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USING AERIAL SURVEY TO RECORD NEW SITES IN THE KEIMOES KITE LANDSCAPE OF SOUTH AFRICA

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ABSTRACT
The recent identification of kite sites on the Keimoes landscape, in the Northern Cape Province of South Africa, has shed light on how past populations built and utilised low stone structures to funnel and capture game. By strategically identifying and using certain aspects of the surrounding landscape, in conjunction with key design aspects, local groups maximised hunting proficiency. With this contribution, we revisit the Keimoes landscape to continue our search for more funnel sites and to establish whether there is consistency in some of their key design aspects, as identified in earlier publications. We introduce three more kite sites and provide their morphological and landscape details. For the first time, we also demonstrate that some of the kites were purposefully located near rocky outcrops from which construction material could be collected.

Keywords: Keimoes, desert kites, hunter-gatherers, Stone Age hunting, strategic landscape use

1. Introduction

Over the last few years, the first kite-like structures from the southern hemisphere have been reported on the northern edge of the Nama Karoo Biome near Keimoes, in the Northern Cape Province of South Africa (Fig. 1a & c; van der Walt & Lombard 2018; Lombard et al. 2020, 2021). These structures are described as low, stone-walled V-shaped funnels, at times covering several hundred square metres with long converging guiding arms that sometimes end in a round enclosure or 'head' (Fig. 1b). These reports provide detail on the characteristics of funnel construction, function, chronology, and site placement relative to the local landscape. They also extended the geographical range for kite-like structures beyond those found in the arid regions of southwest Asia (e.g., Nadel et al. 2010; Bar-Oz et al. 2011; Crassard et al. 2015; Fradley et al. 2022; Barge et al. 2023), or the reindeer hunting and herding funnels of Scandinavia (Ingold 1986; Sommerseth 2011; Jordhøy & Hole 2015; Solli 2018). In terms of their functionality, kites or kite-like structures are most frequently considered as hunting traps (Holzer et al. 2010), where ungulates – such as springbok in the case of the South African funnels (see Lombard & Badenhorst 2019) – would have been guided between the funnel arms. It is, however, also possible that they were used for some forms of animal husbandry (e.g., Ingold 1986; Sommerseth 2011; Crassard et al. 2015). Identifying who made them, and when, from a southern African perspective is challenging because their construction is more informal when compared with Iron Age, or farmer, stone walling further east in the higher rainfall zones (i.e., organised, stone-packed and coursed, e.g., Huffman 2007), and the general lack of associated surface archaeology, faunal and datable materials make it difficult to establish group identities and chronologies (Lombard et al. 2020, 2021). The Keimoes kites represent fixed features on the landscape in a region that has been occupied by both hunter-gatherer and herder groups over the last 2000 years (Orton & Parsons 2018). It is most likely that they were used and managed by multiple groups over time, possibly handed down through generations, and their construction appears to be consistent with Holocene Later Stone Age (LSA) structures that post-date the last 2000 years (see discussion in Lombard et al. 2020 and 2021).

The Keimoes kite studies are the result of a project that aims to expand our understanding of Stone Age communities on the grass/shrublands of South Africa. Through this endeavour, five kite sites (Fig. 1c) have been reported, with the first two (Keimoes 1 & 2) having been identified by environmental specialists during aerial survey work. These kites were subsequently investigated by van der Walt and Lombard (2018), through both ground- and aerial-based surveys, confirming that southern Africa, and specifically the desert-like Nama Karoo north of the Gariep (Orange River), preserved kites similar to those reported in the northern hemisphere. Following their findings, Google Earth surveys were executed across the broader region to establish whether more structures could be located, leading to the identification of Keimoes 3 (the largest of the Keimoes kite sites). Given the general difficulty in documenting these sites through traditional ground-based survey and recording methods, Lombard et al. (2020) commissioned aerial LiDAR scanning to retrieve detailed landscape data from which kite placement, microtopography, and function could be investigated. Once again, and during expanded Google Earth surveys of the broader region, Keimoes sites 4 and 5 were located (Lombard et al. 2021).

As a result of these recent findings, new questions arose about the Keimoes landscape. Are there more sites in the broader region? Could more sites be identified if a more systematic aerial surveying strategy was implemented? It is clear from previous studies that when more aerial surveying was conducted, more sites were being located, making it reasonable to assume that zooming out from the landscape and covering more of the surrounding region would yield positive results. Doing so led to the identification of three additional kite sites in the extended region. It was not immediately clear, however, whether these new sites would be similar to those already reported, and if they would be associated with specific landscape features (e.g., nearby pans, as has been reported for sites 1-5; Lombard et al. 2020, 2021). With these questions in mind, the purpose of this paper is to present the results of our systematic aerial survey of the Keimoes landscape and to provide the morphological and landscape details of the newly located Keimoes sites 6-8. We continue to build upon research that considers the strategic settings of the sites by assessing their placement on the landscape in terms of elevation, landscape and visibility characteristics.

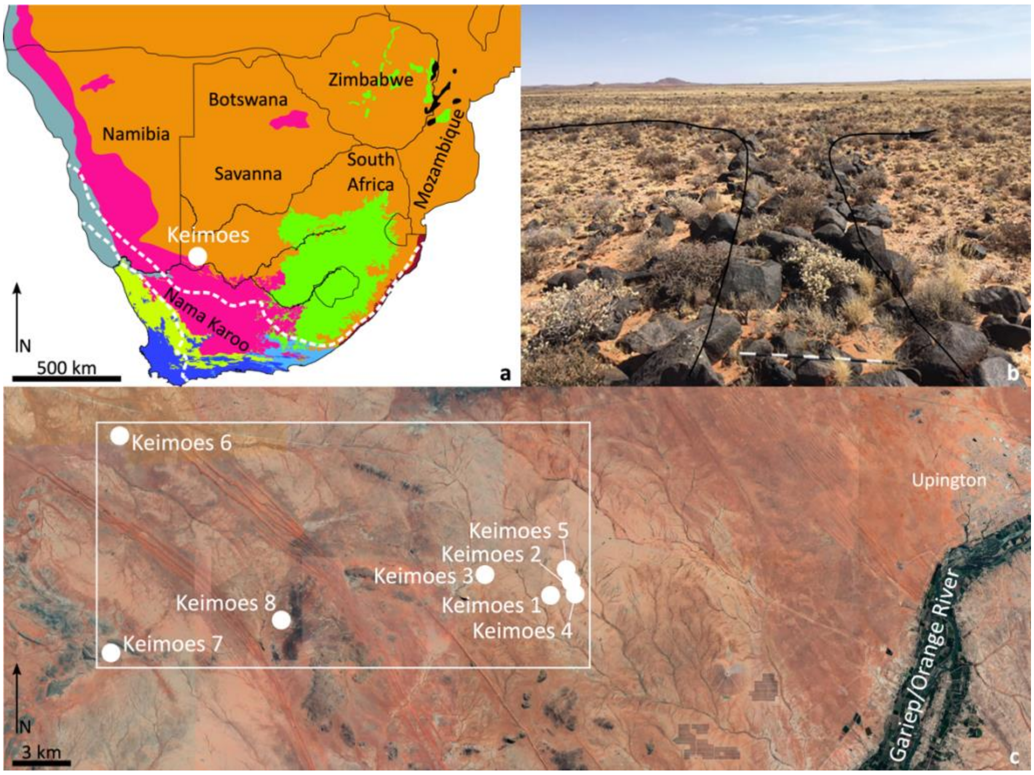

Figure 1. Map of southern Africa showing relevant biomes and rainfall regimes (between dashed lines=year-round rain, below bottom dashed line=winter rain, above upper dashed line=summer rain), and the location of Keimoes (a). View of the Keimoes landscape and kite stone walling, with kite funnel arms indicated in black (b; modified from van der Walt & Lombard 2018, photograph by Jaco van der Walt©). Location of the Keimoes kite sites west of the Gariep (Orange River), with the newly reported sites (6-8) representing the most western in the region (c).

2. Methods

Aerial (orthographic) survey

Since random Google Earth surveys had already yielded positive results, we conceptualised a systematic survey strategy covering the greater Keimoes region. Our survey area included the known Keimoes sites, as well as other LSA sites in the broader region that dated from the last millennium BC into more recent periods, the premise being that unrecorded stone structures may occur within the vicinity of known sites (see Fig. 2a for sites; Humphreys & Thackeray 1983; Parkington 1984). These sites contain stone tool assemblages that fit either the Doornfontein or Swartkop Industries, and they also preserve ceramics and faunal collections (Parsons 2007; Badenhorst et al. 2015). The farm Dröegrond/Graafwater was also included in the survey area given reports of a kite on the property, albeit in an unknown location (Beaumont et al. 1995). To include all these localities a total area of approximately 60 x 300 km (~16324 km^2) was identified, subdivided into 10 x 10-minute grid squares, and labelled alphabetically from west to east and numerically from north to south (Fig. 2a).

Aerial Google Earth surveys commenced following a standardised approach. The viewing angle was set perpendicular to the ground (vs. oblique) and the survey area was always orientated north up. Surveying (eye) altitude varied depending on landscape surface visibility but was predominantly in the range of ~1 (survey area of ~0.8 km^2) to <2 kms (survey area of ~3 km^2). These thresholds were identified by surveying the known Keimoes sites and establishing the maximum altitude at which features could be confidently identified; historic aerial imagery was overlaid, when needed, for improved site visibility. Surveys began in the northwest corner of each square and proceeded in transects running north-south, completed while moving in a west to east direction with approximately 30% overlap between transects. To ensure transects were straight, cursor movement keys were used to pan versus panning with a mouse or using the built in Google Earth navigator. Tracking pins were dropped at the end of each completed transect to ensure full survey coverage and adequate visual overlap between the transects. All features were recorded using numerically labelled pins in the order that they were used and according to the grid square code (e.g., a1.1, b1.2 etc.). By applying this approach, Keimoes 6 was identified by one of us (SB) in grid square k1, while the locations of Keimoes sites 7 and 8 were provided by Mr Walter Smit (Western Cape Government, Department of the Premier), also identified through desktop aerial survey.

Kite measurement protocols

To investigate the morphometric properties of the Keimoes structures, a series of morphometric measurements were recorded in Google Earth Pro using the path, polygon and measuring tools. Our measuring protocols follow those described in Lombard et al. (2021; Fig. 2b), for which the details are not repeated here, and we also apply descriptive statistics to assess the extent of morphometric funnel variability and standardisation.

Landscape analyses and functional interpretation

To investigate site placement relative to the topography of the local landscape (as explored in Lombard et al. 2020, 2021), elevation profiles were created in Google Earth Pro. The profiles comprise a single transect running between two points on the landscape, starting 500 m away from each funnel and moving towards the middle of the guiding arms, ending at the funnel head. Each profile output contains maximum and minimum elevations above sea level, in addition to positive/negative values for: elevation gain/loss (in metres), and maximum and average slope gradients (as percentages). The profiles themselves also provide a clear view of the landscape leading up to the funnels.

To assess the visibility of funnels on the landscape, shuttle radar topography mission (SRTM) DEM data (USGS EROS Archive n.d.) were analysed in ArcGIS 10.5 while using the line-of-sight function. Following the line-of-sight approach described in Lombard et al. (2020: fig. 6), visibility paths were created across the landscape when approaching each funnel from ~150 m away, with a viewpoint (eye-level) elevation set to 1 m (the average eye-height of a springbok). This provides a clear illustration of the visible/non-visible parts of the landscape around each funnel.

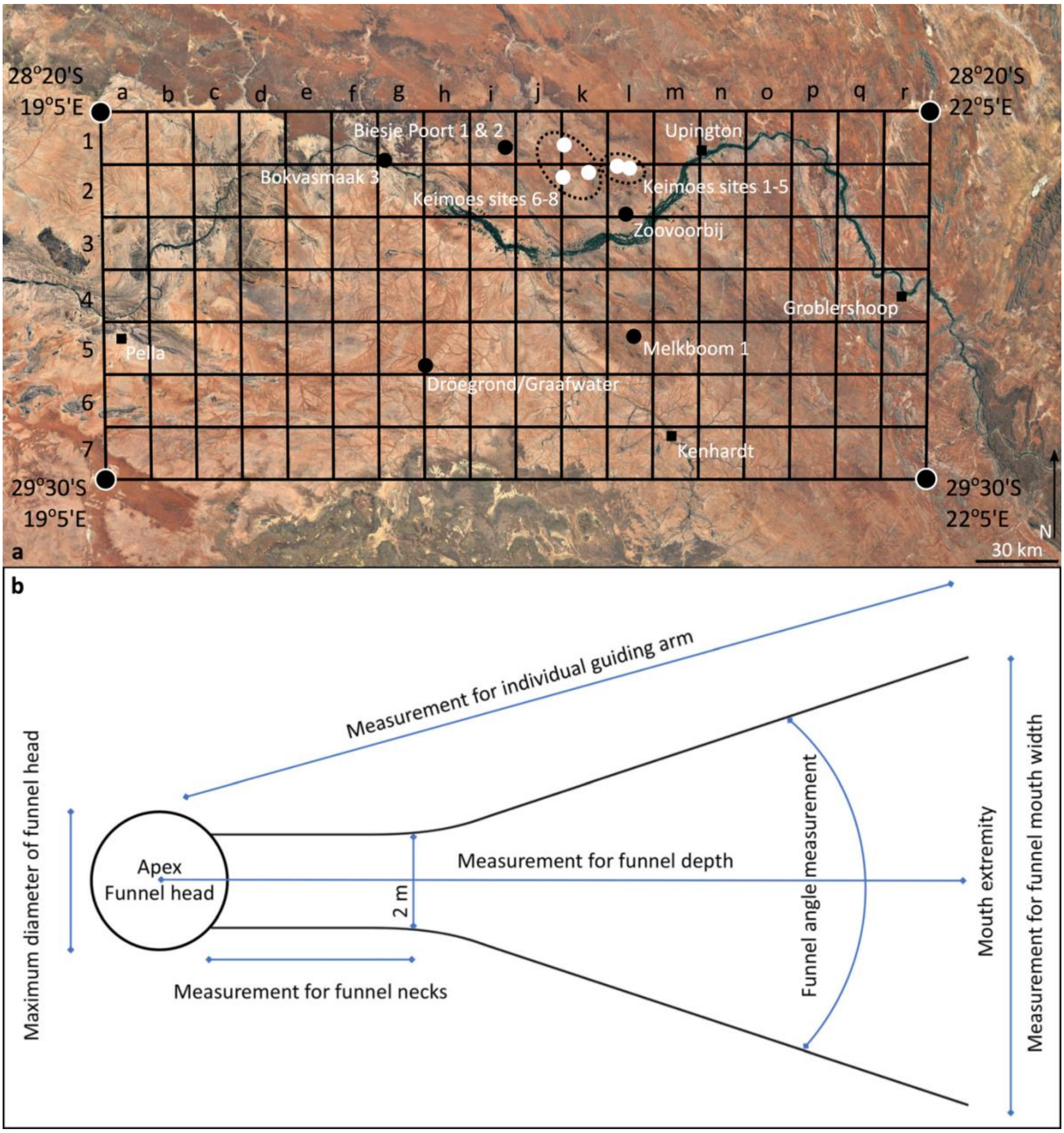

Figure 2. The Google Earth survey grid showing known site locations and the grid coding system (a). The Keimoes sites are shown by white dots whereas other known sites are shown by black dots; local towns are indicated by the black squares. Morphometric measurements (b) for the Keimoes kite funnels (from Lombard et al. 2021: fig. 2).

3. Results

Site descriptions and morphometric funnel characteristics

Although our study was completed remotely without ground truthing, it is possible for us to speculate on the construction of the kites based on earlier field observations and published descriptions for the five sites further east (van der Walt & Lombard 2018; Lombard et al. 2020, 2021). In general, the Keimoes funnels were constructed by sourcing local dolerite boulders and stacking them into funnel-shaped features, while also incorporating local outcrops where possible (for e.g., using *in situ* dolerite boulders in the walls of guiding arms, as described by van der Walt & Lombard 2018). The construction characteristics of the funnel walls differ by location, where the guiding arm extremities tend to reflect less-organised, single-tired boulder packing with lower wall heights (<0.5 m), in contrast to the funnel necks and heads that reflect more deliberate construction (i.e., vertical stacking and higher walls, much of which has subsequently collapsed). Some of the funnels have circular enclosures at their apices (van der Walt & Lombard 2018), while others may have screens or low walls protruding from their guiding arms (see Lombard et al. 2020).

Keimoes 6 is now the most northern Keimoes kite site and it occurs ~20 km northwest from Keimoes 3, while the Gariep is ~34 km to the southeast. The site occurs on sloping ground between two large drainage lines running southeast to northwest, away from the Gariep, and it comprises three separate funnels with a total of 453.1 running metres of walling covering an area of 3043 m^2 (Fig. 3; Table 1). In terms of arrangement, the funnel heads of kites 6b and 6c are within 40 m of each other, whereas 6a is roughly 100 m away to the northwest, collectively reflecting a somewhat clustered configuration. The funnels are all orientated differently: the funnel mouths for both 6a and 6c open towards the east, whereas 6b opens towards the southwest. Given these orientations, 6a and 6c open towards the drainage line to the north, roughly 700 m away, while 6b opens towards the larger southern drainage line, approximately 1.4 km away. Morphologically, the designs of the Keimoes 6 funnels are all similar, although there are some differences; all the funnels contain long guiding arms and narrower neck areas that end in characteristic, circular enclosures, which presumably have collapsed but have an average diameter of 2.5-3 m. Short guiding arm lengths range from 62.9 to 67.6 m, followed by long arm lengths ranging between 83.9 and 88.5 m, confirming that these Keimoes 6 funnels are the largest of the three newly reported sites. Although the difference in these ranges is small and reflects some consistency in size, the funnel surface area for 6b (1412 m^2) is considerably larger than that of 6a (894 m^2) and 6c (737 m^2). Funnel depths range from 64.8-70.7 m, neck lengths from 13.3-24.1 m, and mouth widths from 40-68 m (Table 1). All funnels have acute opening angles ranging from 20.7-53°.

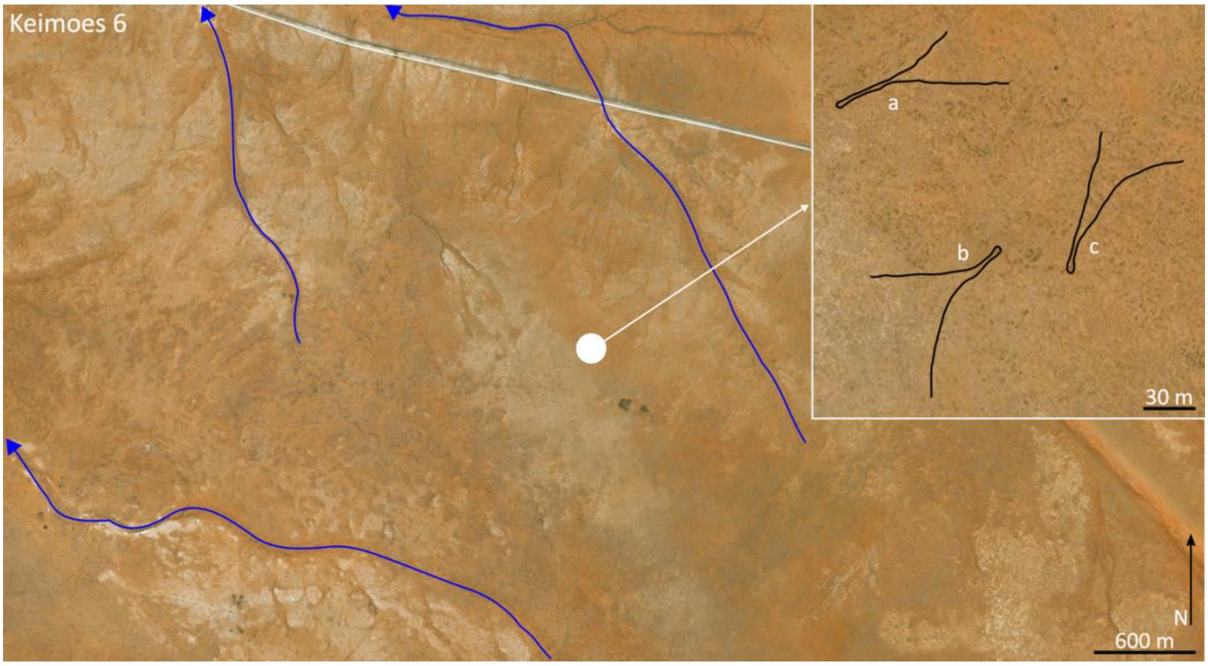

Figure 3. Aerial imagery of Keimoes 6 (white circle) and the surrounding landscape. Drainage lines are indicated in blue with drainage directions indicated by the arrows. The inset image shows the funnels outlined in black, where the funnel letters correspond with Table 1.

Keimoes 7 is equidistant from Keimoes 3 and it is now the most southern and western Keimoes funnel site, occurring within an area characterised by more irregular topography due to local bedrock exposures north, west, and east. The Gariep is 24 km to the southeast and the site occurs on sloping land adjacent to a small drainage line running north to south (Fig. 4). It comprises two funnels joined in a chain-like configuration, linked by their two short guiding arms that are 25.2 and 26.2 m, while collectively totalling 141.2 m of running walling and covering 365 m^2 (Table 1). The funnel mouths are both orientated the same way, opening to the south, thus facing the open ground to the west of the small drainage line and east of the crest of a small hill towards the southwest. Roughly 250 m to the northeast, a second drainage line occurs running parallel to the first, bisecting the high-lying outcrops to the north and extending uphill to a local drainage divide, which animals may have traversed while searching for alternative grazing/water sources. Morphologically, the funnels contain clear circular enclosures at their apices, with approximate diameters of 3.8 m (7b) and 4.9 m (7a). Long guiding arm lengths are 55.8 m and 34 m, followed by 26 m and 23.7 m for funnel depth, 8.4 m and 6.5 m for neck length, and 42.5 m and 20.4 m for mouth widths, for funnels 7a and 7b, respectively. Overall surface areas are largely comparable at 179 m^2 and 186 m^2, while opening angles are 40.6° and 63° (Table 1).

Table 1. Morphometric data for the Keimoes kite sites. For corresponding funnel letters, see Figs 3-5. Standardisation metrics for Keimoes kite sites 1-5 are provided below, for comparative purposes (SD=standard deviation, CV=coefficient of variation, *=incomplete, S.=short, L.=long, C.=combined). Note that incomplete funnels are excluded from standardisation metrics, and head diameters are approximate.

Site/ funnel	S. arm length	L. arm length	C. arm length	Funnel depth	Neck length	~Head diameter	Mouth width	Surface area (m^2)	Angle	Opening direction/ degrees
Keimoes 6 (3 funnels, with a total of 453.1 running metres of walling covering 3043 m^2)										
6a	62.9	83.9	146.8	66.4	24.1	2.5	40.0	894.0	20.7	ENE/67
6b	67.6	88.5	156.1	70.7	14.9	3.0	68.0	1412.0	53.0	SW/235
6c	63.2	87.0	150.2	64.8	13.3	2.5	42.4	737.0	32.0	NNE/24
Keimoes 7 (2 funnels, with a total of 141.2 running metres of walling covering 365 m^2)										
7a	26.2	55.8	82.0	26.0	8.4	4.9	42.5	179.0	63.0	SE/141
7b	25.2	34.0	59.2	23.7	6.5	3.8	20.4	186.0	40.6	SSW/207
Keimoes 8 (3 funnels, with a total of 155.8 running metres of walling covering 532 m^2)										
8a	12.2	24.5	36.7	16.3	4.8	3.2	23.2	188.0	57.9	WNW/291
8b	27.5	36.5	64.0	29.4	7.3	1.9	19.5	206.0	30.7	SE/129
8c*	4.7	50.4	55.1	10.4	13.5	2.9	46.2	138.0	17.6	SSW/207
Standardisation metrics for all complete funnels										
SD	22.9	27.7	50.2	23.6	6.7	1.0	17.3	485.7	15.8	-
Mean	40.7	58.6	99.3	42.5	11.3	3.1	36.6	543.1	42.6	-
CV	56.4	47.3	50.6	55.6	59.2	31.7	47.4	89.4	37.1	-
Standardisation metrics for Keimoes kite sites 1-5, as per Lombard et al. 2021										
SD	20.5	24.9	44.8	19.2	6.6	1.2	20.2	656.2	14.1	-
Mean	53.5	68.2	122.5	52.1	17.1	4.2	38.8	781.0	35.0	-
CV	38.2	36.5	36.5	36.8	38.5	28.8	52.1	84.0	40.4	-

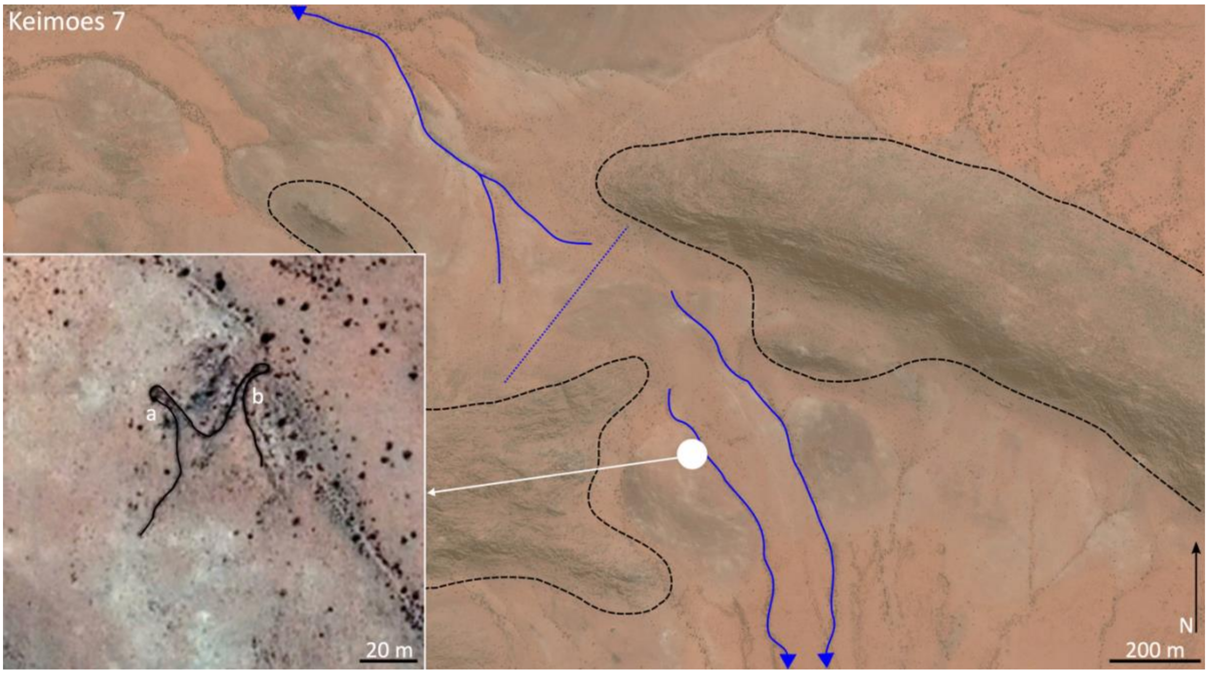

Figure 4. Aerial imagery of Keimoes 7 (white circle) showing nearby rocky outcrops (dashed lines) and main drainage lines (blue lines with arrows). The drainage divide is shown by the stippled blue line. Funnel outlines are provided in the inset image, in black. Note placement of the funnels adjacent to a small drainage line (east). Site and funnel letters correspond with Table 1.

Similar to Keimoes 7, Keimoes 8 also occurs in an area characterised by nearby rocky outcrops and drainage lines (Fig. 5). In fact, the site itself occurs on a small stone outcrop, while additional, larger outcropping hills occur ~300 m away to the northwest and ~650 m to the northeast. A drainage line running east to west occurs <50 m to the south, and this drainage line, once again, extends uphill to a local drainage divide. The Gariep, at its closest, is ~22 km away to the southeast, while the largest Keimoes kite site (3) is ~10 km to the northeast. The site comprises three funnels for a total of 155.8 running metres of walling covering 532 m^2: one small funnel isolated to the north (8a), covering 188 m^2, followed by two closely associated funnels 8b and 8c ~130 m to the south, covering 206 m^2 and 138 m^2, respectively, with the latter retaining one complete guiding arm, a funnel head, and then a second partially complete guiding arm (Fig. 5; Table 1). Similar funnels, incomplete and either poorly preserved or damaged versus being different features altogether, have been reported elsewhere on the Keimoes landscape (Lombard et al. 2020, 2021; see funnels 3m, 3n, 5a-c). All the Keimoes 8 funnel mouths open toward different directions. Funnel 8a opens west towards ground between it and the nearby hill, while 8b opens southeast towards the nearby drainage line; 8c, while difficult to establish, appears to face southwest where the drainage line spreads out into a network of smaller channels ~70 m away. Morphologically, the Keimoes 8 funnels are the smallest with long arm lengths ranging from 24.5-50.4 m, and 4.7-12.2 m for short arm lengths. At the funnel apices, circular heads are visible with diameters ranging from 1.9-3.2 m, coupled with narrowed neck lengths from 4.8-13.5 m (Table 1). Funnel depths are short, from 10.4-29.3 m, while mouth width ranges from 19.5-46.2 m. Funnel opening angles range from 17.6-57.9° (Table 1).

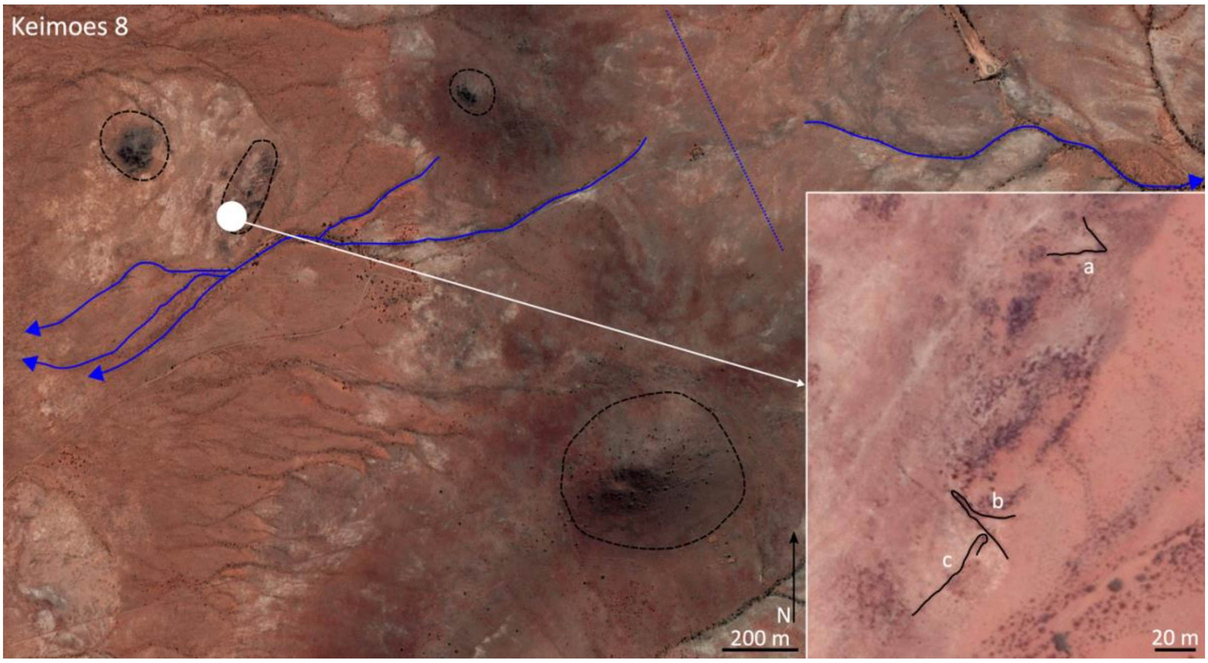

Figure 5. Aerial imagery of Keimoes 8 (white circle), comprising two complete and one incomplete funnel (outlined in black). The site occurs on a rocky outcrop (dashed lines) and close to a main drainage line (blue lines with arrows). The drainage divide is shown by the stippled blue line. Site and funnel letters correspond with Table 1.

The calculation of standardisation metrics illustrates some trends that are consistent with those reported earlier for sites 1-5 (in Lombard et al. 2021). Accordingly, the least variable feature of the newly reported funnels is the diameter of the funnel heads (CV=31.7), which was also the case for sites 1-5 (CV=28.8). The inter-site trend for less variability continues for angle, and long and combined arm length measurements (Table 1). For all Keimoes kite sites, the most variable feature is funnel surface area (CV=89.4; 84 in Lombard et al. 2021). Overall, though, there is little evidence of standardisation in the construction of the kite funnels, as reflected in the relatively high CV values (equal to or greater than 31.7). Based on the new morphometric values provided here, we are now also able to update the minimum construction criteria that we believe likely influenced effective funnel function, as presented in Lombard et al. (2021), namely: a funnel depth of at least 16.3 m, a mouth width of at least 13 m, a surface area of at least 78.5m^2, and an opening angle of no less than 18.3°. Funnel necks need to be at least 4.8 m long while head diameters need to be 1.9 m or larger.

Site placement, visibility, and landscape topography

By assessing the character of the landscape at each site, Figure 6 confirms that most of the funnel heads are constructed in areas of higher elevation relative to where the openings of the guiding arms were placed. This is clear for funnels 6a, 6c, 7a and 8c, where the landscape rises steadily when approaching, and where the funnel heads occur at the highest elevation along the 500 m transect; 8b, on the other hand, is the only funnel that shows a consistent drop in elevation across the 500 m transect, but within 75 m elevation values increase again and the profile mimics that of the other funnel transects. These broad patterns are confirmed by the positive elevation gain values where the former funnels show elevation gains ranging from 7.1-11.6 m, whereas funnel 8b shows an elevation loss of 9.6 m followed by a small gain (2.9 m) nearer to the funnel head. Although the placement of funnel 8b appears to be an anomaly when comparing its landscape profile to that of the other sites, its proximity to suitable stone for walling construction (the nearby outcrop), coupled with its proximity to a nearby drainage line, may have served as the primary factors influencing site placement.

Funnels 6b, 7b and 8a also indicate a consistent rise in the landscape when approaching, however the funnel heads have been constructed in areas of lower elevation relative to the land immediately before them. Variable landscape topography is evident in the profiles themselves, primarily in the 0-75 m range where topographic undulations are visible, but it is also confirmed by their larger negative topographic values for elevation loss, maximum and average slope percentages (Fig. 6). The funnel head placement of 8a is likely linked to the crest of the nearby rocky outcrop, upon which the site has been constructed. The funnel head of 7b is concealed in the base of the small drainage channel east of the site, whereas the funnel head for 6b is only marginally lower than the elevation of the approaching landscape (by 0.5 m), so in general the site occurs on flat land with minimal elevation change across the 500 m transect (~2 m; Fig. 6).

Our line-of-sight analysis confirms that funnels 6b, 7a, 7b, and 8a are not visible when viewed from 150 m away (Figs 7-9). For funnel 6b, this includes the funnel neck, head, and part of the guiding arms, but it excludes the visible, distal portions of the arms as they open to the southwest (Fig. 7). Based on its elevation profile (Fig. 6), parts of funnel 6b are hidden due to a small topographic rise within 75 m of the funnel head, thereby obscuring the view of the funnel. Funnels 7a and 7b are not visible when approaching from the south (Fig. 8). But, instead of visibility being obscured by a topographic high, it is in fact due to a depression that occurs within 75 m of the funnel heads. For funnel 7b, this comprises the drainage channel within which the head has been placed. Finally, funnel 8a is not visible when viewed from the west, and visibility here is obscured by a small, higher-lying rocky outcrop within ~75 m of the funnel head (Figs 6 & 9).

For the remaining complete funnels, all portions of 6a, 6c and 8b are visible, corroborating the elevation profiles shown in Figure 6. Namely, that the landscape leading up to the funnel sites becomes steeper, and that all portions of the funnels occur on the gently rising upslope parts of the landscape that are visible from some distance. This is particularly the case for funnels 6a and 6c, whereas for 8b the landscape begins to drop in elevation from <150 m, so the preceding higher ground to the southeast provides a higher vantage point from which to view the landscape and funnel. That being said, the funnel does open toward a widened drainage channel, which in the past may have served as a strategic location from which to herd animals while they navigated sandy or potentially waterlogged soils. Given that herd movements may have been more restricted under these conditions, even if just for brief periods after intense seasonal thunderstorms, then funnel 'invisibility' may have been less important.

Overall, we can confirm the following trends for the newly reported Keimoes funnels:

1. Funnels are predominantly placed on gently rising slopes to take strategic advantage of high points on the landscape. These high points provide vantage points from which to spot approaching game.

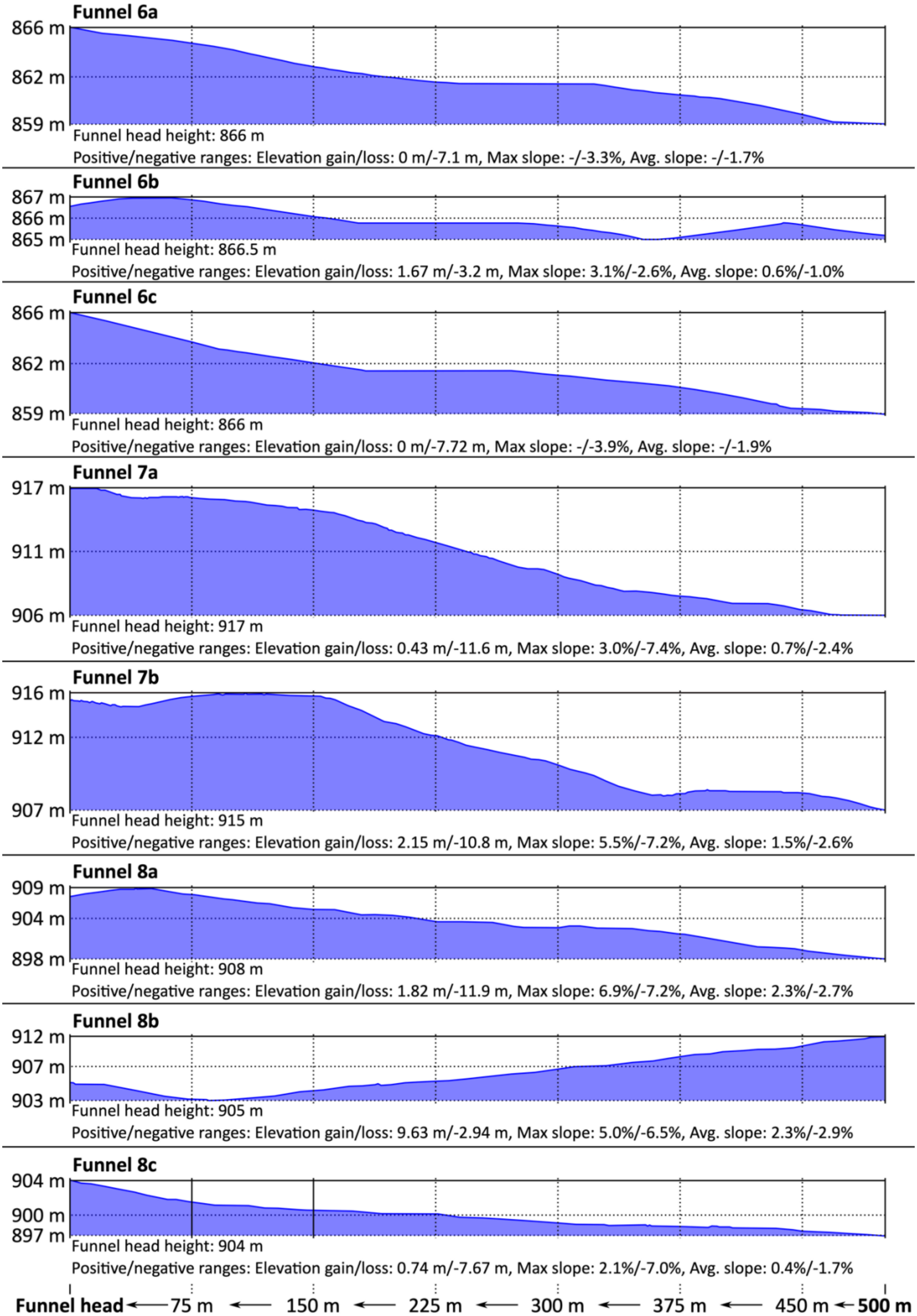

Figure 6. Funnel elevation profiles, exported and modified from Google Earth Pro, with associated topographic data. The blue profiles indicate the landscape surface when approaching funnel heads from 500 m away, with all (save for 8b) indicating the heads are uphill of the guiding arms.

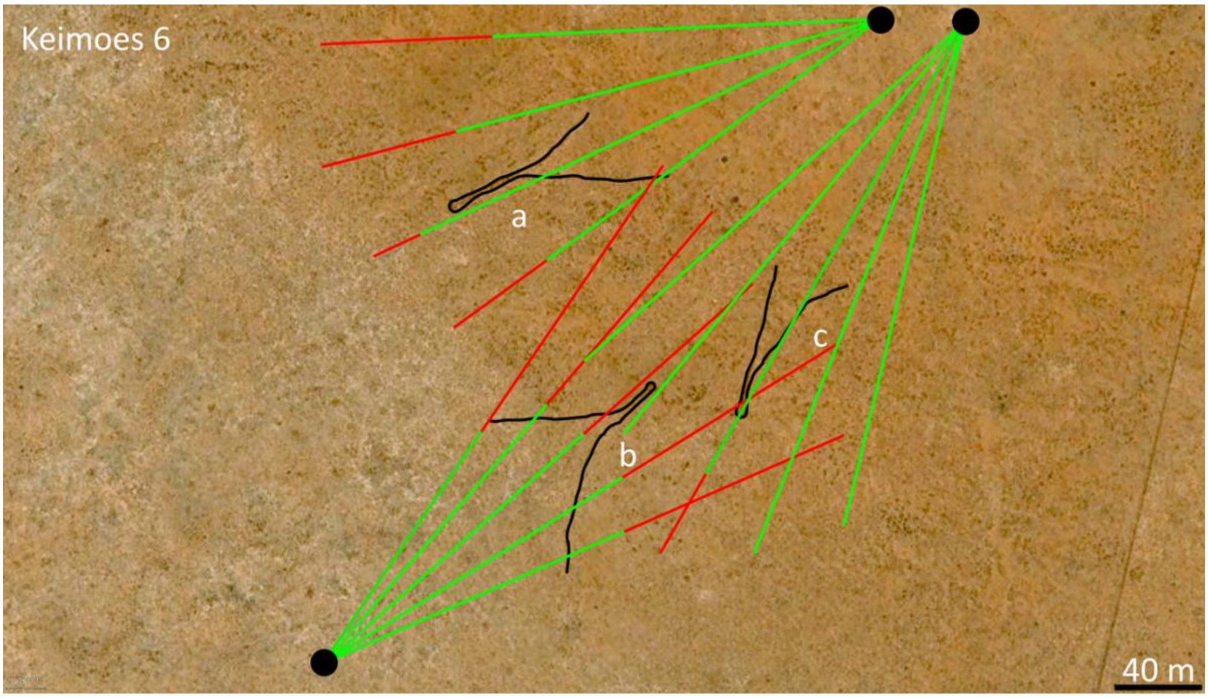

Figure 7. Line-of-sight map for the Keimoes 6 funnels when approaching from 150 m, (black circle) at an eye-height of 1 m (green=visible).

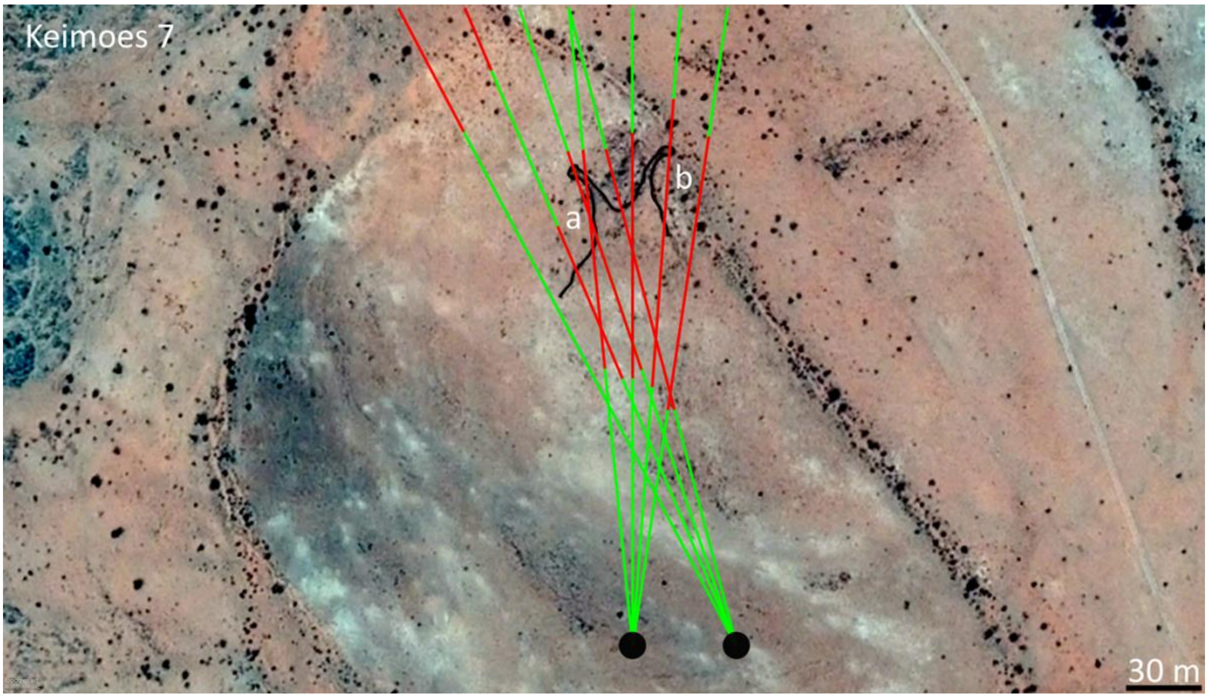

Figure 8. Keimoes 7 line-of-sight map (green=visible, black circle=150 m away).

2. Some funnels have been tactically placed on the curves of hill summits, concealing heads and necks and obscuring them from oncoming herds. For others, funnel heads and necks occur at elevations above the guiding arms, placed on undulating slopes that hide the upslope funnel apices or within topographic depressions that limit funnel visibility.
3. Funnels were constructed near to rocky outcrops from which construction material could be sourced, drainage lines, or open land between drainage lines, and near drainage divides, which suggests clear efforts to position sites in areas where animals would have been congregating or migrating, within specific parts of the surrounding landscape.

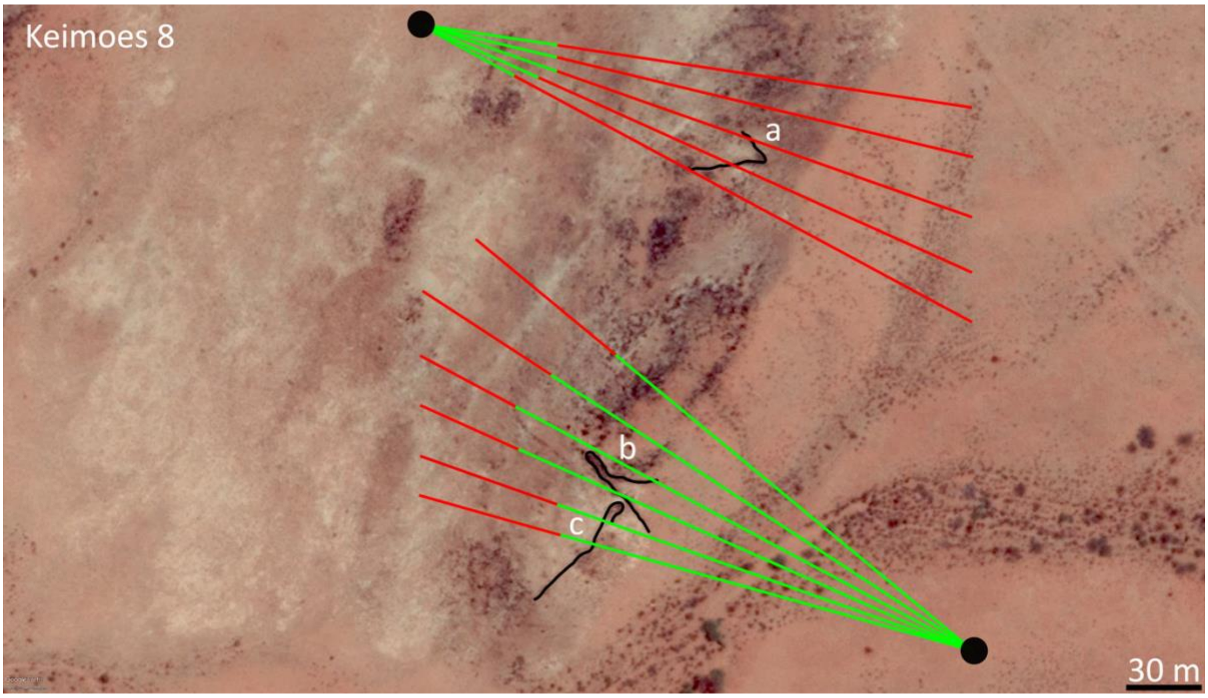

Figure 9. Line-of-sight results for the Keimoes 8 funnels (green=visible). The analysis was not run on the incomplete funnel 8c.

4. Interestingly, a trend not reported here is funnel placement near to or facing pans. None of the newly reported sites appear to be associated with pans, which differs from the observations made by Lombard et al. (2020, 2021) for the previously reported Keimoes sites (1-5).
5. Keimoes 7 and 8 were deliberately constructed within an area of greater topographic variability, given the nearby drainage lines, small rocky outcrops and nearby hills. Overall, the Keimoes landscape is flat, suggesting deliberate site placement in areas of undulating topography where herd movements may have been slowed due to sandy and/or waterlogged conditions around drainage lines, or where funnel construction was made easier given the abundance of local rocks for walling.
6. Lastly, we did not find any screens, protrusions or extensions emanating from the funnel walls of the newly discovered kite sites (as reported at Keimoes 3 and 5; Lombard et al. 2020, 2021).

4. Discussion

Our results confirm that people on the Keimoes landscape implemented standardised kite construction strategies based on funnel placement and visibility criteria, thereby confirming the strategic use of landscape elevation and microtopographic changes. Although the Keimoes funnels vary morphologically, their consistency in placement on gently rising slopes and areas with irregular topography implies that deliberate attempts were made to target higher-lying areas. Doing so would have afforded better game viewing opportunities, and the positioning of sites 6-8 relative to nearby drainage lines and divides, and open land with grazing potential, further supports their strategic placement. This is coupled with attempts to limit funnel guiding arm and head visibility, where topographical high points and undulating topography leading up to the funnels were used to obscure their view from oncoming herds, which is a consistent trend for the majority of the Keimoes kites (Lombard et al. 2020, 2021).

There are notable differences though between the previously reported kite sites 1-5 and those reported here, particularly where the new sites are not associated with pans; however, the western Keimoes landscape described here differs from that further east, having fewer pans and greater topographical variation due to the presence of hills and rocky outcrops (particularly around sites 7 and 8). As a result, it seems that funnel placement for sites 6-8 followed a different set of protocols where proximity to suitable raw materials for construction and to nearby drainage lines was prioritised, which may in turn imply that the funnels were designed to target animals moving through the landscape in search of water and good grazing, versus further east where sites 1-5 were placed nearer to areas where animals would already have been congregating to target these resources. Both the east and west Keimoes site clusters occur on landscapes with well-developed drainage lines, so although funnel placement relative to sources of standing water varies by site, the overall strategy was to place sites in areas with higher surface water potential (Lombard et al. 2020, 2021).

Despite still being uncertain as to the function of the kites, we agree that the most likely scenario is their use in communal, large-scale hunting efforts, specifically adapted to the surrounding landscape and environment. The Keimoes funnels represent permanent modifications to the landscape, where thousands of local dolerite boulders were arranged and placed strategically according to the criteria described above. Their construction would have required considerable time and effort, which likely required the cooperation and involvement of groups from across the region, and given their enduring nature they were likely managed by and passed down through multiple generations (Lombard et al. 2021). Such inter-generational custodianship would have led to the accumulation of knowledge about prey habits, seasonal movements, and abundance, which suggests that the Keimoes inhabitants would have had a deep understanding of the local landscape and how to best construct the funnels to maximise hunting proficiency (Lombard & Badenhorst 2019). The users might also have participated in client-patron relationships with nearby communities that involved procuring wild animal products through mass hunting activities. Labour relations were not uncommon between hunter-gatherers and either herder or farmer communities in several parts of Africa, including as hunters (e.g., Wright 1978; Bahuchet 1999). Further exploration of this possibility may lead to a better understanding of social relations rooted in these fixed locations.

A lack of associated surface archaeology hinders our ability to clinch the hunting argument, but data from the surrounding region further support a hunting scenario. In particular, evidence for the large-scale exploitation of small- to medium-sized bovids is found at the LSA site of Droëgrond (cal. AD 1296-1710; Smith 1995), ~90 km to the southwest, and the only other funnel reported for the region is situated at Graafwater just a few kilometres away. Based on this evidence, Beaumont et al. (1995) suggested that the arid Nama Karoo landscape likely drove a unique hunting strategy particularly adapted to this region of southern Africa – not too dissimilar from strategies employed in the arid landscapes of northern Africa and the Levant, for gazelle and Barbary sheep. If we consider some of the other trends in funnel construction and placement, their use in hunting appears even more probable: one, their placement along proposed migration/movement routes (as documented at the Negev kites; Bar-Oz et al. 2011), with discussions on springbok hunting by Lombard and Badenhorst (2019) confirming ethnohistoric accounts of large-scale springbok migrations throughout the region, coupled with strategic seasonal hunting by local San groups; two, funnel placement near water sources and open plains with grazing potential, which has already been reported for all the Keimoes funnels (Lombard et al. 2020, 2021, and here); three, rock art nearby that depicts hunting scenes (Crassard et al. 2015); four, associated mass fauna (Bar-Oz et al. 2011); and five, lithics that would imply hunting, killing and butchery (e.g., points, blades, arrowheads; Helms & Betts 1987; Hadas 2011). Currently, we lack evidence for indicators three, four and five, but Hollmann and Lombard (2020) do report evidence of petroglyphs depicting giraffes, elephants, lizards and ostriches near Keimoes 3, which confirm use of the landscape by hunter-gatherer groups at some point in time, although we cannot be sure the art is associated with the funnels or whether it was made during the same period; hunting scenes have not been identified in the vicinity. Finding fauna and associated hunting implements would be a significant step towards resolving kite functionality, which would require future surveys and excavations at multiple funnels. It is also possible that animals were removed from the funnels and butchered elsewhere, so future investigations should prioritise the assessment of all archaeological signatures across the broader landscape.

5. Conclusion

Our research provides details for three new kite sites in the broader Keimoes region, and we continue to learn about the strategies that were used in site placement to maximise resource acquisition efforts in a challenging landscape. There is potential in the future to investigate aspects of group contact and interaction, because the Keimoes landscape has a complex social history, and the kites themselves imply a level of landscape custodianship and successive generations of use or possibly ownership. By prioritising the investigation of material culture associated with these structures, if recoverable, we may be able to explore group identities and potentially establish who was responsible for their creation, because their use and management may very well have included input from multiple groups not associated with their establishment. Differentiating herder and hunter-gatherer identities across the region may be possible if there are observable differences in lithic techno-typological frequencies and ceramic and bead production traditions, between sites, coupled with the presence of domesticated livestock. For example, Beaumont et al. (1995) and Parsons (2007) have explored two distinct LSA industries in the Northern Cape, the Swartkop and Doornfontein, which are considered hunter-gatherer- and herder-produced, respectively, with each having diagnostic markers in formal stone tool compositions, domestic livestock remains, ceramic tempering and style, and settlement patterns. Furthermore, rock art has been used to differentiate forager from herder traces (Smith & Ouzman 2004). Whether this is possible in relation to the kite sites must be assessed, and how to assess whether these cultural remains are chronologically related to the structures requires considerable thought. Such an approach also relies on colonial identity constructions of groups that elsewhere have been noted as mutable (e.g., Barnard 1992; Challis 2018). Nevertheless, questioning such identities will also allow us to hypothesise about social cohesion and group cooperation on the Keimoes landscape. The very nature of the region, with its dry conditions and seasonal abundance of resources, perhaps dictated the need for local populations to band together during times of surplus to maximise hunting and resource acquisition efforts. Once we can identify cultural markers, we should be able to develop a more holistic understanding of both the landscape and the adaptive strategies that groups employed within these particular settings. Such questions are not unique. They are being asked elsewhere in southern Africa in regions with complex social histories, for example around the Seekoei River (Sampson & Neville 2018) and in the middle Limpopo Valley (e.g., Forssman 2020). The Keimoes landscape, with a more nuanced investigation of its surface archaeology, may therefore provide another opportunity to explore identities that, in turn, may shed greater light on site chronologies throughout the region. Future research will also prioritise more extensive aerial surveys of the surrounding region, to potentially locate more sites, and excavations will target those larger sites for which there may be greater potential for artefact preservation, which at the current stage would likely be at Keimoes 3 since it is the largest and most complex of all the funnel sites.

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