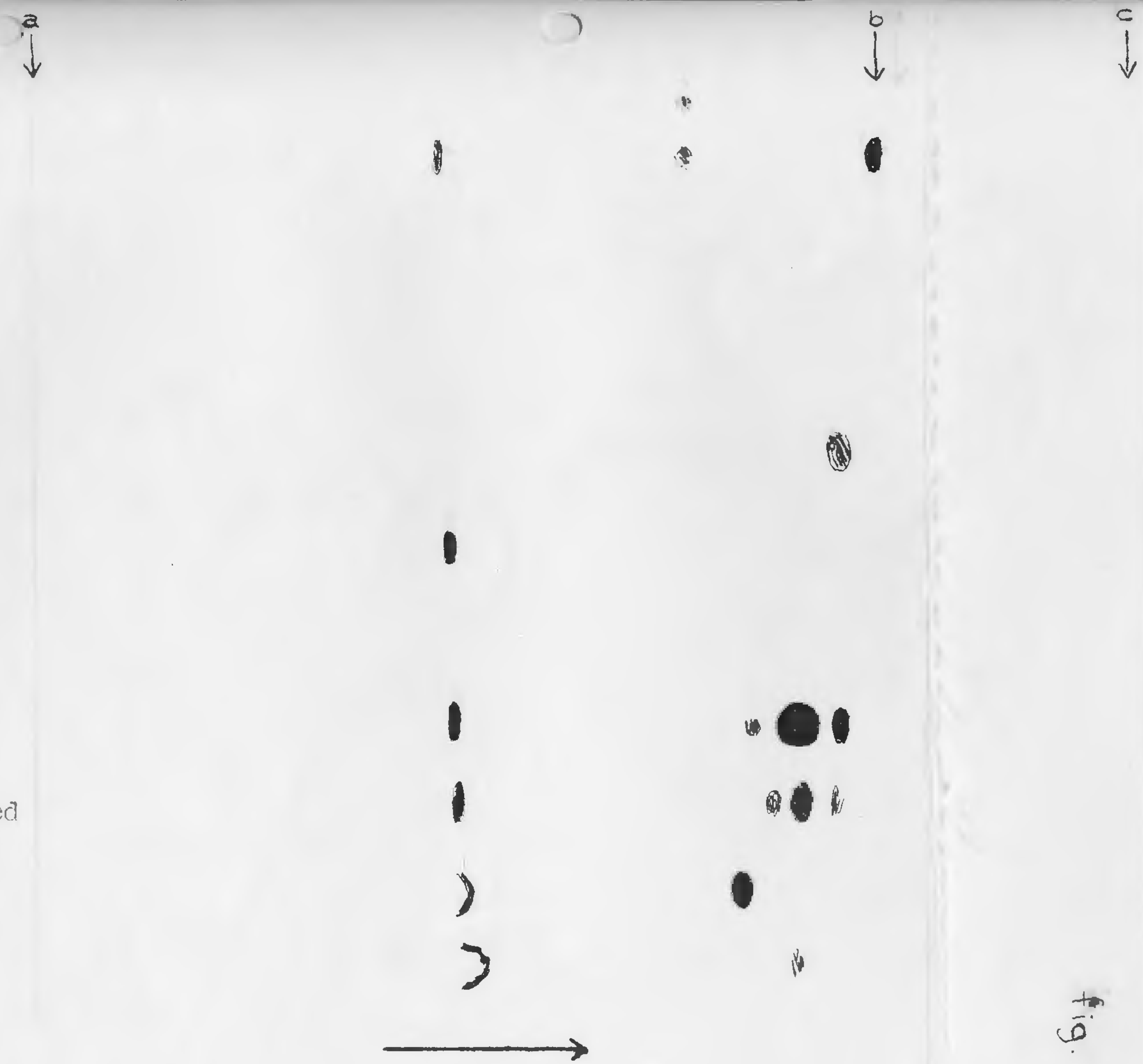


fig. 20

Plate V

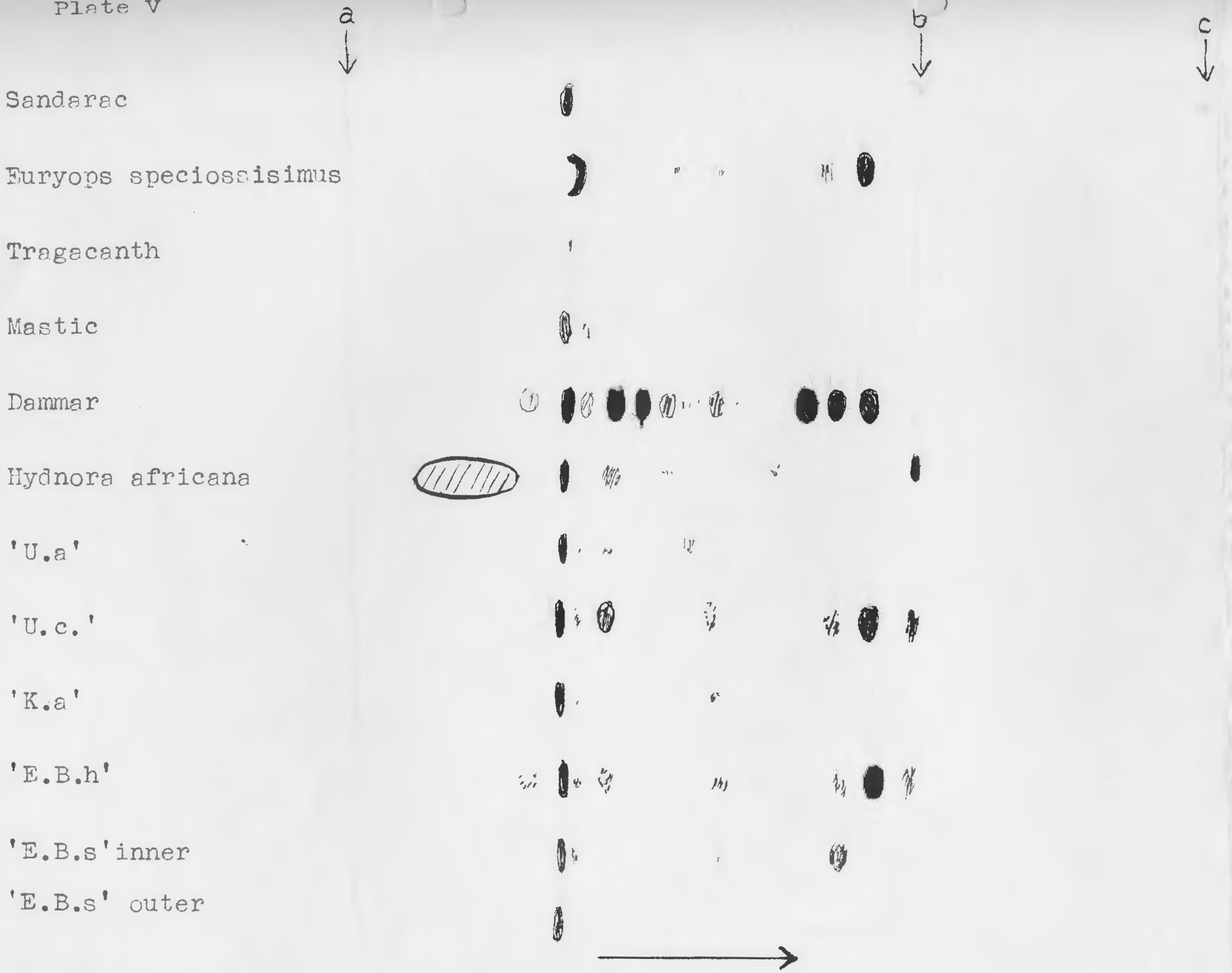
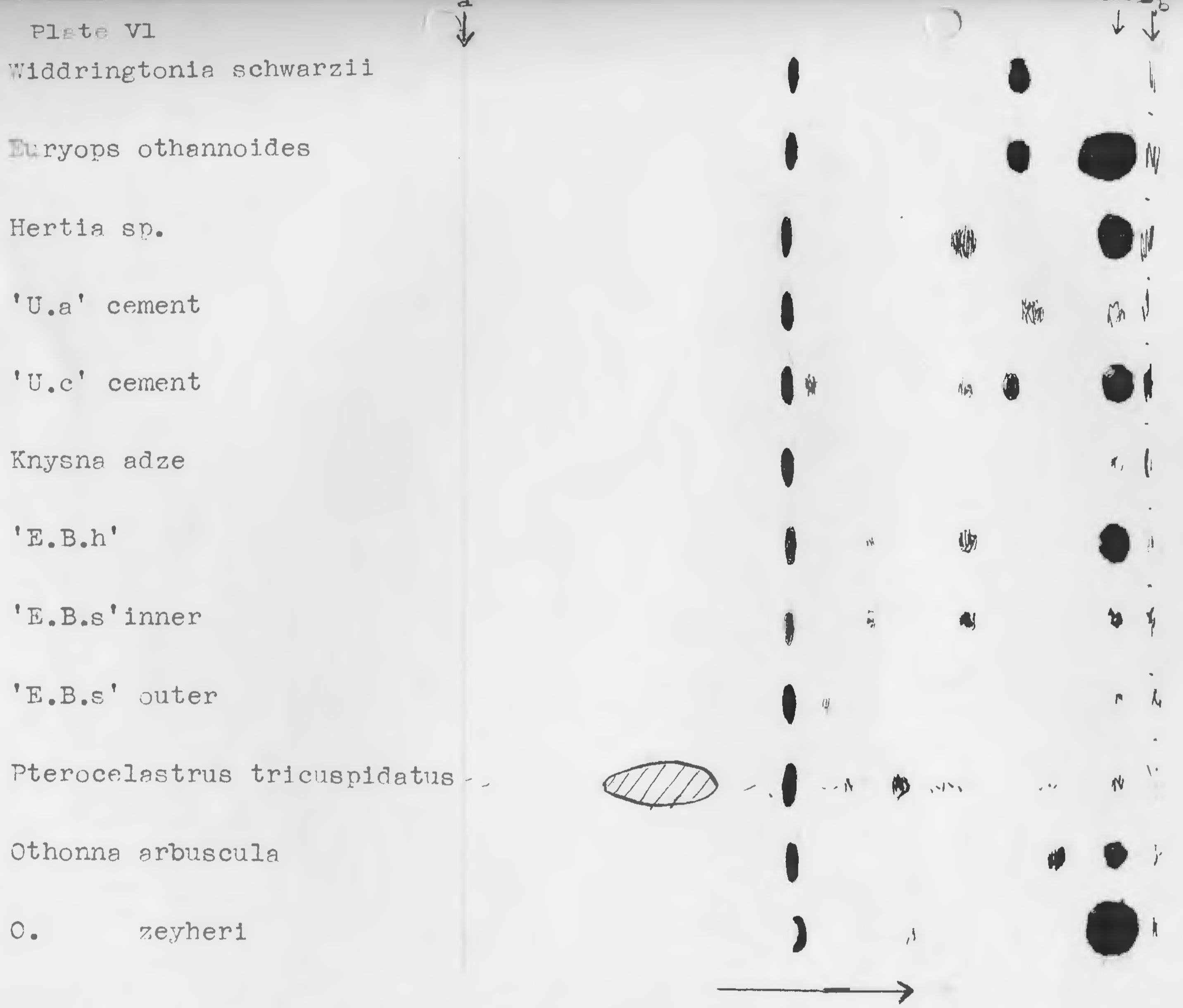


fig. 21

Plate VI



band II was selected for I.R. spectroscopy

fig. 22

The E.B. h and U.c items showed up quite strong spots, while K.a and E.B.s did not show any major constituents. None of them are clearly idetical, while the same sample even varied on different occasions in intensity. The more prominent ones however were very similar - ie. U.c and E.B.h, especially in plate V. E.B.s was similar to them on plate Vl. Of the controls, Hertia is identical to E.B.h, but all the Compositae seem reasonably close. Only dammar of the commercial resins showed more than one prominent spot, having a lot of constituents.

One striking point is that a single recurring spot occurs in all but one of the cements and controls. Tragacanth, the exception, would appear to be a gum as no spots showed up.

It is not easy ~~trying~~ to interpret these results. The basic problem is knowing how identical a sequence must be before one can claim a direct relationship. Furthermore, it is not certain when two nearly corresponding spots are significantly different. At this stage, one can only remark on the number of cement spots that correlate with spots among the Compositae, and in particular Euryops and Hertia. Not only do these correspond remarkably well with E.B.h and U.c, but the leading spots are prominent in all of them, meaning that they are quantitatively important as well.

Plates V and Vl were then sprayed with a 22% solution of Sb_2Cl_3 (in $CH Cl_3$) to see if any other constituents would react with it and show up as a colour. One result was that the reagent reacted with the aluminium plates, but a reasonably clear picture was obtained (fig.23). Some of the important spots did not show up at all, while a lot of trace elements did, which complicates interpretation. For the moment it is more meaningful to consider only the more important constituents, but possibly a slightly stronger concentration should have been spotted.

It was then decided to try and see if the large fast-moving spots were identical, and if they could be identified. This was done by means of thick layer chromatography and infra-red spectrometry.

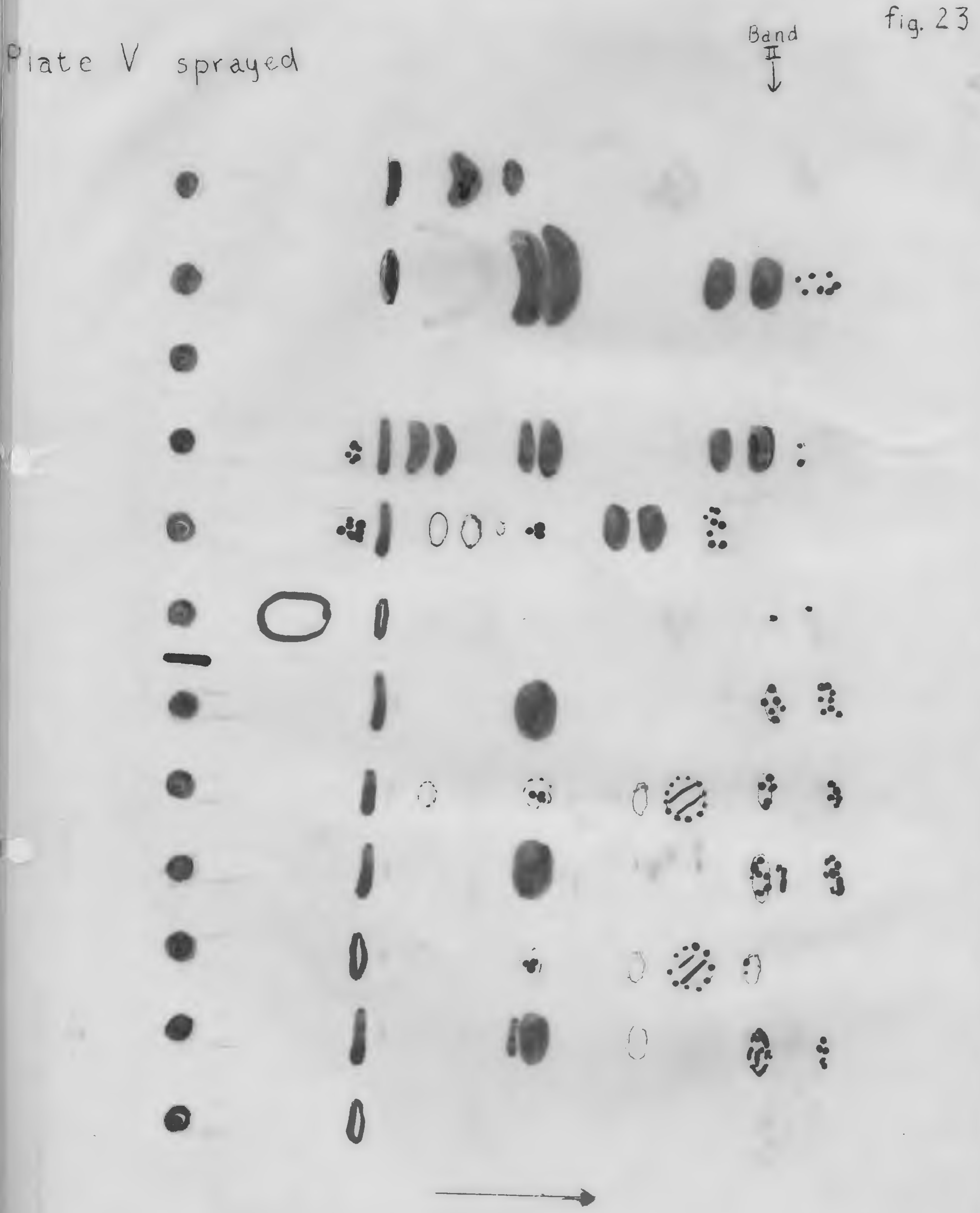


Plate V sprayed
Band II
fig. 23

fig. 24

Plate VI sprayed

Band II ↓

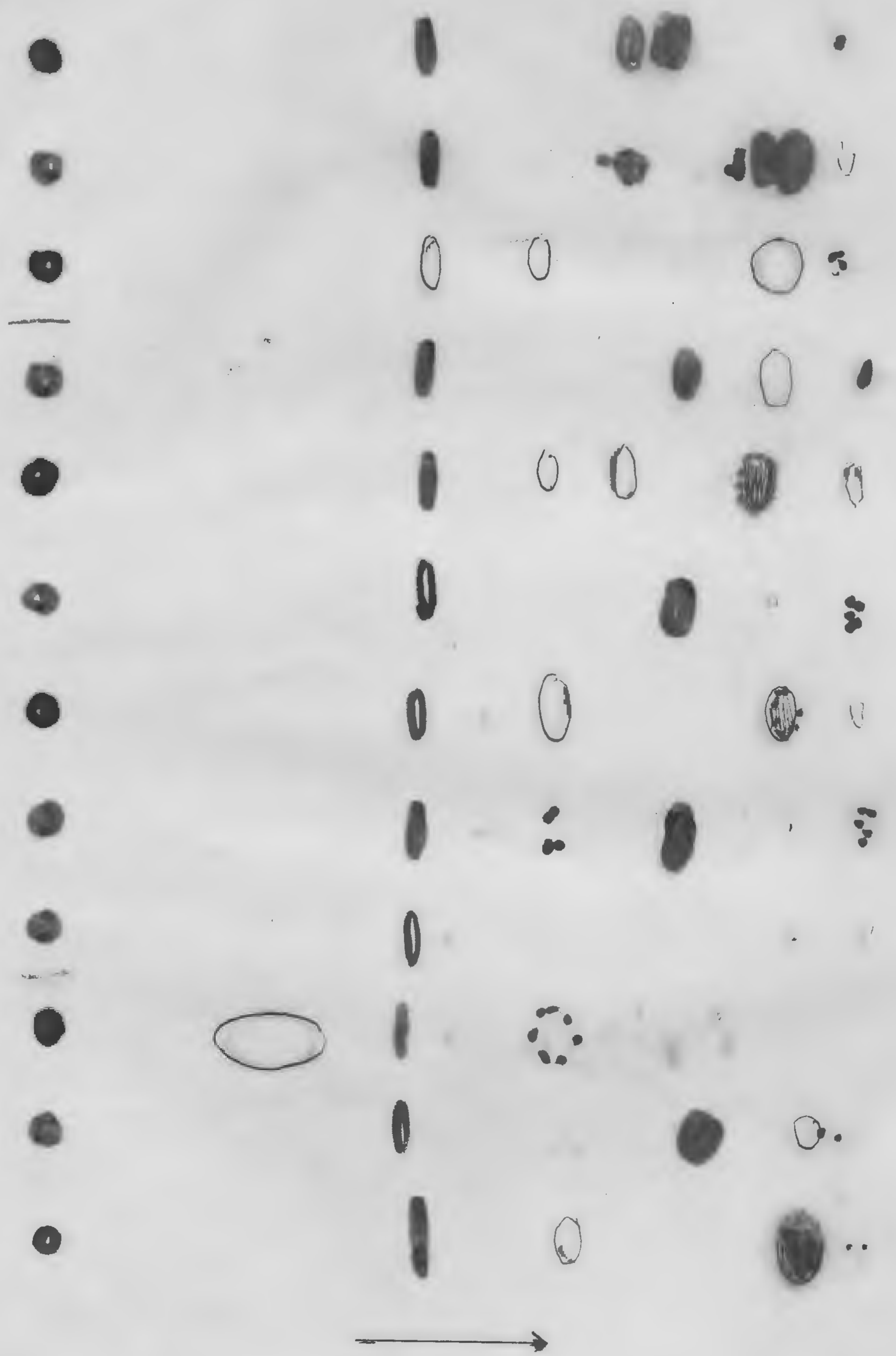
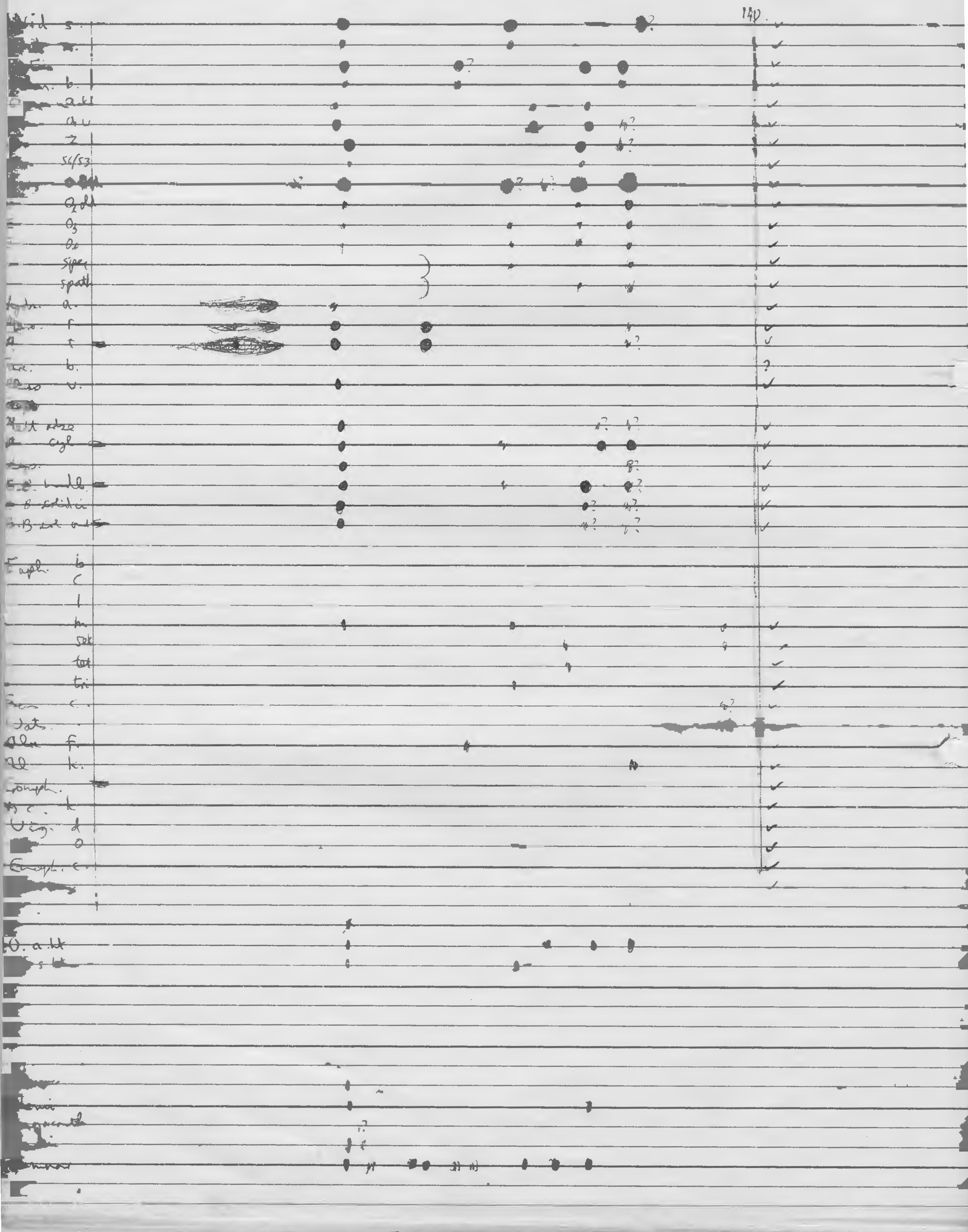


fig. 25 General reference chart, showing approximate comparibility (Not R_f)



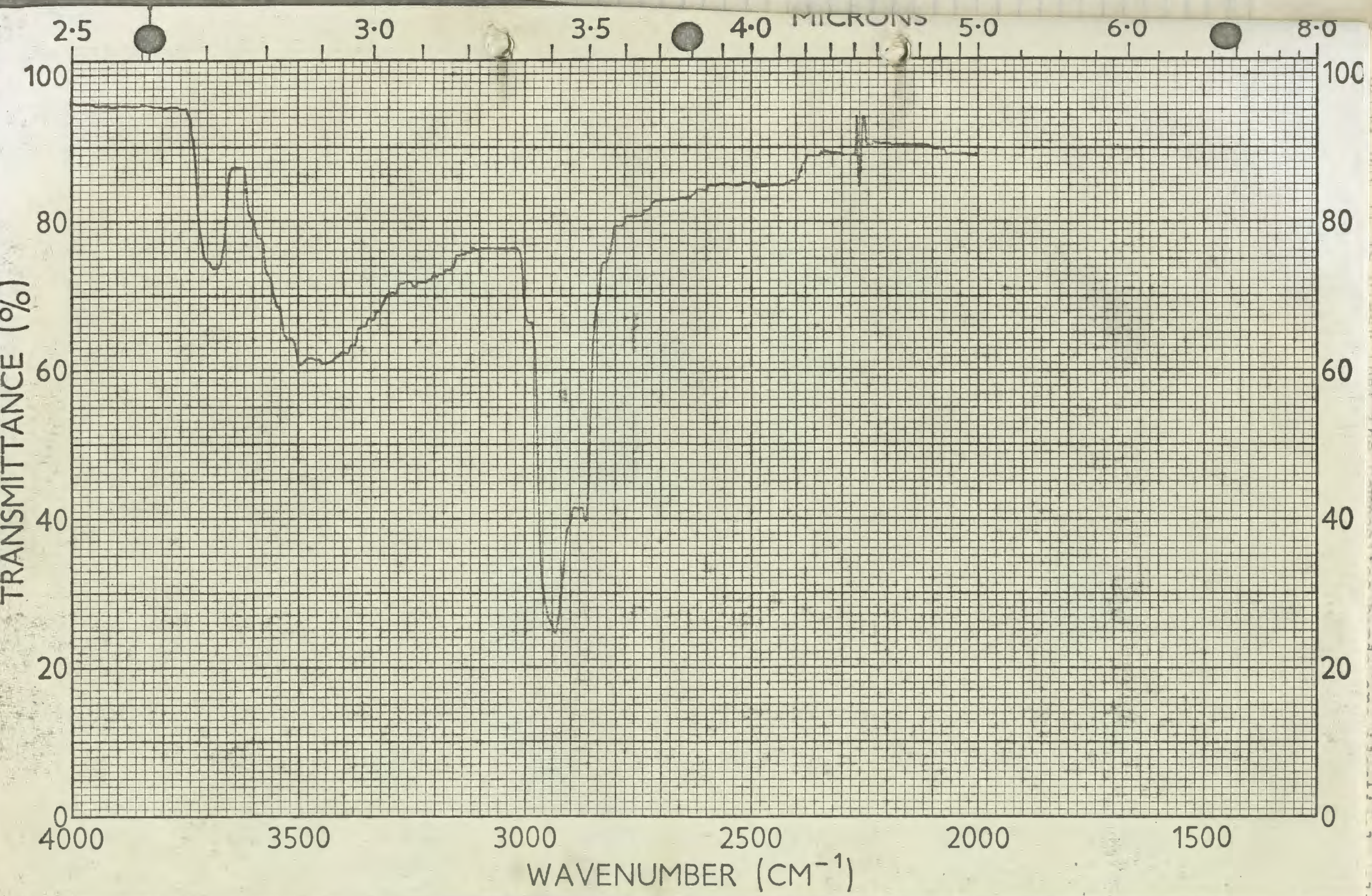
4. Infra-red spectrometry. It took a number of trial runs to establish the right concentration of plant resin in solvent that was sufficiently strong to show up well on the spectra but not result in overloading on the thick layer plate. The solution was laid down on the plate by means of a hypodermic syringe, and the plate was run as previously in the benzene:methanol solution. The bands were then removed and washed in a solvent, the silica being separated by a sintered glass filter. This was then dried on a rotary evaporator. 1 ml chloroform was used to dissolve the residue, and this was transferred to a 0,5 ml I.R. spectrometer cell. The principle of the I.R. spectrometer is similar to the colourimeter except that a beam of light of changing wavelength is passed through the sample (and through a reference of chloroform to cancel out the solvent), and the absorbancy is plotted against frequency on a revolving drum. Wavelength range is from 4000 to 625 cm^{-1}.

Initially 0,5g of E. othannoides was dissolved in 5ml benzene, and the bands were removed from the plate in 15ml methanol, but only 0,3 g of O. arbuscula and Hertia sp. were used, as the bands were tending to merge outwards from over loading. For E. speciossisimus and O. zeyheri only 0,2 g in 3ml of chloroform was used, and chloroform was used to wash the bands from the silica. Chloroform evaporates rapidly, and so it was easy to lay down relatively narrow spotting lines quickly.

E.B.h and U.c were selected of the cements as they had the most prominent leading spots. The remainder of the 5ml of D.M.F.was merely laid on the plates, otherwise the procedure was the same.

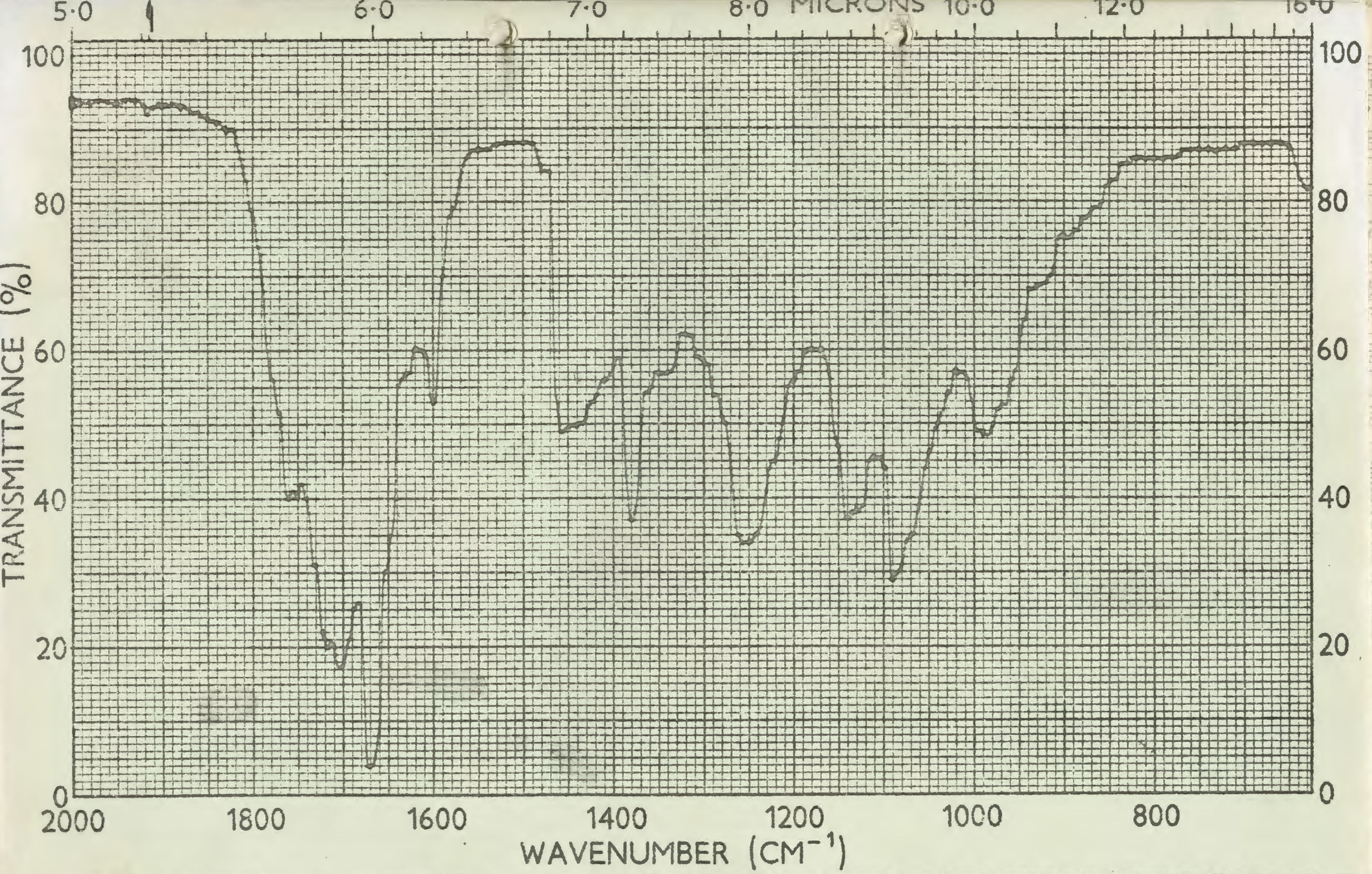
It was found essential to recheck the bands to see how well they had separated, and as a result the E. othannoides, O. arbuscula and Hertia sp. bands had to be rerun due to contamination, whereas the others were relatively pure constituents. In the end, very weak spectra were obtained for E. othannoides and O. arbuscula, and so they have not been considered in the interpretation. One feature is that the cement samples have retained their strong aromatic smell.

The results are in figs.26to35. The spectra are not easy to inter-



SAMPLE Othonna zeyheri 11 ORIGIN	SOLVENT $CHCl_3$ CONC. 1:200 CELL PATH REFERENCE	SCAN SPEED SLIT REMARKS [illegible]	OPERATOR DATE 10 Oct 74

NO. 26

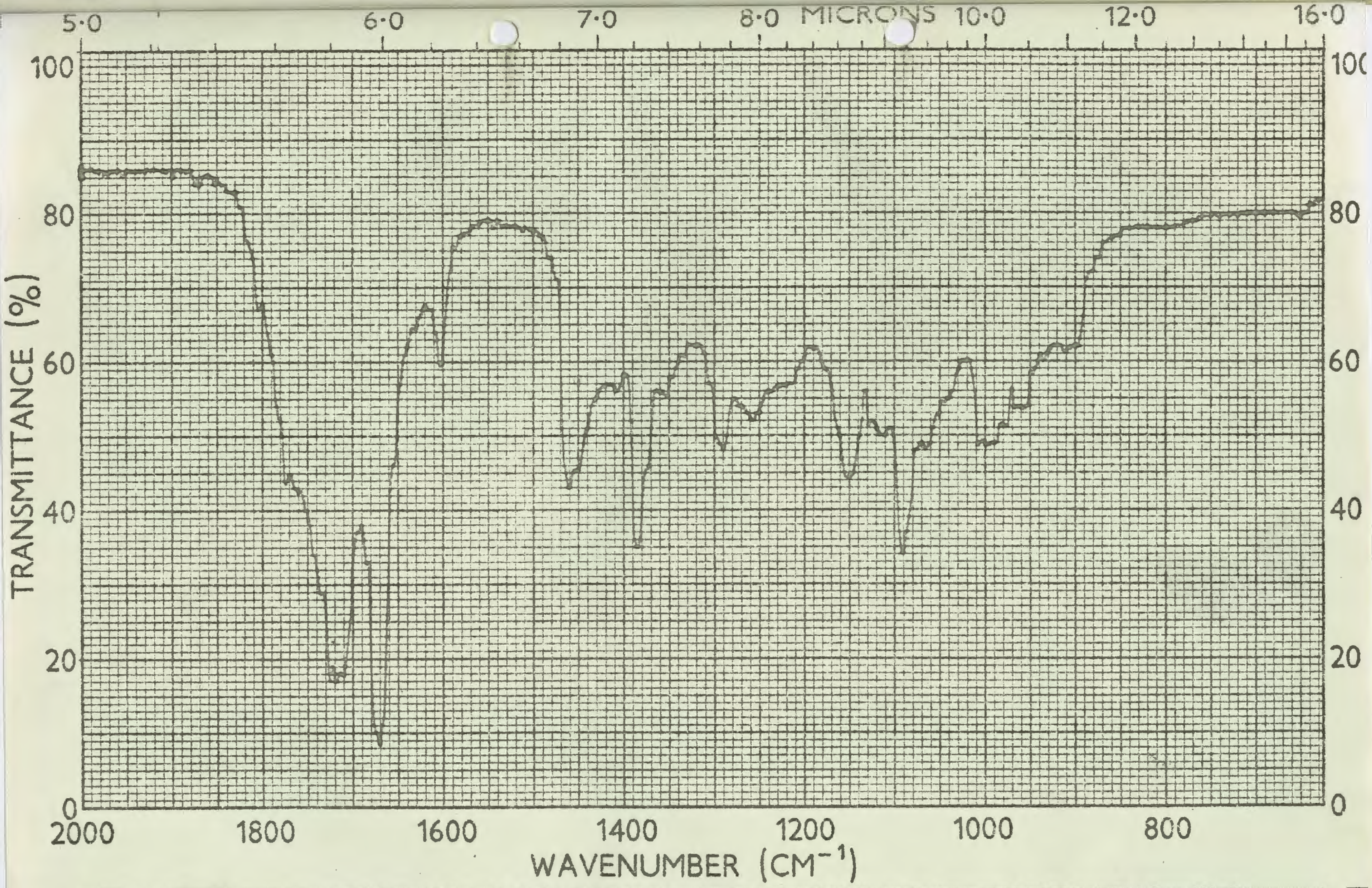


SAMPLE Ohozsha. zeyheri. Band 11.	SOLVENT CH Cl_3	SCAN SPEED	OPERATOR
	CONC.	SLIT	DATE 10/Oct.
	CELL PATH	REMARKS slight contam with slower spot.	

NO. 27

SAMPLE Euryops s. Band II.	SOLVENT CHCl$_3$	SCAN SPEED	OPERATOR
	CONC. 1.2 ml	SLIT	DATE 6 Oct 74.
	CELL PATH	REMARKS Good.	
ORIGIN	REFERENCE	cfs O.Z.	

NO. 28

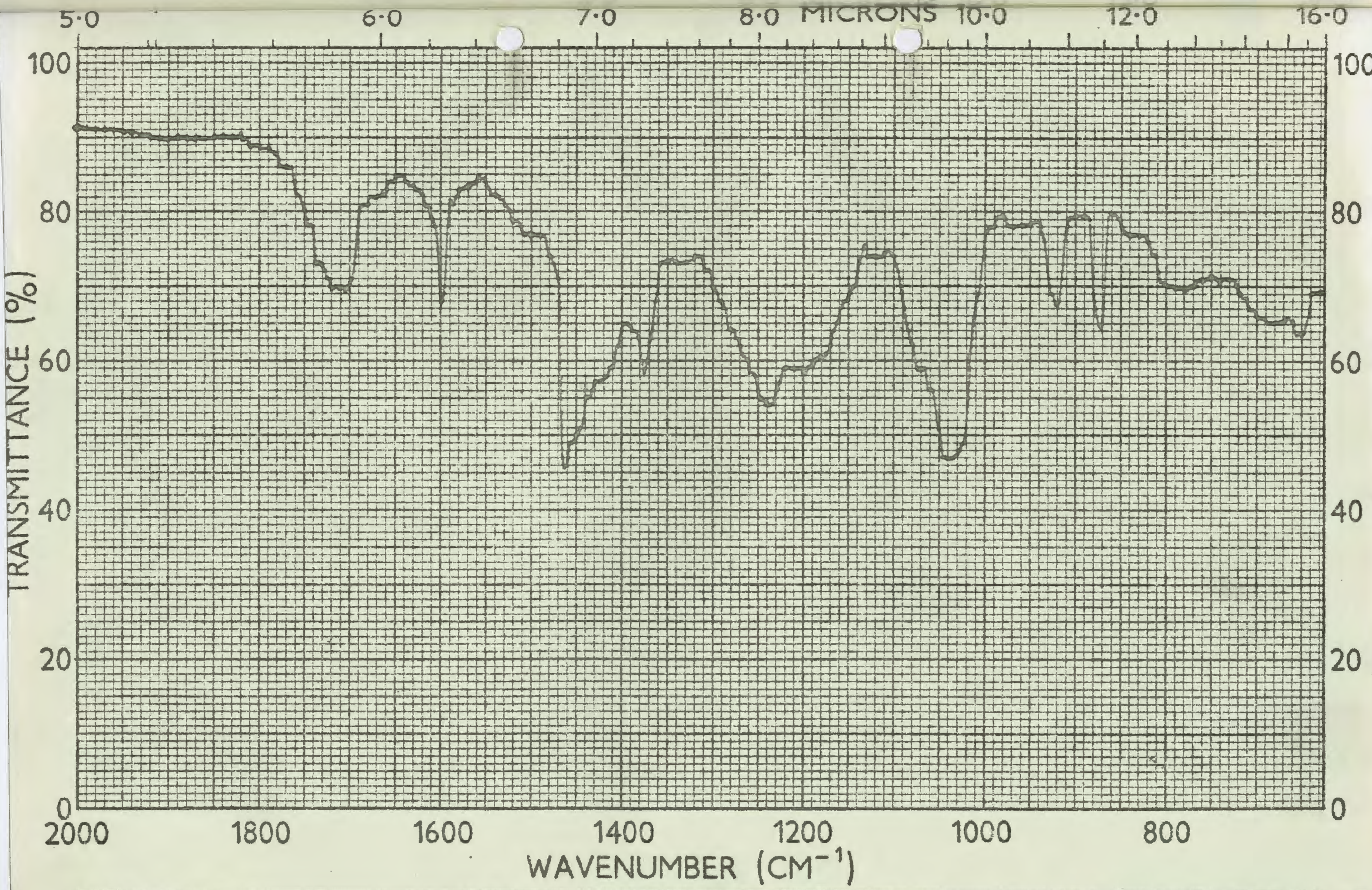


SAMPLE Euryops S. Band 11	SOLVENT	SCAN SPEED	OPERATOR
ORIGIN	CONC.	SLIT	DATE 6/10/74.
	CELL PATH	REMARKS Good. Sample sep into 3 ident leading bands.	
	REFERENCE		

NO. 29

SAMPLE Hertia sp Band II	SOLVENT $CHCl_3$.	SCAN SPEED	OPERATOR
	CONC. 2.6µg / 2ml	SLIT	DATE 20 Sept 74.
	CELL PATH	REMARKS Good	
ORIGIN	REFERENCE		

NO. 30

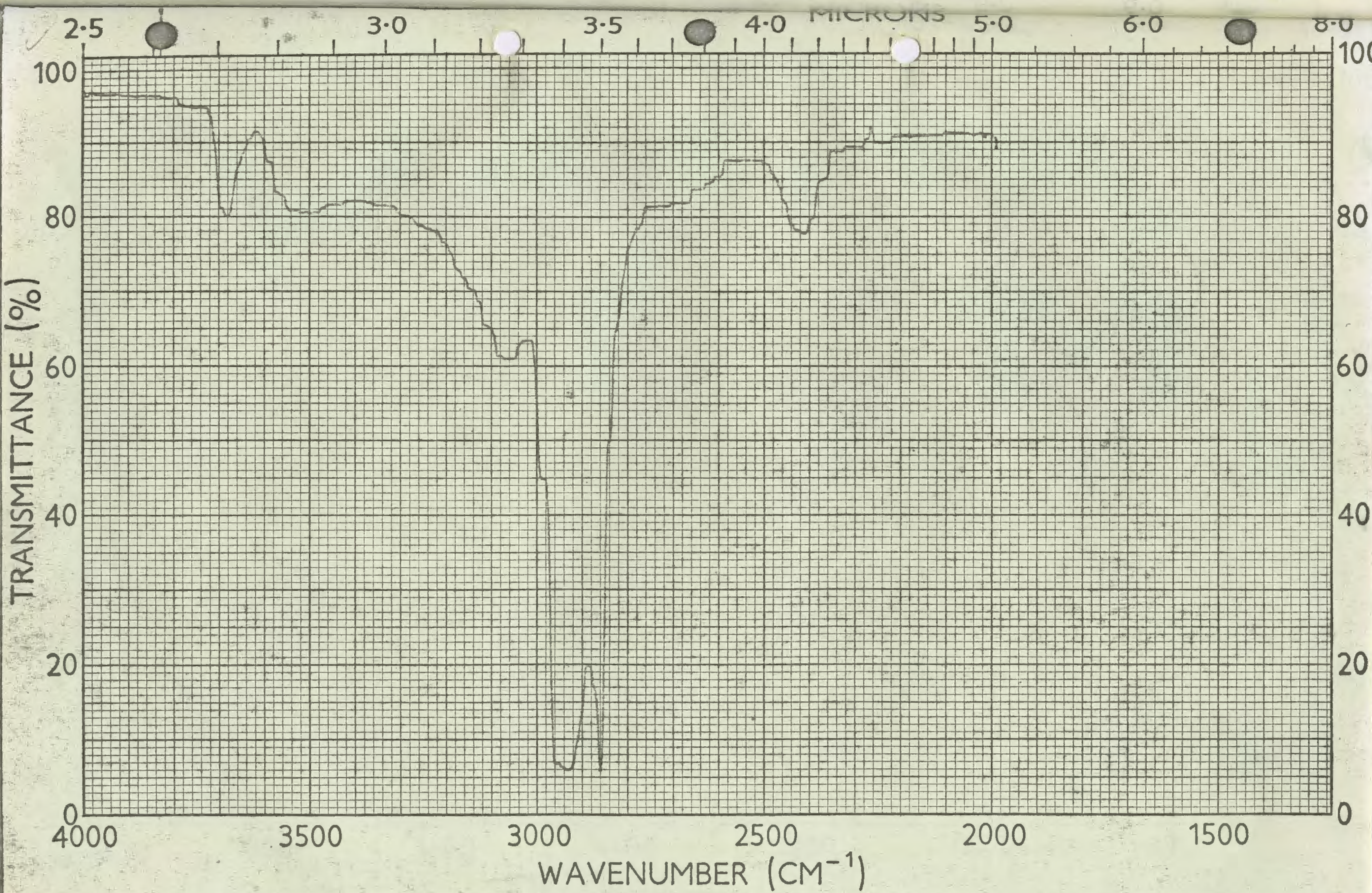


SAMPLE Hartia sp. Band 11	SOLVENT $CHCl_3$	SCAN SPEED	OPERATOR
	CONC.	SLIT	DATE Sep 74
	CELL PATH	REMARKS Good.	
ORIGIN	REFERENCE		

NO. 31

SAMPLE Unknown cyl. Band II	SOLVENT $CHCl_3$	SCAN SPEED	OPERATOR
	CONC. /·2ml	SLIT	DATE 20 Sep 71
	CELL PATH	REMARKS ✓	
ORIGIN	REFERENCE		

NO. 32



SAMPLE Elands Bay 'handle' Band II	SOLVENT CH Cl3	SCAN SPEED	OPERATOR
	CONC. 25μg/-2 ml.	SLIT	DATE Aug 74
	CELL PATH	REMARKS : Good.	
ORIGIN	REFERENCE		

NO. 34

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prat, but it is clear that the Compositae bands are identical, although *Hertia* less so. However, not only are the two cement samples different from the Compositae, but they also differ from each other, which rather undermines the striking similarities obtained in the chromotography. Either the wrong bands were selected for comparison - which is possible as there are no reference controls in thick layer chromotography, the bands are not sufficiently pure, or as is possible, different constituents are moving at very similar speeds in the selected mixture. Clearly the experiments have not progressed sufficiently far for it to be possible to state with any conviction what may have been used. Each new level of research has raised a new set of problems. As such it is felt that writing up the results at this stage may give a wrong impression of the real potential of the method described. One tends to judge a technique by its ability to give positive results.* In conclusion it can be stated that there are similarities nevertheless, but the problem is attributing significance to them.

CONCLUSIONS

Problems. Mention has already been made of the difficulty in recognising plants in the field, and problems in collecting exudations. Although *Pterocelstrus* showed up so poorly in the experiments, this does not mean that it should not be considered again. There may be some subtle problem like seasonal availability. However plant classification has changed in the last 50 years, and it is possible that a nother plant, like *Gymnosporia acuminata* is actually involved.

One of the real problems has been the lack of research into South African resins in general. This is in part due to their great complexity. Thin layer chromatography of course need not get involved with identification of the ingredients themselves, but knowledge of resin behaviour and associated problems would have assisted, especially with I.R. spectroscopy. Thus it is known that gums and resins do vary with time and place but

* Nevertheless, the similarity of the hydroxyl band (3700 cm⁻¹ approx) and the very distinctive double peak of the carbonyl band (2900 cm⁻¹ approx.) and the one at 1700 cm⁻¹ between the Elands Bay (overleaf)

this probably affects more the minor trace constituents or relative proportions. Certainly greater research in local resins would have aided this programme.

There have been problems in the laboratory itself and without supervision and facilities the experiments would have been impossible. As it was, hours of work were sometimes negated due to ignorance by elementary mistakes, or by having to resort to trial and error.

In addition, the programme of research would have produced better results if it had been prepared months in advance. This was of course impossible under the circumstances (having to abandon a previous project in March), and so it was impossible to plan the research thoroughly enough. Consequently, correspondence and reading was providing additional information as late as August.

The final problem should be apparent, and that is that it is really at least a two year and full-time project, for only then can one monitor plants more comprehensively, ~~and this would have~~ allowed greater detail to be spared on certain deserving aspects, like analysing the water soluble carbohydrates of the cements, testing to see if inorganic material etc. was denser on the surface, experimenting with trying to work resin, rechecking, etc.

These points have been stressed so that any one who intends pursuing the experiments will have some idea of the problems involved.

<u>Interpretation.</u> It should be stated first that the experiments have not proceded far enough for it to be possible for us to say with any authorit what the ingredients are, and they should rather be regarded as a trial run. Only a handful of plant products were collected, and probably only a small number of potential genera for the Cape area considered. Not only would more genera provide greater range for correlation, but they would attach more significance to the high degree of similarity shown by some of the specimens.

At the outset it was known that there would be the problem of breakdown in such old specimens, and the inability of being able to control for this. Minor tests did suggest that it may not be as great as feared, however. After all, for the samples to have survived, it is probable that the major adhesive constituents should have remained intact.

On the positive side, it is felt that the experiments have produced some results. With regard to ingredients, the predicted identification of resins has been confirmed, whether in pure form or as in certain latex constituents, although the former would be more probable. The Compositae, especially *Hertia* sp., show (up) striking similarities to two items, including the Elands Bay ones in the chromatographs, while the Knysna tool differed from the others in showing up few spots. At the present stage the Compositae must be considered as a distinct possibility for some of the cements, while it would seem that different resins were used, especially in different areas. There is also the possibility of decomposition, which might apply to the Knysna implement. With this in mind, it is possible that (certain) regions with more indestructible resins are likely to display the cementing strategy more readily than other areas, where because of different sources, it may appear as if they never used it, the cement having disintegrated. However, it is clear that it is not possible to remove subjectivity from interpretation completely.

At this stage it seems unlikely that one could classify beyond the generic level with confidence, but knowledge of plant distribution could aid in this. Closely related species could have identical resins or differ in the proportions of constituents rather than actual types.

With regard to the method used, it is felt that the experiments have shown that this technique can work, and should be persevered with, provided that the problems noted above are remembered, and that the method be given a more exhaustive test. Chromatography is the only technique with which one can hope to be able to analyse resins, and although time consuming, it is relatively economical and does not require too complex a laboratory. The basic problem seems to be setting a valid level of interpretation. Future work should consider this aspect, and use a wider range of controls. The method can be used on a number of other organic materials in archaeological problems, but it should be noted that it is basically a destructive process, although only small amounts are required (approx. 0,1g), and the material can still be subjected to a number of tests.

Finally, it is felt that the project has contributed to the understanding of the whole hafting strategy - the exploitation of the recycling properties of resin, the addition of fibre or grit for strengthening it, and the manipulation or circumvention of physical rules and problems in the manufacturing process, for example. These are aspects that were learned, and which helped allow the better exploitation of the late Stone Age environment.

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