ZIMBABWE

Gradient and Soil Analysis Identify the Function of Stone-built Tunnels in the Archaeology of the Eastern Highlands, Zimbabwe

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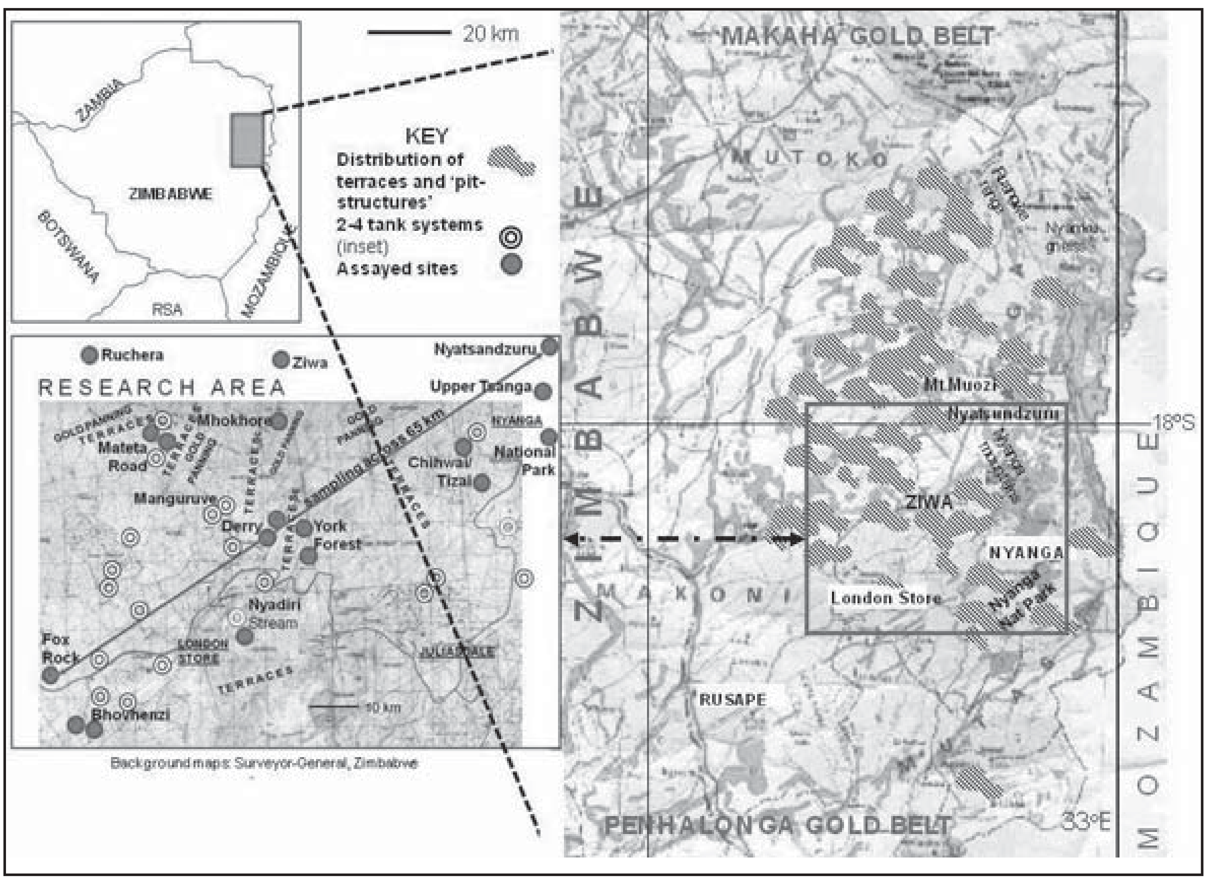
Introduction

In March 2005 affiliate of Zimbabwe Geological Survey Ann Kritzinger was issued a permit by the Research Council of Zimbabwe to examine the Nyanga archaeology of Zimbawe's Eastern Highlands from a mining perspective. This perspective challenged the dominant theory that hundreds of stone-built 'pit structures' and the widespread hillslope terracing of the Nyanga landscape derive from an agricultural form of land use. The agricultural hypothesis postulates that the penning of livestock in the 'pit structures' was to provide manure essential for raising the fertility of terraced hillslopes in order to enable cultivation of millet. The mining interpretation is based on the direct evidence of rock and soil assays, and the physical parameters of structural design. Well documented, and a characteristic feature of Eastern Highlands' landscapes, Nyanga archaeology is dated between the 14th and 19th centuries and extends sporadically for an estimated 7000 sq km between the Makaha and Penhalonga gold belts (Figure 1). Kritzinger's research area, expanded from an initial 20-km radius centred around latitude 18°22´S and longitude 32°35´E, covers a 65-km radius from south of London Store to Nyatsundzuru.

Figure 1: Map of research area showing places mentioned in the text. Inset diagram: spatial distribution of tank sites studied.



Anomalies Questioned

Factors for Kritzinger's rejection of the agricultural theory are the:

i) infertility of the soil on steep stony hillslopes; unsuitably narrow width of terraces (commonly 1-3 m); no evidence of manuring or material protection of crops from wild animal depredation;

ii) consistent presence of quartz in the archaeological landscape, a lithic anomaly that is not addressed in previous research. It manifests in vein quartz and quartz rubble on terraces, crushed quartz on and around 'pit-structures', and numerous heaps of sorted quartz in the landscape; and

iii) standardized design of the so-called 'pit structures' which exhibits principles for recovery of a heavy metal by gravity concentration. 'Pit structure' is a misnomer for a stone-lined tank "usually four to nine metres in diameter and 1.80 to 3m deep" (Soper 2002: 89) built up from bedrock within a massive oval or circular platform, through which a paved inlet tunnel "commonly around seven metres" (Soper 2002: 90) and an outlet drain are engineered to retain the gradient of a hill (Figure 2).

Apart from the Makaha and Penhalonga gold belts, and a short-lived gold rush to Nyamvu gneiss east of Ruangwe Range in the 1930s, it has long been held that Zimbabwe's Eastern Highlands have no economic mineral resources (e.g. Stocklmayer 1978). Paradoxically, today's undercover gold panners are living testimony to the presence of gold in the region. The anomalous characteristics quoted in i) and ii) above are typical of strip mining of eluvial (placer) gold deposits, ore dressing and classification. Evidence for precolonial exploitation in terms of i) and ii) is currently under investigation in the field. This paper focuses on one of the structural design features given in iii), namely the inlet tunnel and in particular the construction of its uphill entrance (Figure 3). The paper does not cover other elements of the tank systems such as the hopper-like slots in tunnel roofs, work bays, oven-type structures, and heavy-duty grinding equipment – all under examination in the wider remit of the present research (Kritzinger 2009: 80-81).

The restrictive dimensions of uphill entrances and steep inclines with inbuilt curves are critical data to understanding the tunnel as an integral component of what is perceived to be hydraulic engineer-

Figure 2: Standardized design of tank systems: hydraulically engineered and built up from bedrock retaining the slope of a hill.

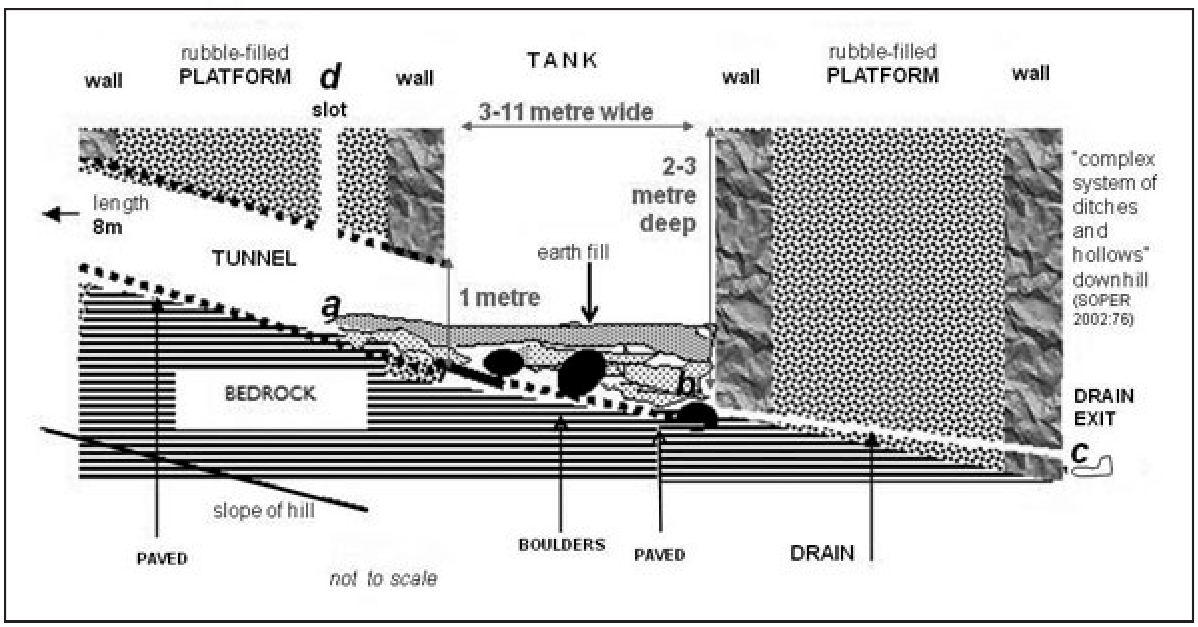
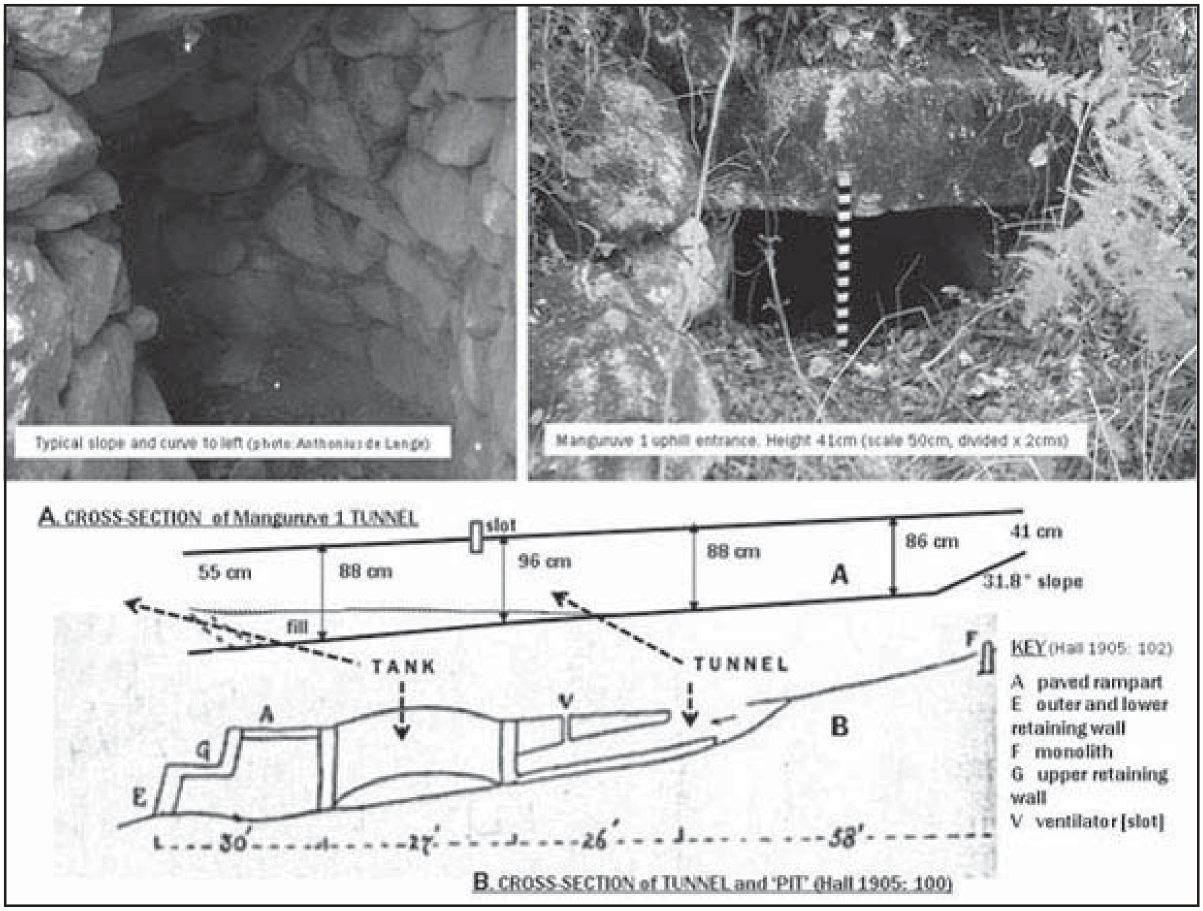


Figure 3: Key interpretative data at tunnel uphill entrances: gradient, curve, and restricted dimensions.



ing. Toward this understanding, it was considered essential to review statistics taken and conclusions made since records began at the turn of the 20th century. As can be seen from the outline presented below, field examination of tunnels declines steadily from that time, until a 'dwarf cattle' theory at variance with physical dimensions effectively eclipses it in the 1990s.

Review of Tunnel Statistics 1900–2000

Hall and Neal (1904: 24) sketch a "Section of Pits, Inyanga", showing a slope to the tunnel but not the 'pit'. There is no drain and this standard component of tank construction is also absent from Hall's professionally drawn cross-section with linear measurements (Hall 1905: 100). Hall positions its tank and tunnel on the incline and the benchmark of a steeper initial slope is correctly identified at the tunnel's uphill entrance (Figure 3). Hall notes the "curve invariably present in these passages", and estimates that "the fall in the passage floor averages 8 inches to 12 inches in 10 feet [approx 20-30 cm in 3 m]" (Hall 1905: 98, 99). Hall's picture captioned "Exterior of Entrance … leading into stone-lined pit" (Hall 1905: Plate XIV) and Gwatkin's "Close up of ground entrance" (Gwatkin 1932: 554) appear to be the only photographs of uphill entrances in print until Kritzinger's image of a "Restricted uphill entrance into tunnel" published by National Museums and Monuments of Zimbabwe in the next century (Kritzinger 2008: 7).

Randall-MacIver illustrates the design feature that "the tunnel makes a sharp turn of nearly half a right angle" (Randall-MacIver 1906: 9) in a "Ground Plan of Pit-Dwelling" at Ziwa National Monument and gives two examples of tunnel cross-sections (Randall-MacIver 1906: Plate IV). Like Hall and Neal's 1904 sketch, slopes are indicated but there are no drains and no dimensions. Regarding the latter

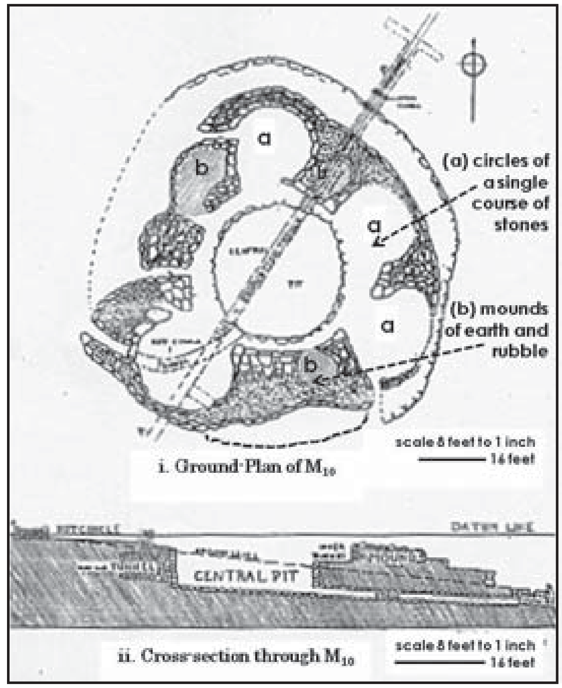
Randall-MacIver argues against an emerging theory that the ‘pits’ were built for “the housing of cattle; this suggestion may be confuted by the mere statement of the dimensions of the passage” (Randall-MacIver 1906: 11).

Three decades later at his excavations at Penhalonga, Mason describes the “stone-lined, curved tunnel which runs from the exterior on the hillward side and opens into the pit” (Mason 1933: 565). Two plan views feature this curve (Mason 1933: 564, 573), one accompanied by a cross-section with a hint of tunnel leading into sloping ‘pit’ and drain (Figure 4). Mason recognized the hydraulic nature of the complexes (Mason 1933: 565, 568) but “deliberately refrained from speculating on their function” (Soper 2002: 9). His contemporary Fripp mentions the “steeply sloping flagged floor” of an excavated ‘pit’ (Fripp and Wells 1938: 402) and shows the tunnel as curved in a sketch plan.

Stead (1949: 81) draws attention to the “difficult problem in training cattle to enter a tunnel the maximum dimensions of which are 20 inches [51 cm] wide and 41 inches [104 cm] high”, and stresses the bovine phobia for dark holes upon which the cattle-grid principle is based. A professor of animal science at Colorado State University, expresses this phobia as, “[cattle are] afraid to walk into pitch-black space … They don’t like any kind of experience that temporarily blinds them, and that includes looking into a bright light when they are standing in relative darkness” (Grandin 2005: 22). Such aversions would apply to the entry and exit of dark tunnels.

Over the past half century mention of tunnel uphill entrances is minimal. Maximum dimensions predominate, and Summers describes tunnels as “remarkably standardised in both design and measurements. All are built on a slight curve, so that it is impossible for light to penetrate from the outer to the inner end; all measure 2ft. wide [61 cm] and 4 ft. high [1.22m], the variation being a few inches either way. …The extremely small passage, however, provides an objection to [the] theory … that these tunnels would permit the passage of … small Mashona cattle” (Summers 1958: 236-237). Of 60 tank systems examined (Summers 1958: 18, 50), Summers publishes a cross-section “on line of passage” of a ‘pit enclosure’ at Ziwa, recording the diameter of the platform and its depth on the downhill side and informing that “[l]eading from the entrance is a passage sloping sharply down to the pit” (Summers 1958: 75). ‘Pit

Figure 4: Plan and cross-section of a Penhalonga tank system (after Mason 1933: 573).



enclosures’ at (relatively) lower altitude have a free-standing passage in place of a tunnel, but still retain slope, tank, and drain. Summers gives a second plan for ‘pit structure XXXV B’ in the Nyanga National Park adjacent to ‘pit structures’ C and D (Summers 1958: 64-67). Missing data of gradients and dimensions are published together with assay results from soil samples in Table 1 (NP/XXXV Bi, Bii, C, D).

Recent decades see the livestock stall-feeding theory perpetuated, with the drain explained as a device for flushing out slurry, “something like a sewage farm” (Sutton 1988: 23). In a letter to *The Herald* national newspaper 23 Sept 1993 Chipunza points out that “[t]he construction of the ‘pits’ with narrow tunnels and small entrances make them inappropriate for holding large stock such as cattle,” to which Soper replies 4 Oct 1993 that “small cattle … to have penetrated the tunnels” was “strictly a matter of conjecture”. Within a year Soper (1994) details a “possible role of small cattle and the use of their manure”.

Tunnel Information in the Present Decade

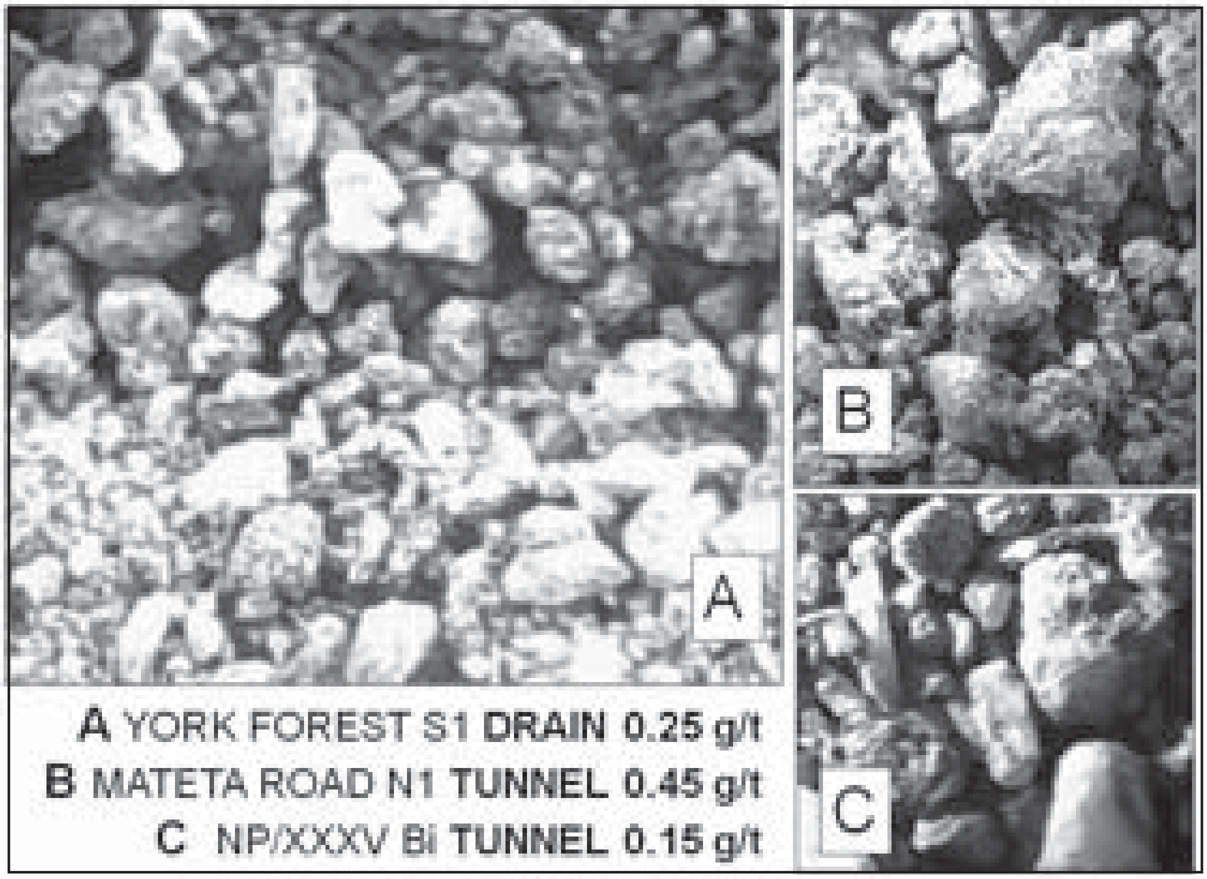
By the turn of the millennium the only tunnel construction data published by Soper are from two ‘ruined’ and two extant ‘pit-structures’. One of the

Table 1: Location of 35 hydraulic tank systems, direct evidence of residual gold in 30 samples, and 25 gradients indicating gravity feed at uphill tunnel entrances.

coordinates Easting	coordinates Northing	location local name	location map	sample taken from	lab[2]	assay result Au (g/t)	tunnel entrance slope[1] Height :Width cm	curve at uphill entrance
0460825	7981125	Mhokore Hill 1	[c]	TUNNEL	ZL	0.06	sloping	to left
0447560	7971500	Fox Rock 1	[c]	DRAIN exit	IMR	0.20	sloping	
0453677	7965038	Bhovhenzi 2	[c]	TUNNEL	ZL	0.07	28.8° H:W 99:63	to left
				DRAIN entr	ZL	0.05		
0453579	7965129	Bhovhenzi 3	[c]	DRAIN exit	DM	0.72	30.8° H:W 72:61	straight
0454550	7966490	Bhovhenzi 8	[c]	DRAIN entr	ZL	0.06		to left
0461276	7973232	Derry 3	[c]	TUNNEL	ZL	0.06	27.9° H:W 62:78	to left
				DRAIN entr	ZL	0.09		
				DRAIN exit	ZL	1.78		
0461328	7972981	Derry 4	[c]	TUNNEL	ZL	0.09	33°.8 H:W 72:78	to left
0451268	7998005	Ruchera 1	[a]	TUNNEL	ZL	0.08	29.8° H:W 84:56	to left
0481728	7994139	Uppr Tsanga 1	[b]	TUNNEL	ZL	0.04	sloping H:W 84:60	straight
0457800	7975800	Mateta Rd W1	[c]	TUNNEL	ZL	1.49	32.1° H:W 52:57	to left
		Mateta Rd W2	[c]			nys	23.5° H:W 52:54	to left
0457729	7975545	Mateta Rd W3	[c]			nys	33.6° H:W 53:80	to right
0457709	7975525	Mateta Rd W4	[c]			nys	29.8° H:W 95:50	to left
0461527	7971965	York Forest S1	[c]	DRAIN		0.25	29.3° H:W 84:56	to left
0461300	7974400	York Forest N1	[c]	DRAIN exit	LWJ	0.08	sloping	to left
0483512	8014785	Nyatsundzuru	[e]	TUNNEL	ZL	0.52	sloping	to left
0460868	7971791	Derry 1	[c]			nys	31.1° H:W 60:50	to left
0461052	7971997	Derry 2	[c]			nys	25.3° H:W 80:60	to left
0459495	7972671	Manguruve 1	[c]			nys	31.8° H:W 41:65	straight
0459470	7972705	Manguruve 2	[c]			nys	34.6° H:W 32:50	straight
0459557	7973039	Manguruve 3	[c]			nys	20.5° H:W 76:68	to left
0459571	7973082	Manguruve 4	[c]			nys	10.4° H:W 66:62	S-bend
0479500	7983450	NP1 (Soper No 6)	[b]	DRAIN entr	ZL	0.32	sloping	to left
0459900	7970360	Nyadiri Strm N	[c]	DRAIN exit	IMR	0.10	sloping	to left
0468764	7976220	Tizai 1	[c]	TUNNEL		0.45	v steep H:W 35:35	to left
0467031	7974361	Tizai 4	[c]	TUNNEL	ZL	0.05	29.8° H:W 68:72	to right
0465353	7975356	Chihwai 1	[c]	TUNNEL	ZL	0.96	34.3° H:W 43:53	to left
0460897	7994196	ZIWA/SN113 i	[a]	"PIT"	ZL	0.20	16.6°	
0460942	7994190	ZIWA/SN113 ii	[a]	DRAIN	ZL	0.25	20.8°	
0461000	7994222	ZIWA/SN113 iii	[a]	DRAIN	ZL	0.20	sloping	
0461124	7994380	ZIWA/SN113 iv	[a]	TUNNEL	ZL	0.26	22.6°	
0473856	7980890	NP/XXXV Bi	[d]	TUNNEL entr	ZL	0.15	21.6° H:W 63:50	to left
		NP/XXXV Bii		TUNNEL exit	ZL	0.12		
0473251	7980495	NP/XXXV C	[c]	TUNNEL entr	ZL	0.09	32.8° H:W 30:33	to left
0473312	7980545	NP/XXXV D	[c]	TUNNEL entr	ZL	0.08	30.3° H:W 64:60	to left
0457928	7976465	Mateta Rd N	[c]	TUNNEL entr	ZL	0.45	29.6° H:W 66:58	to left

[1] Gradients measured by Johnson 40-6080 inclinometer. This essential interpretative data is not recorded in previous recsearch.
[2] ZL: Zimlabs; LWJ: Biometallurgy (L. John); DM: Dept of Metallurgy; IMR: Institute of Mining Research.
nys = not yet sampled
All GPS coordinates recorded using the projection system ARC1950 UTM Zone 36K. 1:50 000 MAPS:
[a] = Nyanga 1832 B1; [b] = Troutbeck 1832 B2; [c] = Juliasdale 1832 B3; [d] = Inyangani 1832 B4;
[e] = Regina Coeli Mission 1732 D4

Figure 5: Three soil samples and their residual gold values. At 10X magnification the samples can be seen to be quartz ground to sufficient fineness to liberate gold. (Micro-photography by Pazvakawamba and Chasara)



former has a passage "constricted to a width of only 25 cm in the lower 35 cm" (Soper 2002: 165); in the second "[t]he walls of the passage are up to 1.15 m high; the width at the base varies between 45 and 60 cm and the top is up to 78 cm wide" (Soper 2002: 172). Of the two extant 'pit structures', one has a curved tunnel shown in plan with the information that the "pit end of the tunnel is 136 cm high, 44 cm wide at the bottom and 60 cm wide at the top" (Soper 2002: 181). The second has a tunnel "just over 8 m long", its distinct curve shown in plan (Soper 2002: 175, 176). The only cross-section published by Soper refers to this 'pit', its tank and drain inclined but tunnel entrance dimensions absent, with only a third of the "pit end of the tunnel" illustrated. It is at this end that maximum dimensions are most standardized, yet Soper maintains that "[e]ntrances at either end have remarkably consistent measurements, 1.10 m high and 50 cm wide with a variation of about 10 cm", proportions that could accommodate "dwarf cattle only a metre or so in height" (Soper 2002: 90, 91).

Recovery of bones from an atypical midden on Mt. Muozi of cattle "unlikely to have been more than 0.9-1m at shoulder height" (Plug in Soper 2002: 160) leads Soper to generalize that "[t]he pit accommodates the family cattle which were of dwarf size to fit through the tunnel" (Soper 2007: 97). Two estimates for horn spans of 49 and 52 cm from Muozi introduce the solution of polling to overcome "the tight fit for the entrance passages and tunnels" (Soper 2002: 124). Additional to the problems of horns and extra height at neck and hook, the need for cattle to raise their heads when descending a slope has not been considered in the academic exercise of herding cattle through tunnels. Regardless of this handicap, Soper calculates family wealth in the number of beasts accommodated at differing elevations by measuring the diameters of 260 'pit structures' between 1300-2000 m asl (Soper 2002: 93). In a "detailed study" at Ziwa (Soper 2002: 98), Chirawu measured 145 diameters of 'pit enclosures', devoting time to "distinguishing between blocked and collapsed structures, especially the linteled tunnel entrance leading into pits" (Chirawu 1999: 34). Data on tunnel uphill entrance gradients and dimensions are absent.

In a case study of terraces on a hill near Ziwa, Soper shows four 'pit enclosures' on his site plan SN113 (Soper 2002: 36). Passing the hill en route to Ruchera, my co-researcher Tendai Gungutsva drew my attention to a worked quartz outcrop which we subsequently found marked on Stocklmayer's geological map (Stocklmayer 1978). A grab sample assayed at 0.11 grams per tonne (g/t), low but enough for us to make another visit, especially as GPS coordinates identified the site as Soper's SN113. Samples taken inside the 'pit enclosures' found on the hill all assayed with values of gold (Table 1: Ziwa/SN113 i-iv). The experience of sampling a site previously examined by Soper, initiated the tracing and sampling of Summers' "XXXV" site in Nyanga National Park, four samples from three tunnels (Table 1: NP/XXXV Bi & ii, C, D) bringing to 30 the number of tunnels and drains sampled in a total of 98 rock and soil samples taken across 65 km to date.

Samples taken from tunnels and drains can be seen with the naked eye to be either quartz crushed to fines (Figure 5) or leached soil often at variance in color to the surrounding earth. These deposits – anomalous in an agricultural hypothesis – are direct evidence of beneficiation, identifying the hydraulic tank systems as gold recovery plants, and indicating specialized knowledge of concentrates and tailings control in the past. After initial scepticism, John (in Kritzinger 2008: 15-16) concluded from sample analysis and lab reports that the results are "too high to be background gold levels they are definitely ore and residue type results … Thus it does seem they were doing something along the lines of processing gold" (John, personal communication). "Still in its infancy, the research has proven facts and regional knowledge as foundations for longterm scientific analysis by mining geologists, mining archaeologists, metallurgists and soil and water science experts" (Strassburger 2010: 8).

Methodology

GPS coordinates recorded with a handheld Garmin device are plotted on 1:50,000 maps (identified in Table 1) and, where acquired, on relevant 1:5,000 maps. Features were photographed with a rod or human scale. Width of uphill tunnel entrances measured between side walls and height from paving to roof slabs. Wherever access permits allowed, samples for assay are taken at the deepest deposit above the paving inside tunnels. This is commonly a depth of 20-30 cm frequently found at a under slot d, Figure 2, below a shallow layer of organic matter. Gradients are recorded by a Johnson electronic level inclinometer 40-6080. As flumes integral to tailings removal, drains are sampled at points b and c, Figure 2. Infill of only one tank has been assayed to date, its 1m depth sectioned horizontally into five samples. Assay results (from top to bottom) are 0.14, 0.16, 0.21, 0.16, 0.14 g/t. The important exercise of tank sampling awaits the acquisition of a soil auger to ensure least disturbance of cultural evidence. Soil samples, approx 1-2 kg, are dry-sieved through 2 mm mesh. Method of testing: fire assay, lead oxide fusion and AAS finish. The main laboratory used is ISO/IEC 17025:2005 SANAS-accredited testing laboratory Zimlabs T0339, Harare. The number of assays was restricted by a self-funded budget.

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