Early copper mining at Thakadu, Botswana

by T.N. Huffman*, H.D. van der Merwe*, M.R. Grant*, and G.S. Kruger*

Introduction

The Thakadu–Makala Copper workings are located in Botswana near Matsitama (21° 03'S; 26° 46'E), about 80 km west of Francistown. The various workings consist of contiguous circular excavations surrounded by waste materials (Figure 1). Thakadu is the most easterly and largest of a string of these 'ancient workings', that follows a copper-bearing horizon for about 2.5 km along a northwest-to-southeast strike. Peolane, about 1 km northwest, is next in size, while the remaining mines along the strike—Noko, Makala, and Logola—each consist of only a few shallow hollows.

These copper workings were rediscovered by Bamangwato Concessions Ltd (BCL) in 1962, during a systematic regional exploration that began at the Bushman Mine, to the north of Matsitama, a few years earlier. During 1965, interested personnel at Borest (the holding company for BCL) obtained a charcoal sample from what appeared to be the bottom of a shaft at Thakadu. The charcoal was radiocarbon-dated (SR-51) to 1540±100 A.D.1, placing it in the Khami phase—a chronological division of the Iron Age named after the Khami Ruins near Bulawayo. According to Summers2, potsherds and glass beads from Thakadu are similar to those found at Khami itself. By 1968, BCL had thoroughly evaluated the deposit through trenching, underground mining, diamond- and percussion-drilling. Falconbridge Exploration Ltd gained prospecting rights in 1977, re-appraising BCL’s findings, and conducting further metallurgical tests.

During 1990, Thakadu Mining (Pty) Ltd of Botswana acquired the mining lease. The next year they hired Marope Research to conduct an archaeological impact assessment. Among other findings, Marope Research discovered village sites with evidence of metal production near Thakadu and Makala. The following year, Thakadu Mining contracted Archaeological Resources Management (ARM) to implement the recommended investigation. During the dry season, when grass was virtually absent, ARM located several smelting areas around the various ancient workings.

At the beginning of 1993, the shareholders of Thakadu Mining changed, and our evaluation programme continued with them. Our programme was limited to test excavations in Thakadu, and a smelting area near Noko, as well as the mapping of the old mines.

Thakadu Mine

Geology and mineralogy

The mine lies in the Matsitama schist belt in the Lepshae-Mmalogong subdivision, comprising metamorphosed sediments and amphibolites. Stratabound copper mineralization occurs as disseminated sulphides on the interface between major calcareous and arkosic quartzite members, but weathering near the surface has oxidized these primary sulphide minerals into copper carbonates. At Thakadu, the amphibolitic country rock abuts against a 10 to 25 m wide envelope of banded quartzites enclosing a chloritized and laminated quartz-carbonate rock, that hosts the cupriferous ores.

Ancient mining at Thakadu exposed 180 m of this orebody, but the work by BCL shows that the orebody continued westwards for a further 270 m. Here the orebody is tabular, narrowing progressively westward from 18 m in width, to 8 m and less, and dips consistently southward at about 45°. The mineralized rocks may have originally outcropped at the eastern end, since it is 3 to 4 m higher than its western counterpart. At this eastern end, complex folding appears to have duplicated the formations into a tight synform structure that plunges westward. As a result, the orebody reaches 30 m in width in this area.

Wrench-faulting oblique to the strike has displaced the ore-zone in a number of places. The resultant brecciated fracture zones became channel ways for enhanced weathering, and the redistribution of metals in solution. The major minerals in this ore-zone include:

- malachite — CuCO₃ . Cu(OH)₂
- chrysocolla — CuSiO₃ . 2H₂O,
- cuprite — Cu₂O,
- tenorite — CuO,
- chalcocite — CuS

with lesser amounts of

- chalcopyrite — CuFeS₂
- bornite — Cu₂FeS₄
- chalcocite — CuS

Archaeological Resources Management, Archaeology Department, University of the Witwatersrand, Johannesburg.
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Figure 1—General view of Thakadu looking northwest. Note hollows surrounded by waste

which occur together with limonite, covellite, and rarer native copper. Near the water-table relict-sulphides occur, these being:

- chalcopryte/bornite — CuFeS₂, and
- marcasite — FeS₂.

Besides occurring as numerous thin filaments in hairline cracks and fractures in the ores on surface, malachite also occurs in fairly massive veins up to 2 to 4 cm wide, and 1 to 3 cm thick. These veins probably ran for 10 to 12 m in sub-parallel lines where open fractures were best developed along the strike.

Surface features suggest that mining proceeded in a series of more-or-less vertical shafts in the ore-zone between various hanging- and footwalls. While waste debris appears to have been thrown onto the northern footwall, little or no waste covers the southern hangingswall (Figure 1). These surface features, and our general understanding of the geology, influenced our excavation strategy.

Excavations

We sited four trenches inside hollows that marked separate shafts (Figure 2). Trench 4 was placed against the hangingswall at the east end, and Trench 3 was located next to the footwall on the opposite side. Trench 2 was placed in between another hang- and footwall in the middle of the synform at the east end. We believed that the western end was probably the last area to be mined because it was shallower, and we therefore placed Trench 1 there.

Trench 1 measured 2.5 x 3.0 m in the beginning, and then a 1 m trench was extended on the west side so that we sampled both sides of the hollow (Figure 3). The surface of this depression was about 2.2 m below the original ground level, and we removed a further 3.55 m of deposit before it was too dangerous to continue.

The east section illustrates the gross stratigraphy (Figure 4). A red soil (layer 1), varying in thickness from 25 to 40 cm, covered boulders, which in turn lay on top of a thick deposit of waste rock containing zones and patches of ash at various depths (layer 2). Charcoal at 70 cm below surface has been radiocarbon dated to 1610±50 A.D. (Pta-6283) and at 3.25 m below surface to 1580±45 A.D. (Pta-6288).

The red soil was clearly blown and washed in from the surrounding Kalahari sands after mining had stopped. Similarly, the large stones were those coarser fractions of waste that had rolled down the slopes of rejected material thrown around the margins of each working. This waste had been hand 'cobbled', that is selected and further broken to extract ore.

Samples of this 'cobbled' waste still contain some 3 to 5 per cent copper, mostly as wispy veinlets of malachite. Tiny chips of malachite scattered in the waste show that the miners further prepared the material by chipping the malachite off the gangue. What is more, the chips show that the miners were after the thick veins.

The shape of the hollow, and the steep angles of the surrounding talus (sloping waste discards), show that this was a roughly vertical open-shaft that had been used to dump waste rock from another shaft nearby. Consequently, this shaft's apparent shallowness is an illusion, and the western end may not have been the last area to be mined.

Trench 2 was a 2.5 x 3.0 m area excavated in a hollow between closely set foot and hanging walls in the middle of the eastern end (Figure 5). The stratigraphy was similar to Trench 1 except that we could discern finer divisions (Figure 6). Some 35 to 46 cm of a recent red/orange wash lay on top of older wash, 10 to 25 cm thick (layer 1). Two further orange zones interrupted a thick (25 to 62 cm) deposit of grey waste (layer 2). A disturbance filled with soil and leaf mould, through this waste, next to the footwall marked the excavation by Botrest in 1965. Loosely packed waste (layer 3) extended underneath this excavation and the grey waste for at least 1.5 m. This lower deposit demonstrates that the Botrest sample did not come from the bottom. The loose waste incorporated one lens of red soil and ended on another. Both layers of waste contained patches of ash and charcoal (Figure 7). Botrest's 16th century radiocarbon date came from charcoal in our Ash 1 from 35 to 50 cm below surface. Other patches occurred at 80 and 90 cm in layer 2. Charcoal from Ash 4 in layer 3 at 1.1 to 1.7 m below surface has been dated to 1700±50 A.D. (Pta-6287).
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The various orange and red lenses in the waste most likely washed in when this shaft was unused, while the ash must have been thrown there during periods of mining activity. Since the hanging- and footwalls are not blackened by smoke, the charcoal was probably used to break rock in the ore zone between the two walls. Evidence for similar activity occurred in Trench 3.

Trench 3 began as a 2 x 2 m area extending from the footwall towards the centre of a hollow at the east-end of the mine (Figure 8). We added a further 1.5 m to reach the centre, and another metre on the north-end to reach the footwall. As with the other shafts, various talus slopes surrounded the hollow. In the excavation the slump (layer 1) from this talus reached a thickness of 60 cm (Figure 9). Against the footwall this slump lay on top of hand-cobbled waste with malachite chips (layer 3), but towards the centre the slump gave way to younger washed in soil (layer 2).

Layer 2 contained thin red and maroon burnt patches at various depths. These burnt patches formed at least four different micro-layers, indicating that hot ash or other material was thrown onto soil washed in, while mining activity carried on elsewhere. Together these micro-layers represent a third phase of activity: first, the shaft was excavated, and then partially filled with waste from another shaft, before the hot ash was discarded. A similar sequence formed the deposit in Trench 4.

Trench 4 was a 2 x 2 m square dug against the hangingwall in the east end. A few centimetres of wash (layer 1) against the stone-wall lay on top of red soil (layer 2) almost 1 m thick (Figure 10). Thin ash-lenses in the red soil probably resulted from the same cause as the burnt patches in Trench 3. Red/grey soil with some ash (layer 3) separated the red soil from grey waste (layer 4). One area in layer 4 contained large waste representing coarser fractions that had rolled down the slope. Excavations stopped on the contact with another deposit of waste.

Finds

Trench 4 yielded five fragments of pottery, mostly from the base of layer 2, near its contact with the waste. One large fragment represented about 1/4 of a jar typical of the Zimbabwe Tradition: it had a beaded rim, sharp neck/shoulder junction, and graphite burnish. Molyneux and Reinecke had earlier found potsherds in the vicinity of our Trench 4, and we found two others in Trench 1. All probably belong to the Khami phase.
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Broken hammerstones were more abundant than potsherds. We found several on the surface of the mine (Figure 2), and kept a sample of ten. Another 11 hammerstones came from the excavations, and most of the excavated sample was associated with the waste. The hammerstones with dimples (91% of those excavated) were used with metal gads to dislodge veins in the ore zone. However, a few hammerstones lacked dimples, and they were most likely used on their own to dislodge the ore. One small fragment of a metal gad was found in Trench 1 at 90 cm in the waste. Considering the number of dimpled hammerstones, we should have found more. Evidently, the soil is too acidic for good preservation. Copper, on the other hand, is not as friable, and a copper earring was found in Trench 1 in waste next to the footwall at about 1 m depth from the surface.

There was no evidence that the ore was smelted inside the mine. For this phase of activity, we must turn to the water-tank site.

Water-tank smelting site

Excavations

Ashy areas in the general vicinity of Peolane and Noko—on the ridge northwest of Thakadu—characteristically contained malachite chips, ore, and tuyère fragments. We test excavated such an area about 130 m north of Noko near the remains of a concrete watertank. We laid out a 40 m datum line through the area, and started two 3 x 3 m trenches (Figure 11), beginning at 2 and 23 m.

Trench 1 revealed four layers: some 10 cm of brown soil and humus (layer 1) lay on top of an ash lens 3 to 5 cm thick (layer 2) containing a concentration of potsherds, broken tuyères, and pieces of sinter; thin red soil (layer 3) underneath merged sharply into a pebbly substratum (layer 4), containing Middle Stone Age artifacts but little Iron Age material. A similar stratigraphy occurred in Trench 2.

Trench 2 was extended 2 m south and 1 m west to uncover features not found in Trench 1. We exposed four furnaces (F1 to F4) spaced about 1 m apart, and oriented approximately east–west (Figures 12 and 13). Each furnace was about 40 cm wide, and 50 to 60 cm long with tuyère ports extending a few centimetres further at both ends, and each penetrated about 25 cm into the pebbly substratum (Figure 14). A pebbly lens on top of red soil in the northeast corner represented reversed stratigraphy resulting from the original furnace construction. The lack of any furnace dagga (baked mud) suggests that these were pit furnaces without any superstructure.
The furnaces were filled with white ash, charcoal, tuyère fragments, and associated with such things as copper wire (F1), a bird bone (F2), cow tooth (F3), and cow mandible (F4). Charcoal from F2 has been dated to 1670±45 A.D. (Pta-6290), and from F3 to 1590±20 A.D. (Pta-6292). A thin layer of hard white ash coated Furnaces 3 and 4, and every furnace contained sinter rather than slag. In the case of F1, the sinter was concentrated in a thick lens outside the furnace. The edges of F1 were also less defined, and they had probably been damaged when the smelt and sinter were removed.

**Sinter analysis**

Under the scanning-electron microscope all samples from the furnace had a slag-like appearance, and they contained almost pure copper beads embedded in a melt, with a dendritic structure resembling fayalite (2FeO SiO₂). The metallic-copper phase usually contained inclusions of copper/iron sulphides such as bornite, chalcopyrite, and chalcocite.

These observations are consistent with the smelting of malachite containing some sulphides, where the silicious host rock served as a natural flux for iron in the ore. However, the abundance of unreacted silica grains shows that fluxing was not complete. The temperature was sufficiently high to melt copper at 1083°C, but some of the oxide melt was only in a semi-liquid state. Since fayalite has a liquidus temperature of about 1200°C, this may have been the maximum temperature reached in the furnaces.

**Finds**

In addition to sinter, the water-tank site yielded numerous tuyère, pottery fragments, and a few Middle-Stone-Age flakes. The flakes probably originated from the pebbly surface. However, the other finds were associated with smelting activity.

Although the ceramic sample was small (there were only nine rims), it included beaded rims and graphite burnish. The pottery is, therefore, the same as that found at Thakadu and belongs to the Zimbabwe Tradition.
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Figure 12—Plan and profiles, water-tank site 2

Figure 13—Water-tank site Trench 2: facing west showing furnaces F2, F1, and F3

Discussion

Although our excavations never reached the bottom of any shaft, we clarified the broad mining procedure at Thakadu. The ore was concentrated in a 10 to 30 m wide zone between the northern footwall and southern hangingwall. The miners dug vertical open shafts in this area. Evidently, they began next to the footwall, throwing waste onto the wall itself. Later they dug closer to the hangingwall, throwing waste into older shafts. The radiocarbon dates from Trench 2 demonstrate this last point. The 16th century date from Ash 1, obtained by Botre, is older than the date from Ash 4 about 1 m deeper. This two-phase exploitation is particularly clear towards the west end. The mine may not have been dug in any particular order, but the deep hollow at the east end must have been one of the last.

In all cases the miners were after thick malachite veins, rather than the small veinlets left in most waste. Malachite chips, broken hammerstones, the gad fragment, and various ash lenses show that ore was removed from its host rock on site.

Acknowledgements

We thank R. Steel and J. Begg for their assistance in the field, and N. Walker and M. Mogobo, National Museums and Monuments of Botswana, for organizing the necessary permits.
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Figure 14—Water-tank site Trench 2: Furnace F2

Although the ore was not smelted inside the mine, the water-tank site shows that smelting clearly took place in the general vicinity. Other ash areas with tuyère fragments on the ridge, demonstrate that many more furnace remains lie between Thakadu and Makala. We suspect that there were furnaces around Thakadu itself, but BCL’s exploration in the 1960s disturbed much of the surroundings. On the other hand, the metal workers may have concentrated the furnaces on the ridge where they could dig into the pebbly substratum.

In the water-tank site, the furnaces probably lacked dagasuperstructures. The temperatures and reduced atmospheres in the small pits were probably sufficient to smelt malachite. However, there is no evidence that the smelted copper was refined near the furnaces. Instead, nearby village sites need to be considered.

The original survey by Marope Research located two village sites near the mines. Site 8 (2127CD 8) lies about 500 m north of Thakadu. It is a small village with a central cattle kraal typical of commoner sites in Botswana. EMSSA Conference, Dec., Berg-en-Dal, Kruger Park. 1993.

Both sites 8 and 10 contain Khami-phase pottery like that found in Thakadu and at the water-tank site. As a rule, most Iron-Age settlements in the area date to this phase, and were occupied by Zimbabwe culture commoners. According to oral traditions and other archaeological evidence, these commoners would have most likely spoken Kalanga, that is, Western Shona. This oral and archaeological evidence along with the pottery from the villages and mine, indicate that local Kalanga produced the copper and not itinerate foreigners.

Presumably, Site 8 was politically less important because of its smaller size. Nevertheless, it contained the most abundant evidence of metal production. Burnt soil, potsherds, tuyère fragments, and some ore formed a mound about 10 m in diameter near the central kraal. This mound has not been excavated, but surface finds suggest that copper bloom was probably processed here.

Another link between the villages and smelting areas is provided by the east–west orientation of the furnaces. This peculiar feature has no metallurgical significance, since air was forced in by bellows. Significantly, present-day Kalanga align their villages in a similar way for symbolic reasons. The front should face west, while privately-owned facilities for storing grain—a product of the earth’s fertility—should stand in the back. Villages are organized this way because Kalanga associate secular and public activities with the West, and private and sacred activities with the East. This organizational dimension based on beliefs about life forces was widespread throughout the Zimbabwe culture area during the Khami period, and we can be confident that commoner sites near the mines followed this pattern. The east-west orientation of the copper furnaces therefore appears to be part of a larger network of symbolic associations.

The range of calibrated radiocarbon-dates (following Vogel) from Thakadu and the water-tank site, shows that this copper production extended over an approximately 200-year period, from about A.D. 1480 to 1680 (Table I). On independent climatic evidence this period was marked by high rainfall. This climatic condition of course made it possible for Iron Age agriculturists to live in the area. An earlier period of high rainfall occurred between A.D. 1000 and 1300, but since no pottery dating to this time has been found around Thakadu, copper production here was a feature of the Khami period.

As the exploration by BCL shows, the orebody had not been fully exploited, and so something else caused the mining to cease in the mid-17th century. The cause may have been political. A civil war in about A.D. 1640 destroyed Khami, and some 50 years passed before another major state was established. The Rozwi dynasty controlled this later state from their capital at Danangombe (also called Dhlo Dhlo) further to the east. According to oral traditions, the Rozwi dynasty had little interest in what is now Botswana. This lack of interest may have been partly due to drier climatic conditions. Whatever the full set of reasons, the collapse of the Khami State would have undermined the trade network that made copper production at Thakadu profitable.

References
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Table I

<table>
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<th>Location</th>
<th>A.D.</th>
<th>Calibration</th>
<th>Lab</th>
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<td>1638(1622-1651)</td>
<td>Pta-6283</td>
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<tr>
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<td>1528(1474-1640)</td>
<td>Pta-6288</td>
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<td>1540±100</td>
<td>1497(1437-1651)</td>
<td>SR-51</td>
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<td>Trench 2, Ash 4</td>
<td>1700±50</td>
<td>1663(1648-1678)</td>
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Water-tank site

F2 1670±45 1654(1840-1666) Pta-6290
F3 1590±20 1628(1616-1636) Pta-6292

Mintek’s MAP-making inroads for technology

This year over 200 disadvantaged youngsters are being given a second chance to proceed to careers in technology as a result of the proliferation of the Mintek Aurora Programme (MAP) in industry.

The MAP initiative, which gives students the opportunity to upgrade their matric maths and science marks and so gain entry to tertiary institutions, was started in-house at Mintek in 1992. One of the objectives is to duplicate the initiative in industry, and success has been achieved, with MAP colleges now existing at 15 different locations in Gauteng, Eastern Cape, and Kwa-Zulu Natal. ◆

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Mintek will host its annual Science Quiz for high schools (Minquiz) in several centres throughout the country on 9th March this year. This will be followed by a national final at Mintek on 12th April, at which the provincial finalists will compete for Mintek bursaries for technological degrees at South African technicons or universities.

The main objective of Minquiz is to promote interest in science and technology and to encourage pupils to embark on careers in these fields.

Mintek believes that South Africa’s future prosperity depends to a large extent on the careful development of South Africa’s resources, and to adding value to minerals wherever possible.

Dr Ben Ngubane, the Minister of Arts, Culture, Science and Technology, has agreed to award the prizes at the final event.

Minquiz is co-sponsored by TrustBank. For more information, contact Dr Glyn Moore on (011) 709-4271. ◆