Ancient mining in Southern Africa, with reference to a copper mine in the Harmony Block, north-eastern Transvaal

T. M. EVERS*, B.A. (Birm.) (Visitor)
and R. P. VAN DEN BERG†, B.Sc. (Wits.) (Visitor)

SYNOPSIS

A recently discovered mine on the farms Harmony 24 and 25 in the Letaba district has been investigated archaeologically by T. M. Evers and geologically by R. P. van den Berg. The archaeological investigations shed light on the mining techniques and accompanying metallurgical techniques, while the geological investigations give information on the structure and mineralization of the mine. Comparisons with other investigated ancient workings show that mining was well understood in Iron Age times, before the African peoples had any contact with Europeans.

SAMEVATTING

'n Myn wat onlangs op die plase Harmony 24 en 25 in die Letabadistrik ontdek is, is argeologies deur T. M. Evers ondersoek, en geologies deur R. P. van den Berg. Die argeologiese ondersoeke het lig gewerp op die mynboutegnieke en die daarmee gepaard gaande metallurgiese tegnieke, terwyl die geologiese ondersoeke inligting verstrek oor die struktuur en mineralisasie van die myn. Vergelykings met ander ou werkplekke wat ondersoek is, toon dat mynbou goed begryp is in die Ystertydperk, lank voordat die mense van Afrika enige kontak met Blankes gehad het.

INTRODUCTION

Ancient workings in the Transvaal have been known for many decades and have been described by several authors[1–5]. Unfortunately, apart from that given by Baumann[1] of the Rooiberg tin mines and that given by Mason[5] of the Doornpoort gold mine, descriptions have tended to be generalized. Since 1920 no work apart from Mason's[5] has been done on ancient workings, and the groups of known mines have been largely destroyed or damaged by prospecting and modern mining operations. The discovery of an intact mine on Harmony 24 and 25 in the Letaba area was therefore of great interest.

DESCRIPTION

The mine consists of a line of twenty-five units, with a total length of about 400 m (Fig. 1). Between them the units contain thirty-one shafts and one open stope, some units containing two shafts. The units are numbered west to east. The mine at present has the appearance of a line of pits up to 8 m deep, surrounded by dumps of waste material. The presence of shafts was confirmed by the partial clearance of units 4 and 22. The surface measurements for each unit, which are given in Table I, were taken from the top of the tailings and are thus larger than in reality. As it was often very difficult to establish where one unit ended and the next began, measurements were made to the nearest half-metre. Depths (also in Table I) are averages estimated by use of a tape and Abney level. Small fragments of malachite and azurite in the dumps suggest that the metal sought was copper.

ARCHAEOLOGICAL WORK

Archaeological investigations were carried out in 1972 and 1973 spread over a period of eleven weeks. There were three main aims:

(1) to establish the nature and shape of the workings,
(2) to determine the techniques used in the mining of the copper, and
(3) to determine the relationships between the mine and any evidence for smelting found in the area.

The first aim was only partially realized because technical difficulties prevented complete clearing of any of the shafts. The other two aims were achieved.

TABLE I
DETAILS OF THE HARMONY COPPER MINE

Unit	No. of shafts	Length m	Breadth m	Depth m
1	1	6	6	1
2	1	6	6	1
3	1	9	8,5	2
4	2	18	8,5	5,5
5	2	24	14,5	6
6	2	17,5	14	5
7	2	11,5	9	3,5
8	1 + open stope	52	17	10
9	1	7	7	3,5
10	1	4	4	2
10a	1	4	4	1
11	1	5,5	5,5	0-1
12	2	24	9	4
13	1	7,5	7,5	3
14	2	23,5	12	6
14a	1	3	3	0-1
15	1	3	3	0-1
16	1	3	3	0-1
17	1	14	10	5
18	1	9,5	6,5	3,5
19	1	5,5	8	3
20	1	12	8,5	9
21	1	12,5	10	5
22	1	10	8	12
23	1	8	8	3

*Department of Archaeology, University of the Witwatersrand, Johannesburg.
†East Rand Proprietary Mines Limited.

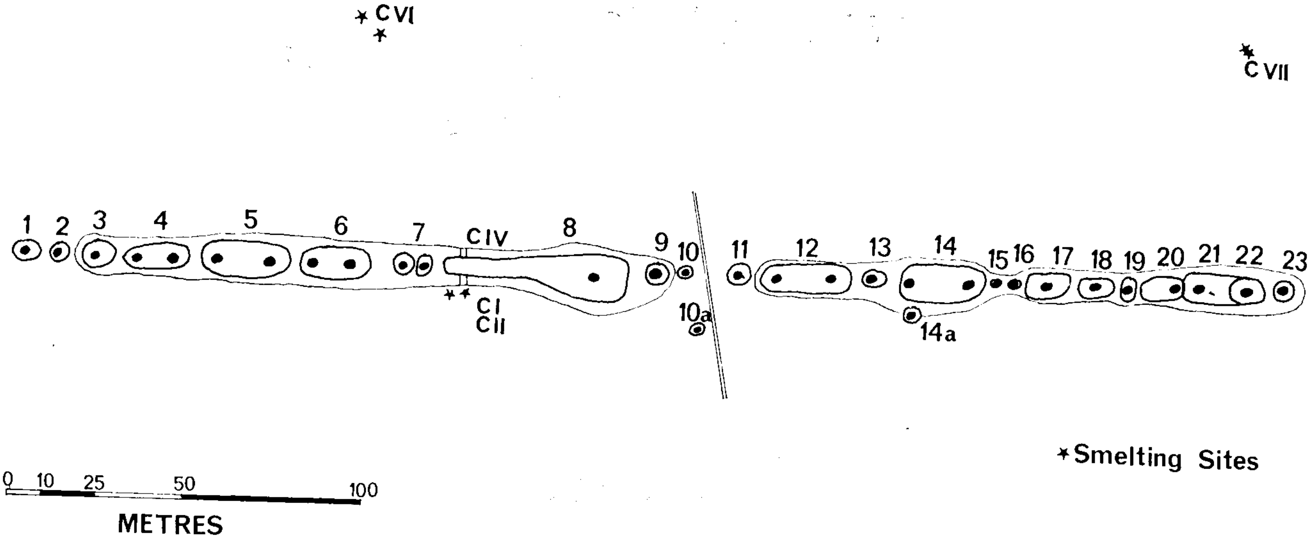

Fig. 1—Sketch plan of Harmony copper mine

THE NATURE AND SHAPE OF THE WORKINGS

To obtain information on this aspect of the mine, two units (4 and 22) were partially cleared. In the clearing of unit 22, a platform was erected vertically above the shaft and buckets were lowered to the digger, who was suspended on a fixed rope. The method was found to be slow and cumbersome. When unit 4 was opened, a tripod with a block and tackle was set up and was found to be satisfactory because up to 15 tons of rubble could be removed every day. Unit 22 was abandoned because of lack of time, and because digging lower down would have been difficult and too dangerous without the expert help of a mining engineer. Unit 4 was abandoned as the north wall was very unstable and required shoring, which was unfortunately beyond the technical capabilities of the team.

Unit 22

This unit (Fig. 2) consists of a vertical shaft 5,5 m deep, opening into a two-section stope at the 5,5 m level. The stope is oriented in a nearly semi-circular arc from west through north to north-east, and dips at an angle of about 50°. The hangingwall dips steeply between the two sections, providing almost a side wall for both. The extent of the rubble fill can be ascertained from Fig. 3 and Plate I. The hangingwall is in contact with the rubble fill 7,4 m from the 5,5 m mark, and the indications are that the stope was originally much deeper.

From the archaeological point of view, the greatest interest of this shaft is the quantity of preserved timbering. Twenty-one posts or pieces of wood were removed or exposed in the clearing operations. Of these, seven were in positions suggesting that, prior to collapsing, they may have formed a platform to facilitate access to the working and the removal of ore. Two niches cut into the rock about 3 m from the surface may have served to anchor such a platform. In the stope, three props were found still *in situ* supporting the hanging wall. Post 1 is very decayed at the point of contact between it and the hanging

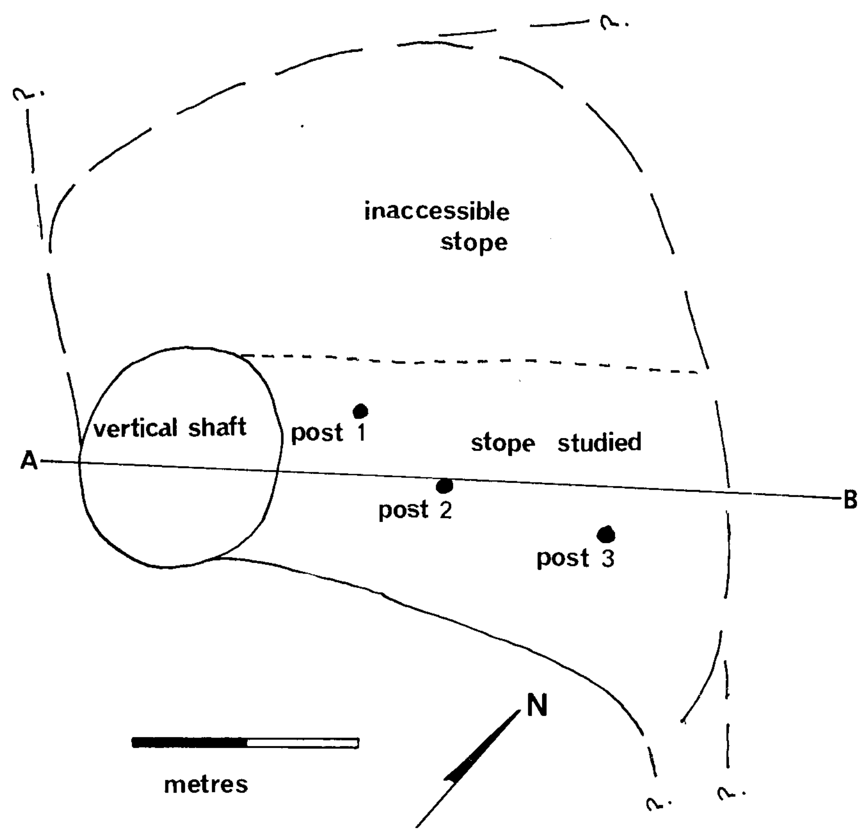

Fig. 2—Plan of unit 22

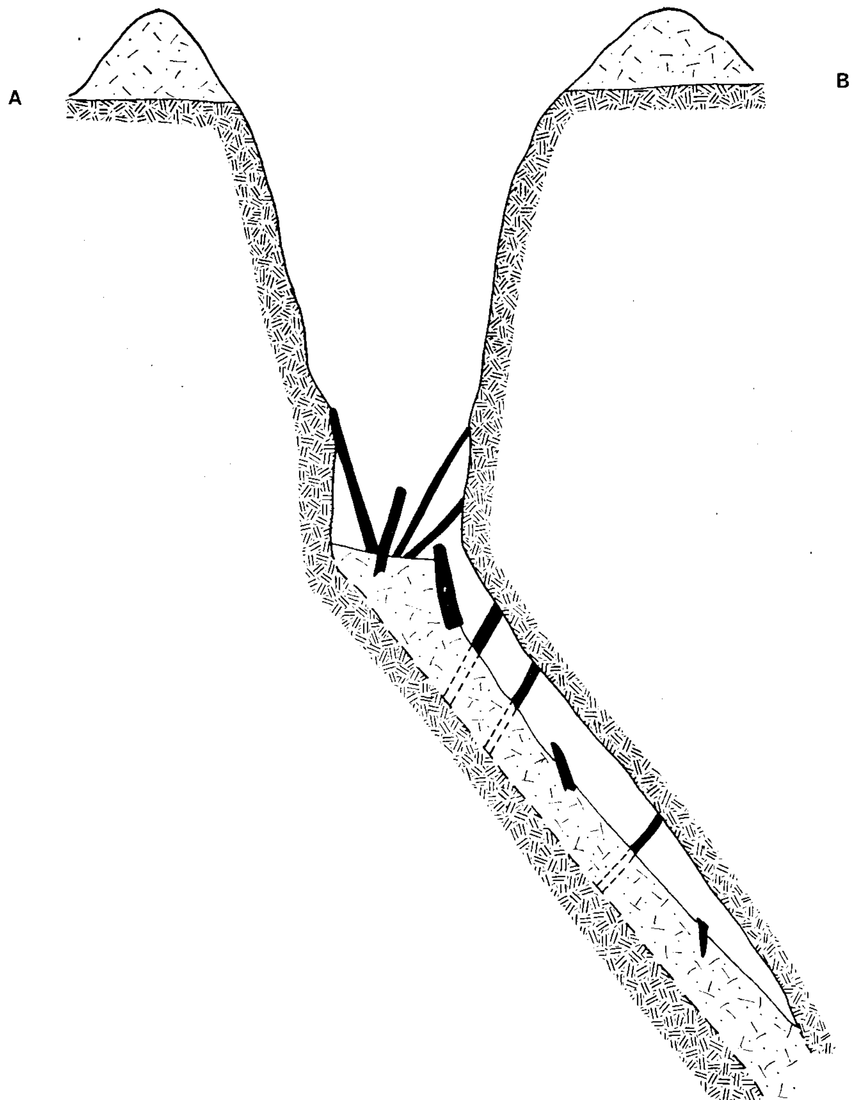

Fig. 3—Section A-B of unit 22

as the side wall was curving round to form the foot wall at this point, it cannot have been much more.

Unit 4

The clearing of unit 4 was undertaken to obtain dating material to test the hypothesis that mining proceeded linearly from west to east. A radiocarbon date of 1260 ± 90 (RL/207) was obtained for the centrally situated unit 8, and the preservation of wood in unit 22 at the east end suggests a later date. Work was hampered by large rock fragments in the rubble till, which, it became obvious, were derived from the structurally unstable north wall. Work stopped at a depth of 4,3 m owing to the unsafe nature of the original shaft.

However, valuable information on past working conditions was obtained. In the west wall, a cavity appeared, which, on being cleared, proved to be derived from the slipping out of a large rock fragment along its bedding plane. This and the unsafe nature of the north side wall meant that this particular shaft must have been very dangerous to work in. This may account for the extremely large dimensions of the vertical workings—5,6 m by 6,5 m. It is possible that the shaft may have been abandoned after accidents, though without skeletal evidence there is no proof of this.

No timbers were found, probably owing to preservation factors, though

wall, but post 2 is in an excellent state of preservation (Plate II), even to preservation of the bark. Post 3, when found, rested at an angle and has since broken, the wood being very weak. Samples are to be submitted to the Forestry Research Station for identification.

Unit 22 at an uneroded point measured 1,62 m west to east, and 1,48 m north to south. The stope dimensions could be measured only in the eastern part as this was the only part accessible. At post 1 the stope is 1,56 m wide (east side wall to the dip in the hanging wall). At post 2, the stope is 1,73 m wide and becomes still wider towards the present base. The actual height of the stope is unknown owing to the rubble fill. However, the largest dimension recorded was 0,68 m, and,

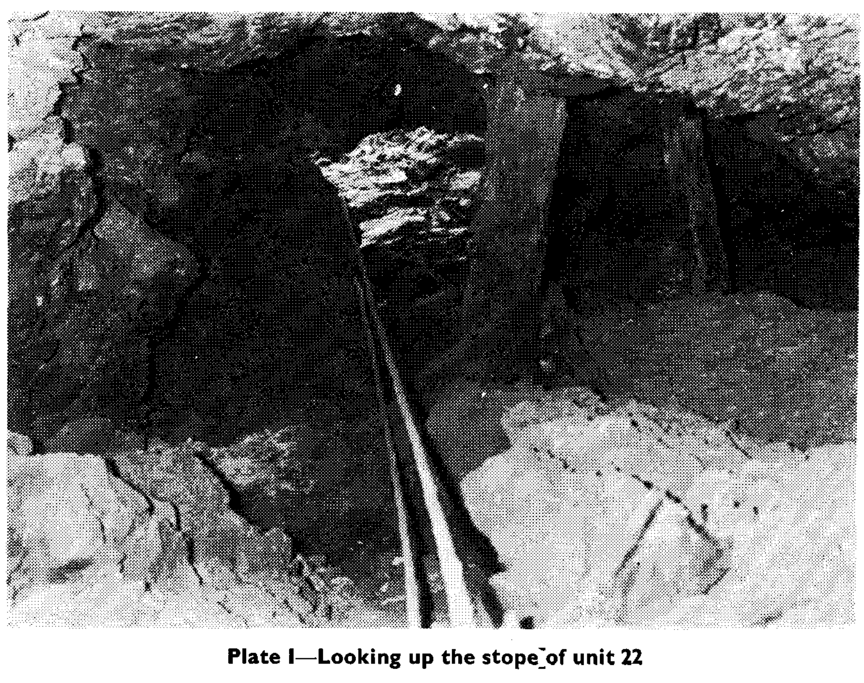

Plate I—Looking up the stope of unit 22

Plate II—Detail of post 2, stope of unit 22

timbering must have been used in one form or another. Unfortunately, no charcoal was recovered and this shaft has to remain undated.

Unit 20

This unit was not cleared, but the opening to the shaft proper was easily visible and penetrated the east wall of the unit to a present depth of 2,0 m. The angle of dip is shallower than that of unit 22, being closer to 40°. This shaft, like all others, follows the line of weakness formed by a shear zone.

EXCAVATIONS IN THE TAILINGS—UNIT 8

Three trenches were dug into the tailings of the open stope of unit 8: C I and C II on the south side, and C IV on the north side. The reasons for digging were twofold:

(1) to test a patch of ash eroding out of the tailings in the position covered by C II, and
(2) to determine the stratigraphy and date of deposits in the tailings, especially of ash levels.

All three trenches were dug in 15-20 cm spits, the profiles of the trenches being the most important source of information. A careful lookout was kept for artefacts. Stone mining tools and slag were found, and some animal bones and a small quantity of charcoal were recovered. A sample of charcoal from C I and IV was submitted for carbon-14 dating and gave a determination 690 ± 90 B.P. (RL/207), 1260 ± 90 A.D.

Trenches C I and II

The trenches were situated in the south tailings, end to end, separated by a 1,0 m balk (see Fig. 4 for C I). In C I six ash levels were visible in the west profile separated by fire and coarse rubbles. The lower ash level is black, not the light grey of the others, and may not have the same origin. Some slag was found in this black ash, and the slag and ash may be derived from the smelting area 10 m away to the south.

The looseness of the rubble in C II precluded a detailed analysis of the stratigraphy.

Trench C IV

Trench C IV was dug right through the tailings out the north side of unit 8, immediately opposite C I and C II. The two profiles tell a story similar to, but more detailed than, that told by C I (Fig. 5). The west section is the more useful.

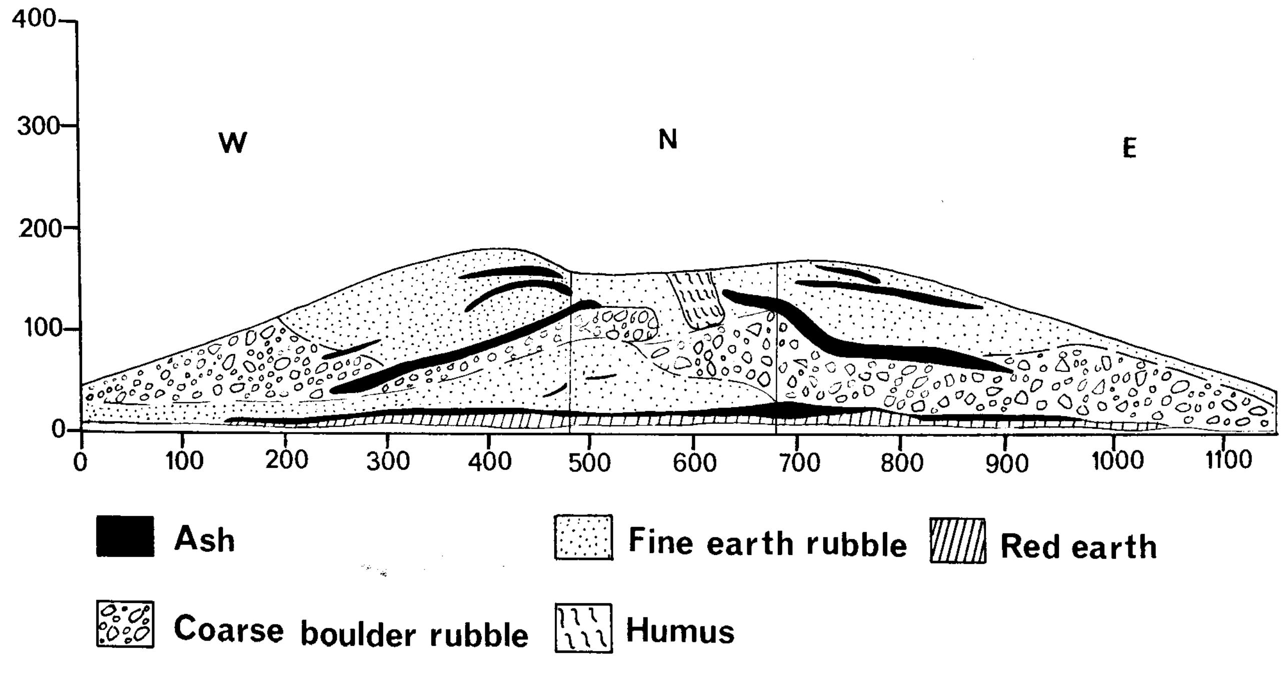

Fig. 4—Profile of trench C I

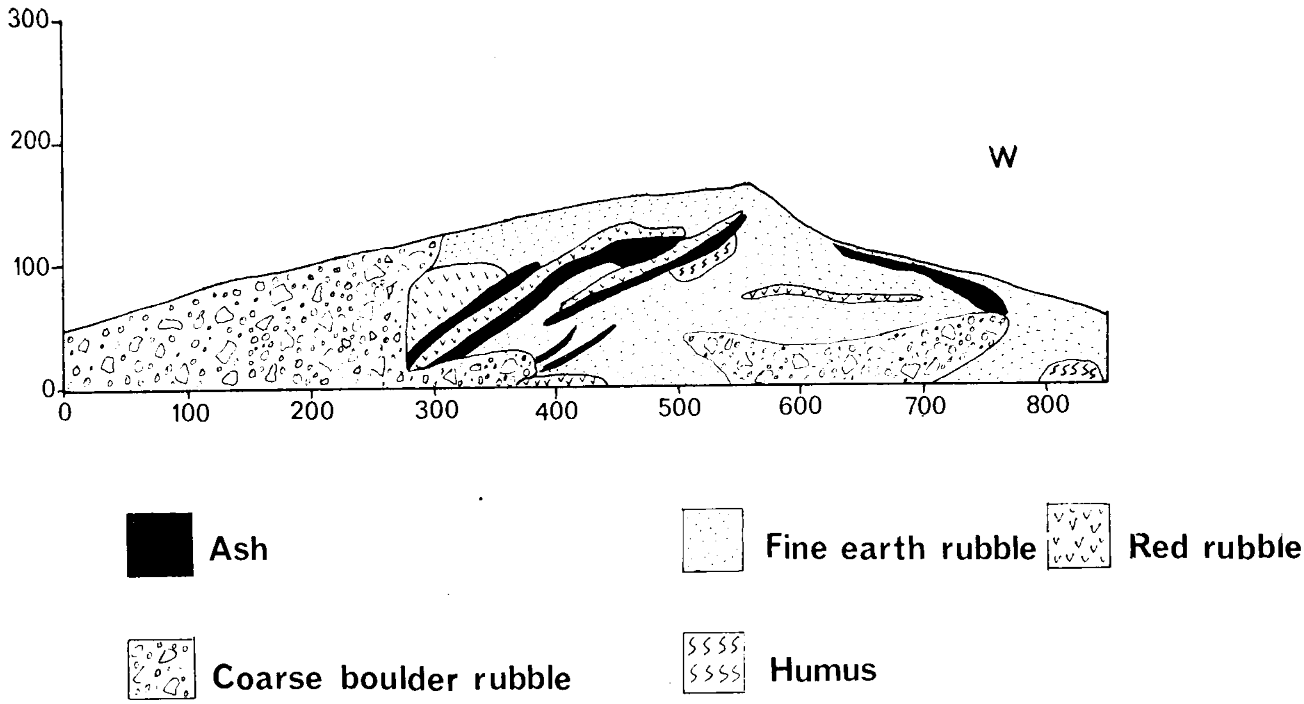

Fig. 5—West profile of trench C IV

The south end of this section consists of a very coarse rubble, which on the edge of the mine looks as if it was deliberately stacked to form a retaining wall. Away from the stope, the profile records successive layers of ash, reddish rubble with a rock fracture different from that in the coarse rubble, and earth with fine rubble, which forms the bulk of the deposit.

The reddish rubble and the ash are the most interesting layers here, with two possible interpretations.

(1) The colour and fracture of the reddish rubble in conjunction with the presence of ash may be the result of thermal stresses like that generated in the fire-setting process.

(2) The erosion rubble may come from the reddish brecciated fault fill.

The first interpretation is very attractive, and circumstantial evidence points to its being correct. In all cases, the reddish rubble directly overlies ash. In fire-setting, the succession of layers runs from top to bottom as follows:

(a) fire and waste products (charcoal and ash),

(b) rock in immediate contact with fire and thus directly affected by it, and

(c) rock only indirectly affected by fire.

When the fire is removed and dumped into the tailings, one can expect the stratigraphy to be inverted. An examination of the profiles shows this to be the case, and fire-setting can therefore be reasonably postulated as the source of the ash and the red rubble.

MINING TOOLS

The only mining tools found were hammerstones, which could be divided into two types: those with dimpled faces, and quartz nodules with scars derived from battering. Details are given in Table II.

The table includes only those tools recovered before May 1973. The two classes are characterized by the presence or absence of dimple scars. Class 1 tools (those with dimple scars) compare well in size and weight with those described by Baumann[1] from Rooiberg. The dimple scars in the hammerstones from Rooiberg are much deeper than those from Harmony. Harmony specimens have dimples with depths of less than 1 mm-5 mm; Rooiberg specimens have dimples equal to or greater than 10 mm deep.

TABLE II
HAMMERSTONES FROM HARMONY COPPER MINE

Site	Dimensions mm	Weight g	No. of dimples	Raw material
C IV 6	68 × 87 × 83	850	2	Diabase
C I 6	116 × 93 × 89	1110	5-6	Diabase
C IV 1	Irregular	688	2	Quartz
Surface	83 × 84 × 86	1110	5-6	Diabase
Surface	85 × 84 × 83	1031	3	Diabase
Surface	72 × 93 × 94	1110	5	Diabase
Surface	128 × 75 × 122	1110	8	Diabase
Surface	100 × 111 × 84	1110	6	Diabase
C IV 1	Irregular	1110	—	Quartz
C IV 2	,,	1110	—	Quartz
C II 2	,,	607	—	Quartz
C II 4	,,	1019	—	Quartz
C IV 5	,,	897	—	Quartzite
C IV 3	,,	427	—	Quartz
Surface	,,	843	—	Quartz

ASSOCIATED METALLURGICAL FEATURES

In addition to mining, at least some smelting appears to have been done in the immediate vicinity. Three smelting furnaces were located and excavated (C VI, C VIII A, and C VIII B), and several other smelting sites distinguished by finds of scattered pieces of slag were also found.

The three excavated furnaces are on the north side of the mine between 60 and 85 m from the nearest unit. C VI is 63 m from unit 5, and C VII is 75 m from unit 22.

The furnaces all conform to the same type, which is well known in the Transvaal Lowveld from the reports of Schwellnus[6] and of Van der Merwe and Scully[7]. C VI was well preserved, even to the hollow in front of the furnace opening, which appears to have been a specially prepared hollow 0,35 m deep. The present surface level is probably also the past land surface in that slag and other waste products of smelting were found on the surface and in the top 5 cm. Clearing round the furnace revealed that the furnace lining was relatively thin—ca 30 mm. Outside this, the original soil had been hard-baked to a further thickness of 150 mm. The plan of the furnace was oval, the tuyère opening being at the narrow end. The widest dimension was 0,590 m, narrowing to 0,13 m at the crumbly tuyère hole. The length was 0,72 m. The major part of the tuyère was found 4 m away. Two furnaces 0,52 m apart were excavated at C VII. Of the two, furnace A was well preserved (Plate III), but B was poorly preserved. Furnace A, like that of C VI, was oval in shape but smaller, measuring 0,48 m by 0,42 m. Unlike C VI, the furnace was bell-shaped, being wider at the base than at the top. As in C VI and furnace B, no clear floor was found at the base, though the lowest point of the tuyère preserved *in situ* in furnace A was probably at this point at a depth of 0,40 m. The tuyère opening funnelled outwards, with clay lining preserved on one side.

Furnace B was poorly preserved round the tuyere opening and may have been broken more extensively by the smelters. Its width was 0,44 m. A trench on both sides revealed by depth of artefacts that a hollow similar to that found at C VI must also have existed in front of furnace A.

Areas with scattered fragments of slag also occur on the south side of the mine opposite units 6-8 at a distance of 8-15 m from the mine, opposite units 3-4 at about 45 m

Plate III—Furnace A at C VII, with tuyère still in place

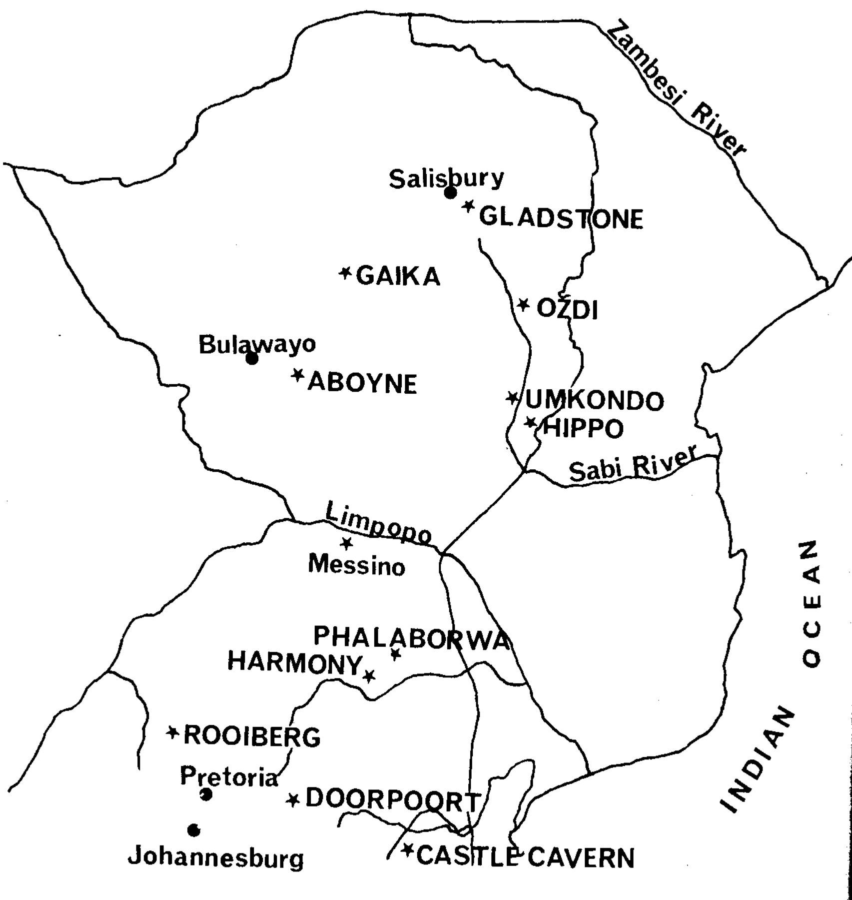

Fig. 6—Map showing the mines mentioned in the text

from the mine, and at position 6/73 nearly 1 km away (Fig. 1).

Other features include ore-sorting areas away from the tailings, the best preserved of which are on the north side of the mine opposite units 13-14, and 5. In all cases, they are far enough away and sufficiently distinct for natural causes of origin to be ruled out. These areas are distinguished by piles of mined material associated with quartz and diabase nodules showing signs of battering.

On the south side of unit 14a, a lower grindstone was recovered. Others were found with furnace C VI and with the slag site south of units 3-4.

The slag samples are being analysed by the National Institute for Metallurgy.

DISCUSSION

Types of Ancient Workings

Discussion is based entirely on those mines where ores were definitely mined for metallurgical purposes (see Fig. 6). In his book on Rhodesian mines, Summers[4] divides the workings into the following three classes:

- Class 1 open stopes,
- Class 1A open stopes with occasional shafts, and
- Class 2 shafts.

The great majority of mines in Rhodesia fall into Class 1, the figures for copper mines being indicative of the position:

- Class 1 138,
- Class 1A 4, and
- Class 2 6.

The figures include mines in the Tati district of Botswana and Messina in the northern Transvaal.

The Harmony mine clearly falls into Class 2. Other mines in the Transvaal that also fall into this class are Rooiberg[1] and some at Phalaborwa[2, 3, 7]. Others fit into Class 1 (e.g., at Phalaborwa[2, 3] and Waterval Onder[2]). There are some mines at Gravelotte that are adits, which constitute another class, Class 3.

Class 1 workings appear to be the most extensive and probably the simplest. Individual stopes are open trenches, sometimes very narrow and as long as 610 m. Stopes end to end can stretch for several miles.

Class 2 workings have underground stopes reached by vertical shafts from the surface. Underground workings at some mines are complex (e.g., Umkondo[4] and Rooiberg[1]) and consist of stopes, galleries, and drives. Shaft sizes vary enormously. At Odzi Mine[4] and Umkondo[4], shafts are rarely above 76 cm in diameter, and, at Harmony, shafts appear to be double the size. The difference probably lies in the mine geology. Certainly, the shale at Umkondo was very soft and a small working preferable.

Class 1 and 2 workings probably reflected differences in geological structure and mineralization. In Class 1 workings, the lode probably stretched from the top to the bottom. In Class 2 workings, the major lode must have been some distance below the surface, and the shaft and underground stope probably represented the most economical method in terms of outlay of energy in return for metal-bearing rock. Other factors in mineralization probably also played a part.

Methods of Ore Extraction

Some mines have excellent evidence for methods of breaking up lodes for transport to the surface. Examples are Umkondo Mine[4], Rooiberg[1], Harmony, Lolwe[7] at Phalaborwa, Messina[4, 8], Gaika Mine[4], and Aboyne Mine[4]. Two methods were used: fire-setting, and the use of hammers and gads. The evidence is incomplete, fire-setting being the best attested.

At Harmony, the evidence lies in the layers of ash stratified in the tailings in trenches C I and C IV. At Lolwe[7] and Hippo Mine[4], quantities of charcoal were found at the bottom of stopes, and at Rooiberg[1] a pile of wood was found piled in readiness for lighting at the bottom of a stope.

Rooiberg[1] and Umkondo[4] Mines both have excellent evidence for the use of hammerstones and gads. In both mines, dimpled hammerstones have been found in quantity, the dimples being derived from the hammering of the ends of the gads into cracks. Iron hoes, probably used as shovelling instruments, are also known from Rooiberg[1]. Ore seems to have been broken up and partially sorted below ground. Evidence for this stems from finds of large mullers below ground as at Rooiberg, and from the fact that some of the waste material was replaced in the stopes as work progressed for reasons of safety and probably also to aid ventilation.

There appears to have been some variation in methods of access to workings. One shaft at Messina[4] had steps cut into the wall to allow people to scramble in and out easily. At Rooiberg, a crude ladder of poles and branch stumps was recovered by Baumann[1]. At Umkondo[4], ropes seem to have been used to hoist men and material to the surface. At Harmony, the vast quantity of timber and the fact that one or two pieces still have branch stubs on them suggest that a ladder similar to that at Rooiberg may have been used.

Removal of ore was probably a greater problem. Little is known of containers, though these are likely to have been of perishable materials such as basketry and leather. Pottery was almost certainly not used owing to its weight and to its extreme fragility. Ethnographic evidence from Messina gathered by Van Warmelo[9] states that the copper miners there used small baskets reinforced by the skins of wild animals. The loaded receptacles were hauled up mainly by women, who suspended the baskets by leather thongs across their foreheads. From West Africa, Gardi[10] illustrates the use of shallow, wide wooden bowls. Perhaps some were used in Southern Africa also.

Water, reduction in size of the lode, and changes in its chemical composition generally led to the closing of ancient workings. Iron Age miners had no means of clearing water from the bottom of workings and often had to abandon rich ore deposits because of water. Where lodes pinched out, stopes were also abandoned. Changes in copper ores from the easily worked carbonates to the sulphides as at Messina also led to the abandonment of workings. The preparatory roasting of sulphide ores appears to have been beyond the technical knowledge of Iron Age metallurgists[8].

Most mining was probably done in natural daylight as the size and depth of working usually allowed light to penetrate a considerable way into the stopes. However, as at Messina, natural light had sometimes to be supplemented by candles made of leaves or pods[9]. Unfortunately, evidence of artificial lighting has not survived in the archaeological record.

Safety and ventilation must have been two of the greatest problems encountered and overcome by ancient miners. Mining was very far from a safe pursuit as the finds of skeletons attest (Umkondo, Aboyne Mine, Gaika Mine). Safety precautions appear to have been of two kinds: the use of timber and careful packing of rubble into mined areas. Few mines have well-preserved timbering *in situ*. The three known are Harmony, Umkondo, and Gladstone Mine[4]. In the first two, props were used to support the hanging-wall, and in the Gladstone Mine more advanced shoring was practised. In place of timber props, pillars of ore were sometimes left in place[4]. Back filling[1-5, 8] seems to have occurred both with open stopes and shafts. Back filling seems to have been done for two purposes: first, to support the hanging wall in underground workings, and, secondly, to aid ventilation by allowing only two means of access to the upper surface at any one time. By doing this, one shaft could be used as an up-draught chimney drawing clean air down the second. This was only really necessary when fire-setting was used, though in some cases bad air would have had to be removed in the same way.

There are three sources of evidence for the identity of the ancient miners, and they all point in the same direction. Skeletal evidence from Umkondo and Aboyne Mines shows that the miners were negroid in character, and those from Umkondo show them to be indistinguishable from the modern Karanga population of Rhodesia. Archaeological evidence shows these negroid peoples to have practised various forms of Iron Age culture, comprising smelting metals, living in permanent settlements, growing crops, keeping herds of cattle, and making pottery. The artefacts and the way of life of these Iron Age negroid men are indistinguishable from traditional Bantu-speaking tribesmen of the present day. Ethnohistorical evidence[9] also states that the miners were the ancestors of the present-day Bantu-speaking peoples. Both the biological and the ethnohistorical evidence shows that all members of a mining community worked in the mine—men, women, and children.

Mines date apparently from fairly early in the first millenium A.D., the radiocarbon dates so far obtained being listed in Table III. Associations with artefacts dated elsewhere confirm this record, especially with regard to the Rhodesian mines, which are better known than their South African counterparts.

GEOLOGY OF THE MINE

The geology of the area in the immediate vicinity of the mine (Fig. 7) was investigated over a period of three days. Much of the evidence leading to the elucidation of the mineralization came from two partly excavated shaft systems. A simplified explanation of the mode of deposition and of the nature of the occurrence follows.

The mineralized zone extends along the contact of primitive amphibolite schists and basement granite. The exposed contact is marked by an east-west trending fault zone, which has a downthrow of at least 10 m on the north side. Extensive lateral movement is indicated by intense drag on both sides of the fault. A second and later episode of faulting is marked by a number of cross fractures and quartz veins that strike in a north-south direction. Little lateral movement is evident along these lineations, which seem to represent tension fractures. It is along these fractures that frequent pegmatitic bodies have intruded. These pegmatites consist of a very coarse quartz, feldspar, and muscovite assemblage, individual muscovite books attaining a length of over 40 cm and individual feldspar crystals being up to 5 cm long. The pegmatites are devoid of other mineralization.

Copper occurs along the entire exposed strike of the major east-west fault zone and is limited to the schist-granite contact. As the ancient mining operations were restricted to the weathered zone, it is not surprising that the major copper minerals encountered are malachite and azurite. The ore mined was of very low grade and was very patchy in nature. Concentration by hand sorting must have been resorted to in order to obtain material sufficiently rich in copper to warrant smelting. Microscopic examination of twenty-six selected strip samples each of 50 cm length and taken across the mineralized zone at two locations yielded the following information:

- 18 were devoid of any visible mineralization,
- 6 contained 0·2 per cent copper, and
- 2 contained 2-5 per cent copper.

Seven selected samples were assayed for gold. These all yielded values of less than 3 g/t.

Mode of Mineralization

How and why the copper mineralization occurs as it does can best be explained by comparison of the Harmony occurrence with the vastly larger Messina deposits. The Messina deposits were formed as a result of

TABLE III
RADIOCARBON DATES FOR MINING IN SOUTHERN AFRICA

Mine	Laboratory No.	Date B.P.	Calendar date
Harmony (Transvaal)	RL-207	690 ± 90	1260 ± 90 A.D.
Umkondo (Rhodesia)[4]	SR-144	320 ± 90	1630 ± 90 A.D.
Gaika (Rhodesia)[4]	SR-140	0 ± 90	? 19th century
Aboyne (Rhodesia)[11,4]	SR-53	780 ± 110	1170 ± 110 A.D.
	SR-58	650 ± 110	1300 ± 110 A.D.
Rooiberg (Transvaal)[12]	GrN-5136	435 ± 45	1515 ± 45 A.D.
Lolwe (Transvaal)[7]	Y-1636	1180 ± 80	770 ± 80 A.D.
Castle Cavern[11] (Swaziland)	Y-1712	1550 ± 60	400 ± 60 A.D.
	GrN-5022	1535 ± 30	415 ± 30 A.D.
	GrN-5315	1550 ± 30	400 ± 30 A.D.
	Y-1995	1430 ± 100	520 ± 100 A.D.
Geelong Mine (Rhodesia)	SR-143	780 ± 95	1170 ± 95 A.D.

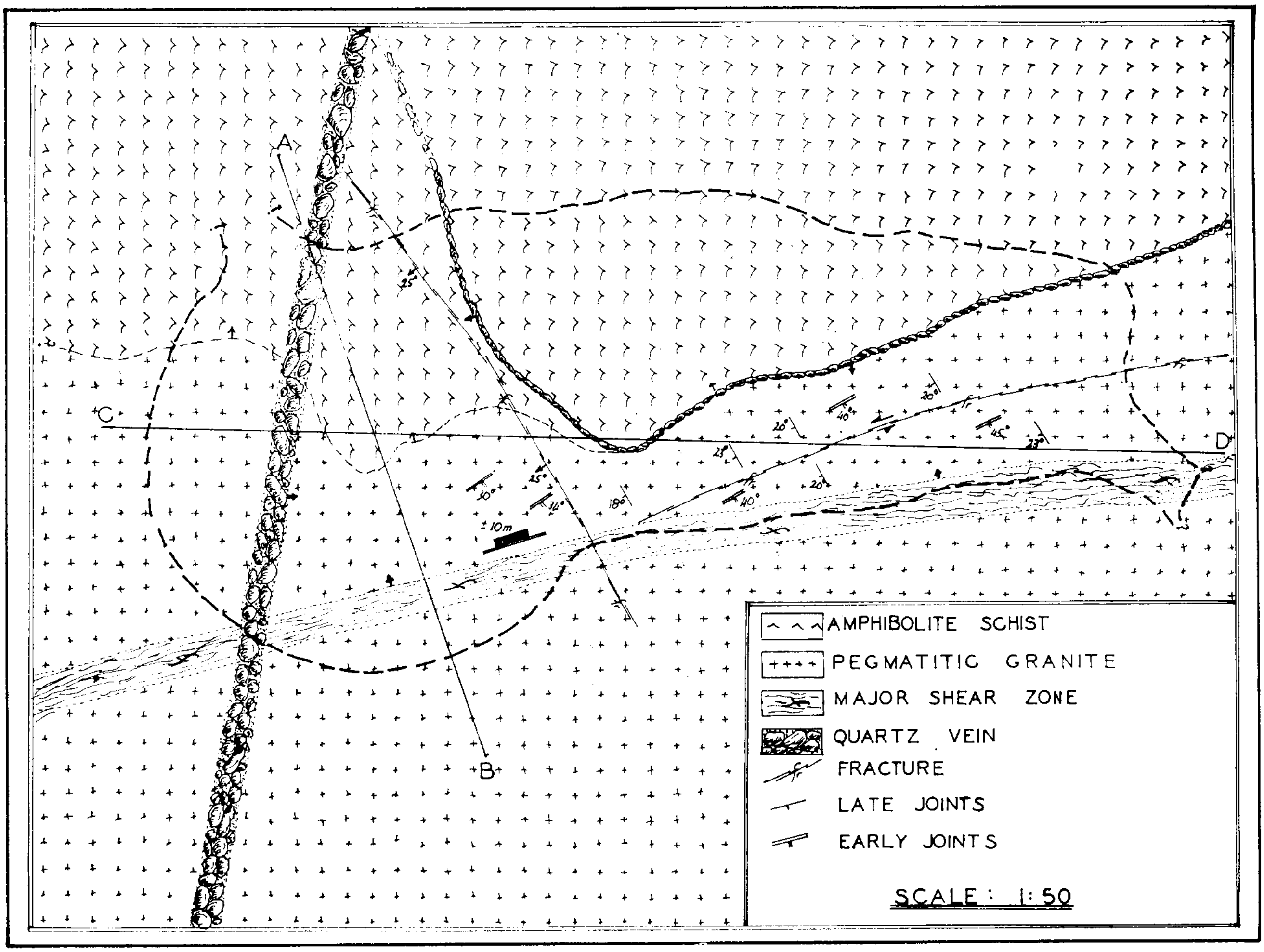

Fig. 7—Geology of Harmony Mine

thermo-tectonic events that occurred in a rock system of suitable composition. The economic mineral deposits represent the end products of a series of reactions initiated by the energy supplied to a thermodynamically unstable system by these events. In the case of the Messina deposits, the thermo-tectonic events were great enough to enable the reactions to proceed to near completion. Thus, in these deposits we find an almost ideal paragenetic sequence of minerals arranged according to their heats of formation. In the case of such zoned orebodies, the controlling effect of structure is quite obvious.

Events leading to the formation of the Harmony occurrences are essentially similar in nature to those that caused the formation of the larger Messina orebodies.

Here, however, the affected area and the intensity of the energy supplying tectonic events were on a much smaller scale. The mineralogical 'rearrangement reactions' could not proceed to completion, and no rich orebody could be formed. The east-west fault zone appears to have provided the major supply of energy, possibly in the form of superheated volatiles percolating through it. The schist-granite contact provided the reactive site, and copper mineralization, possibly in the form of sulphides, concentrated in this area. The copper itself was derived from the amphibolite schists and was not introduced into the area by the solutions. These solutions served only to provide the energy necessary to trigger off a set of chemical reactions that resulted in a concentration of copper minerals near the source of the energy. The low-grade mineralization is quite understandable on the basis of this explanation.

One can thus conclude that the workings of the ancients would follow the strike of the major fault. Underground workings would follow the schist-granite contact immediately adjacent to the major fault. Their extension to the north would not be very likely since the grade of ore would fall off very rapidly with distance from the fault zone. In addition, any northward extension of stoping would involve hazardous mining because the undulating schist-granite contact plunges sharply to the north.

CONCLUSION

All in all, the record of mining in Southern Africa can be seen to stretch over hundreds of years. Technically, the ancient miners are to be greatly respected. In addition to mining with extremely simple tools and techniques, they must generally have made the tools themselves. Prospecting must also have been done by them. It is staggering to realize that only one occurrence of gold in Rhodesia was missed by the ancient miners. The finding of copper deposits such as that at Harmony also demonstrates how far advanced their prospecting knowledge was.

While some people are hesitant to credit the Bantu-speaking population with such skills, it has yet to be shown that an alien people, like the Indians postulated by Summers[4], had any effect on ancient-mining techniques. An African origin is likely as mining and metallurgy seem to have been disseminated into negro Africa overland from north Africa by Egyptian and Carthaginian contacts before the turn of the Christian era.

ACKNOWLEDGEMENTS

Thanks are due to the following, who assisted in various ways: Mrs J. Gamble, the Human Sciences Research Council, Kampvuur Vakansie-oorde Bpk., R. J. Mason, staff and students of the University of the Witwatersrand, P. Wallace, and R. Welbourne.

The project as a whole was supervised by the African Studies Programme Iron Age Committee of the University of the Witwatersrand.

REFERENCES

1. Baumann. *J. Chem. Metall. Min. Soc. S. Afr.*, vol. 19. 1919. pp.120-132.
2. Trevor, T. G. *Ibid.*, vol. 12. 1912. pp. 267-275.
3. Hall, A. L. S. Africa, Geological Survey, *Memoir* 6. 1912.
4. Summers, R. Ancient mining in Rhodesia. Nat. Mus. Rhod., *Memoir* 3. 1969.
5. Mason, R. J. *Prehistory of the Transvaal.* Johannesburg, University of Witwatersrand Press, 1962.
6. Schwellnus. *S. Afr. J. Sci.*, vol. 33. 1937. pp. 904-912.
7. Van der Merwe, N. J. and Scully, R. T. K. *Wld Archaeol.*, vol. 3. 1971. pp. 178-196.
8. Stanley, G. H. *Proc. Durham Univ. Philos. Soc.*, vol. 3, pt 5. 1910.
9. Van Warmelo, N. J. South Africa, Dept. of Native Affairs, *Ethnological Publications* 8. 1940.
10. Gardi, R. *African crafts and craftsmen.* New York, Von Nostrand, 1969.
11. Beaumont, P. B., and Vogel, J. C. *Afr. Stud.*, vol. 31. 1972. pp. 65-89.
12. Vogel, J. C. *Radiocarbon*, vol. 12. 1970. pp. 444-471.

COLLOQUIUM ON COMMINUTION

The Institute has arranged a colloquium on the above topic to be held on 13th March, 1973, at Kelvin House. The following papers will be presented:

'Peripheral Discharge Mill', by A. H. Mokken, Union Corporation Limited

'Structural Design of Large Ball Mills and Rod Mills with Reference to Shell-mounted Bearing Journals', by D. Fenton, Aerofall Mills Limited, Canada

'Developments in Centrifugal Milling', by A. A. Bradley, A. J. Freemantle, and P. J. D. Lloyd, Chamber of Mines Research Laboratories

'Milling Circuit Design for Stable Operation', by A. R. Atkins, Chamber of Mines.

The title of the fifth paper will be announced at a later date.

Members of the Institute who would like to contribute to the colloquium are asked to contact the Institute's Secretary as soon as possible, telephone 834-1271.