

Dating the Naukluft Cascade and Barrage Tufas, Namibia

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Abstract: A three day survey of tufa deposits in the Naukluft Mountains in September, 2019, led to the discovery of many plant fossils, two occurrences of molluscs and one of micromammals, as well as of Middle Stone Age tools embedded in tufa at one site. The presence of mammal fossils and stone tools *in situ* in the tufas is important for estimating the age of tufa deposition, as well as for throwing light on palaeoenvironments and palaeoclimate. More detailed surveys are warranted.

Key Words: Archaeology, Biochronology, Quaternary, Naukluft Mountains, Sedimentation, Tufa, Palaeoclimate

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Introduction

The Naukluft Nappes are comprised of dolomite, limestone, shale and quartzite (Miller, 2008; Rowe *et al.* 2012; Kambinda, 2014) and as a consequence are prone to undergo karst processes. In the Naukluft, as in many places in the world, karstification has resulted in the development of caves, fissures and related phenomena in many places in the mountains. At resurgences of lime-rich waters, deposition of tufa and travertine has frequently occurred, with the result that there are many examples of barrage and cascade tufas in the region, including some, such as Blässkopf, that are of impressive dimensions (Viles *et al.* 2007; Goudie & Viles 2015) (Fig. 1). There has been general agreement that the Naukluft tufas must be relatively young, with most estimates of their ages falling within the Quaternary (Korn & Martin, 1937, 1955). Stone *et al.* (2010) employed Uranium-Thorium isotope dating methods on several tufas from the Naukluft, and obtained age estimates ranging from 970 years (late

Holocene) to 258,000 years (late Pleistocene), but the authors cautioned that tufas are relatively porous geochemical systems such that uranium can be introduced into them or removed from them well after their formation, and this would impact on the estimation of their age of deposition.

During a survey of the tufas in September, 2019, the author found fossil micromammals in tufa at Blässkopf and Middle Stone Age lithic implements embedded in tufa at Thoms (also known in the literature as Klein Blässkopf and Brandfontein). Both of these discoveries confirm the relatively young age of tufa deposition at the sites concerned, but it is clear from the field relationships that other tufa lobes in the same outcrops were deposited both before and after the examples in which the fossils and stone tools were found.

The Naukluft tufas join an ever increasing data base concerning springs, tufas and hominid evolution in Africa, Arabia and Turkey (Barboni *et al.* 2019).



Figure 1. Tufa deposits in the Naukluft Mountains. Micromammals occur at Blässkopf, molluscs at Naukluft and Remhoogte, and plants at all occurrences. Middle Stone Age artefacts occur in tufa at Thoms (Base map modified from Google Earth).

Blässkopf Cascade Tufa

The impressive tufa cliffs at Blässkopf (Fig. 2) are richly fossiliferous. There are many outcrops of moss tufa, forming concentric layers of cellular tufa, as well as tufa containing impressions of reeds and dicotyledon leaves (Fig. 3-4). There are patches of what appear to be filamentous algae coated in tufa. As is usual in cascade tufas, there are caverns of various dimensions, and some of these were the sites of speleothem formation and internal spelean sedimentation. It is also evident that there were periods of erosion of pre-existing tufas, followed by renewed tufa deposition, with gullies eroded

into the tufas infilled with gravel and broken fragments of tufa.

On the west side of Blässkopf there is a steep slightly overhanging cliff, at the base of which were found tufa blocks containing dicotyledon leaves and micromammals (Fig. 4-7). The latter blocks accumulated inside a fissure or cave within the main tufa mass, and are probably the remains of regurgitation pellets of owls that roosted inside the cavity. Mammals so far identified in the tufa comprise rodents (*Otomys*, *Rhabdomys*), sengis and shrews, all of which appear to be closely related to extant micromammals (work in progress).



Figure 2. The Blässkopf Cascade Tufa on Farm Blässkranz, Naukluft Mountains, Namibia. Micromammals were found in tufa blocks on the west side of the cliffs (in shadow, right of image)



Figure 3. Impression of a large plant stem (probably *Ficus*) in tufa at Blässkopf, Naukluft Mountains, Namibia.

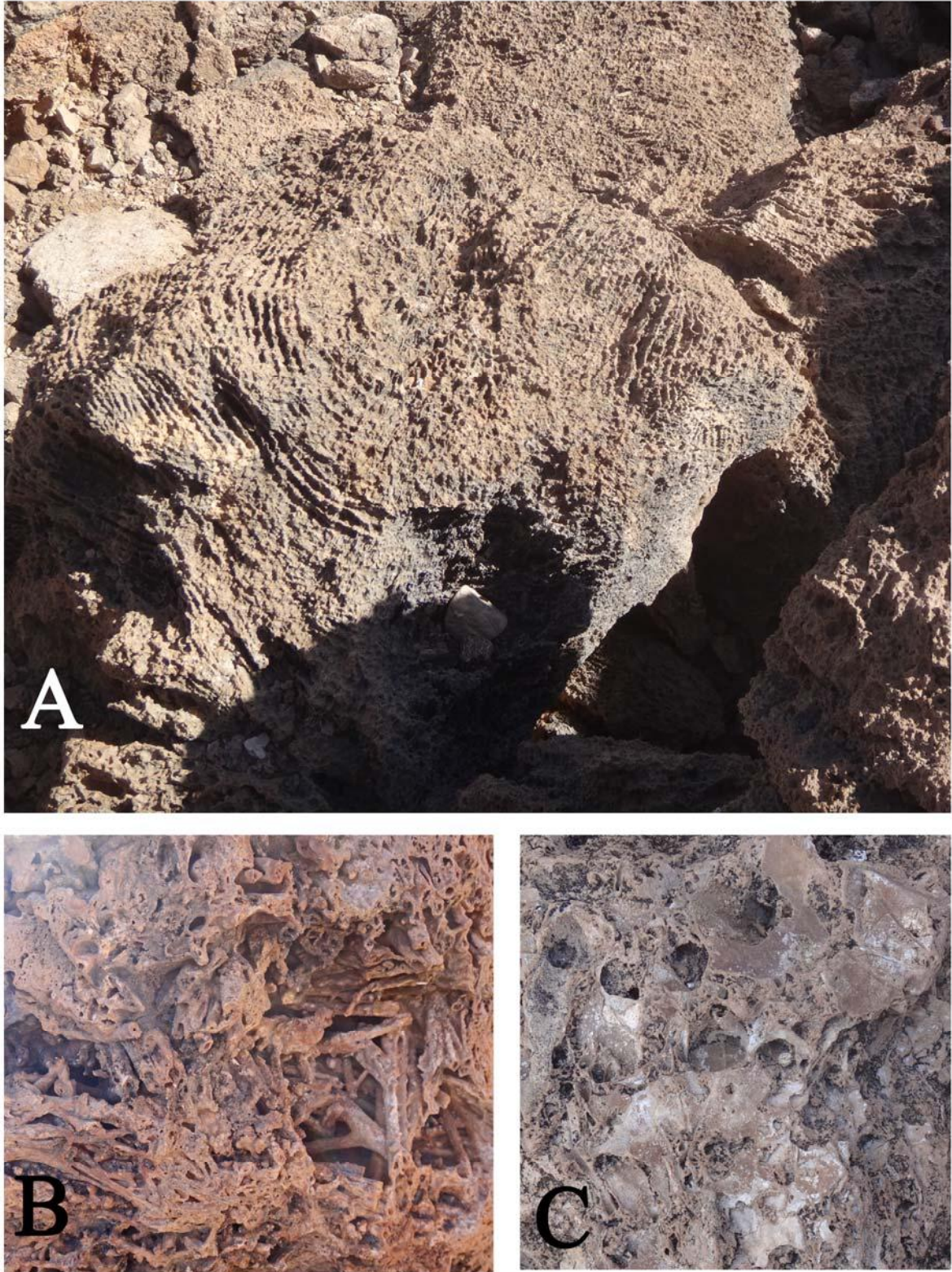


Figure 4. Plant remains in tufa at Blässkopf, Naukluft Mountains, Namibia. A) Moss in a fallen block of bryophyte (or hepatic) tufa dome, B) filamentous algae and possible stems of *Cyperus* coated in tufa C) dicotyledon leaves (probably *Ficus*) preserved as impressions in tufa.

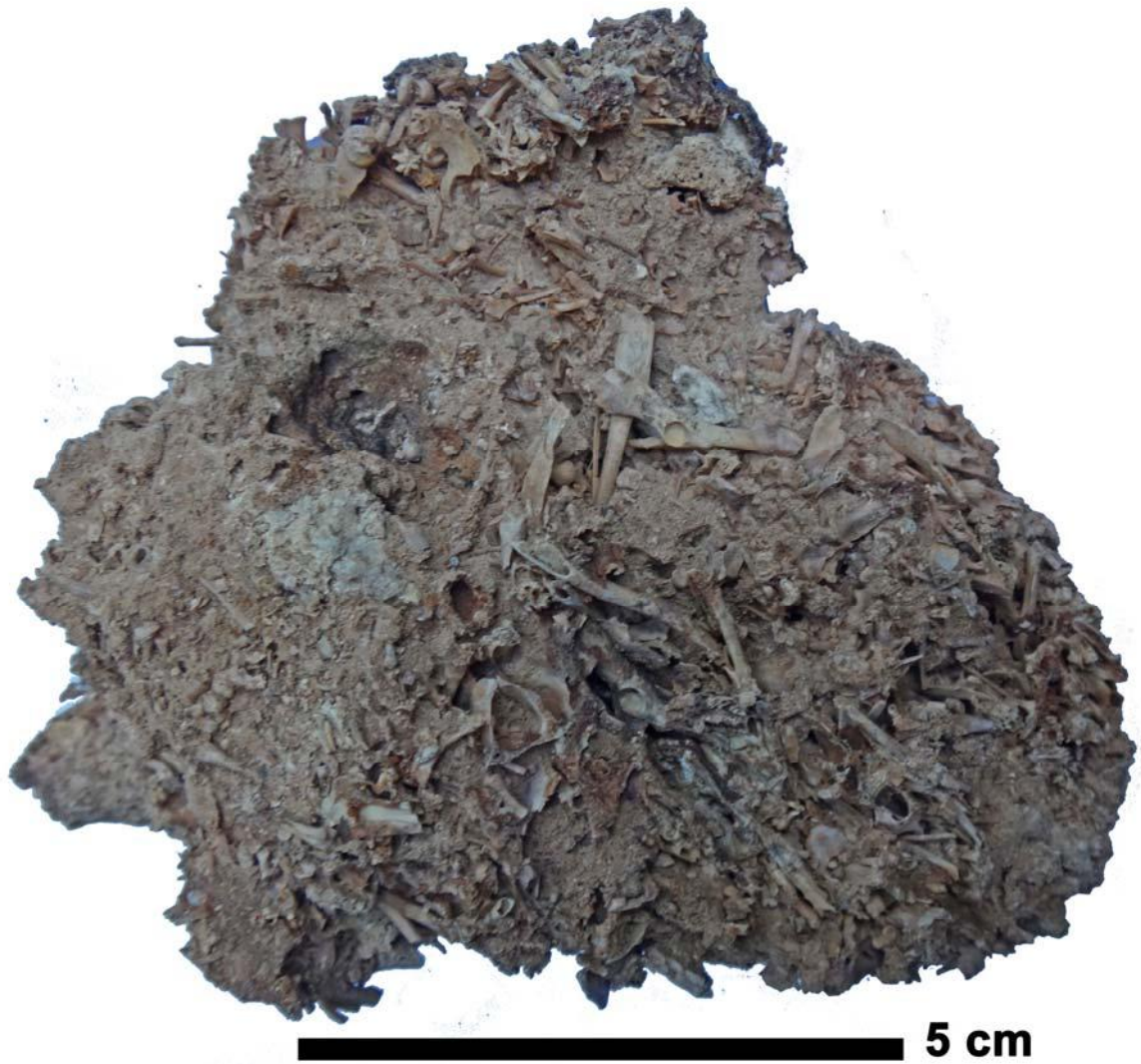


Figure 5. Micromammal jaws, teeth and post-cranial bones preserved in tufa at Blässkopf, Naukluft Mountains, Namibia (scale : 5 cm).

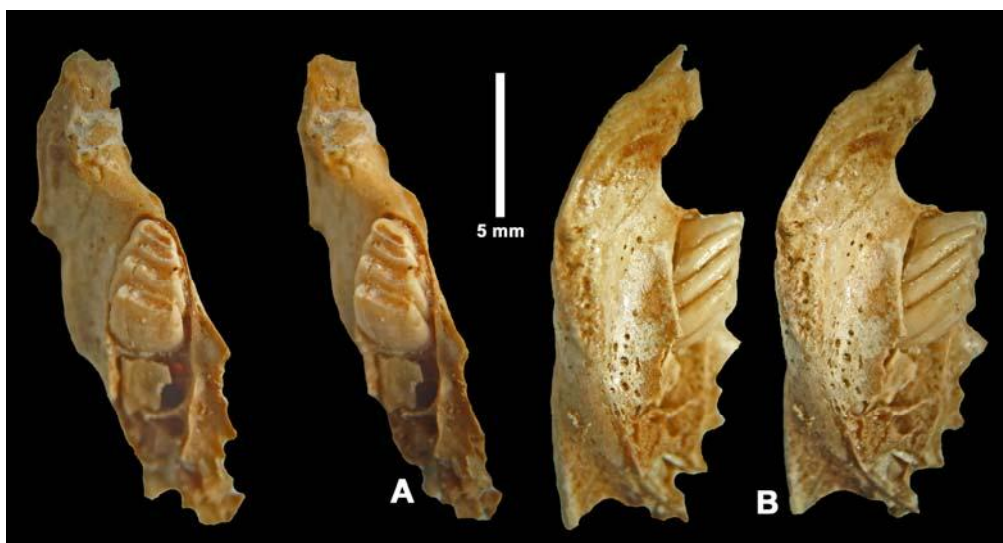


Figure 6. Stereo images of a right mandible of *Otomys* sp. cf. *irroratus* from Blässkopf, Naukluft Mountains, Namibia. A) occlusal view, B) lingual view (scale : 5 mm).



Figure 7. Stereo images of a right mandible of cf *Rhabdomys* sp. from Blässkopf, Naukluft Mountains, Namibia. A) occlusal view, B) lingual view (scale : 5 mm).

Thoms Cascade Tufa

The cascade tufa at Thoms (also known in the literature as Klein Blässkopf and Brandfontein) is about 4 km eastnortheast of Blässkopf (Fig. 8-9). The valley upstream from the tufa dome is infilled with various barrage tufas (Viles *et al.* 2007; Stone *et al.* 2010), some of which have been deeply incised by erosion subsequent to their deposition. There are many plant remains in the cascade tufas which form the main mass of Thoms. Concentric layers of cellular tufa are common, and indicate deposition on mats of moss growing on the tufa. There are also many

occurrences of reeds preserved in tufa (Fig. 10). The most intriguing discovery however was the presence of lithic implements of Middle Stone Age aspect embedded in tufa (Fig. 11). The main area where the stone tools were found is a few metres to the east of the main tufa dome where blocks of tufa have broken away from the nearby cliffs.

The stone implements at Thoms attest to a late Pleistocene human presence in the area, and to tufa deposition soon afterwards, because the tools are unrolled and undamaged by transport.



Figure 8. The cascade tufa dome at Thoms (also known as Klein Blässkopf and Brandfontein) blocking the valley cut into the Naukluft Nappe Complex in the background. Middle Stone Age lithic implements occur in blocks of tufa on the east side of the dome (in shadow, left of image).



Figure 9. Cascade Tufa lobes at Thoms (Brandfontein) Naukluft Mountains, Namibia.



Figure 10. Plant impressions (reeds) preserved in tufa at Thoms, Naukluft Mountains, Namibia.



Figure 11. Unrolled Middle Stone Age lithic implement embedded in tufa at Thoms, Naukluft Mountains, Namibia.

Remhoogte Barrage Tufa

The Remhoogte tufa is vast, but not very thick (Fig. 12-13). It formed a series of barrages in a broad valley, which eventually coalesced into a single areally extensive tufa deposit with a relatively planar upper surface, thickest in the east, thinning towards the west in accordance with the shape of the valley that it infills. The downstream end has low cliffs

and pools in which there are masses of green algae. Fossilised plant remains are ubiquitous, and comprise the usual reeds encrusted in tufa (Fig. 14), as well as impression in tufa of the trunks of larger plants such as fig trees (Fig. 15). The only animal remains encountered were the fossil shells of *Dorcasia*, a land snail that thrives in the Naukluft at present.



Figure 12. Barrage Tufa at Remhoogte, Naukluft Mountains, Namibia, view upstream.



Figure 13. Algae in pools at the downstream end of the Remhoogte Barrage Tufa, Naukluft Mountains, Namibia.



Figure 14. Open network of tufa enclosing plant remains at Remhoogte, Naukluft Mountains, Namibia.

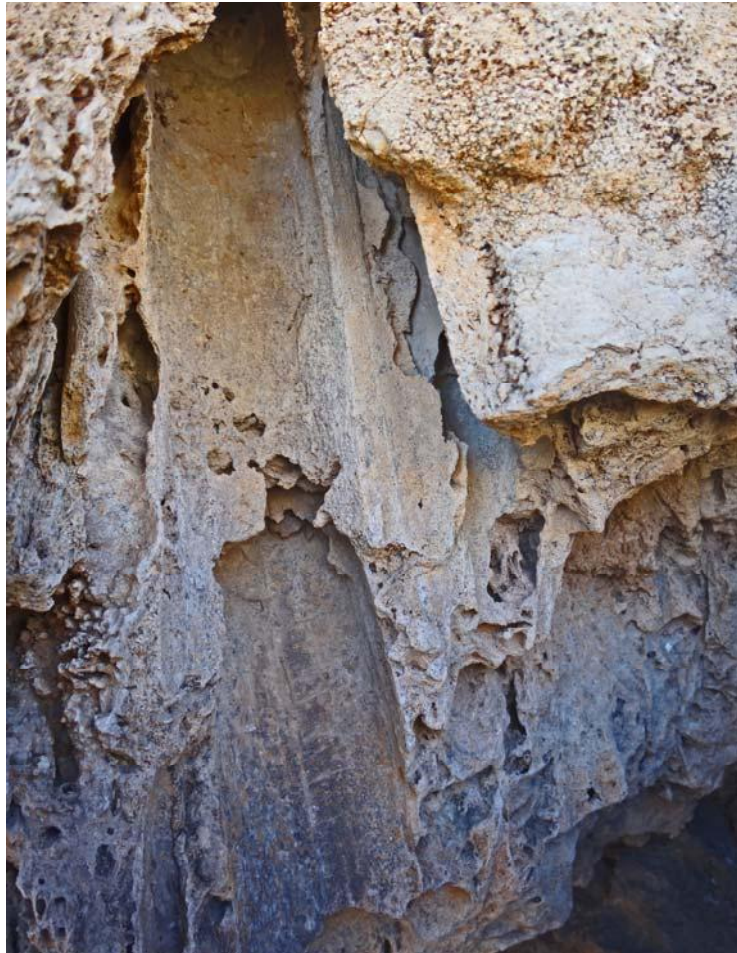


Figure 15. Impressions of large plant stems (probably *Ficus*) in tufa at Remhoogte, Naukluft Mountains, Namibia.

Tufas near the Naukluft Park Headquarters

The Waterkloof Walking Circuit which is close to the Naukluft Park Headquarters, encompasses many masses of barrage tufa infilling valleys deeply incised into rocks of the Naukluft Nappe Complex (Fig. 16). Fossil plants are ubiquitous in the tufa, and comprise a variety of reeds, grasses and dicotyledons (Fig. 17-18). Fossil land snails (*Dorcasia*)

(Fig. 19) and freshwater snails (*Bulinus*) were found in tufa in the valley close to the Park Headquarters and remains of freshwater crabs were observed in tufa two km upstream. No mammal fossils were observed, but time limitations prevented detailed examination of all the outcrops, of which there are many.

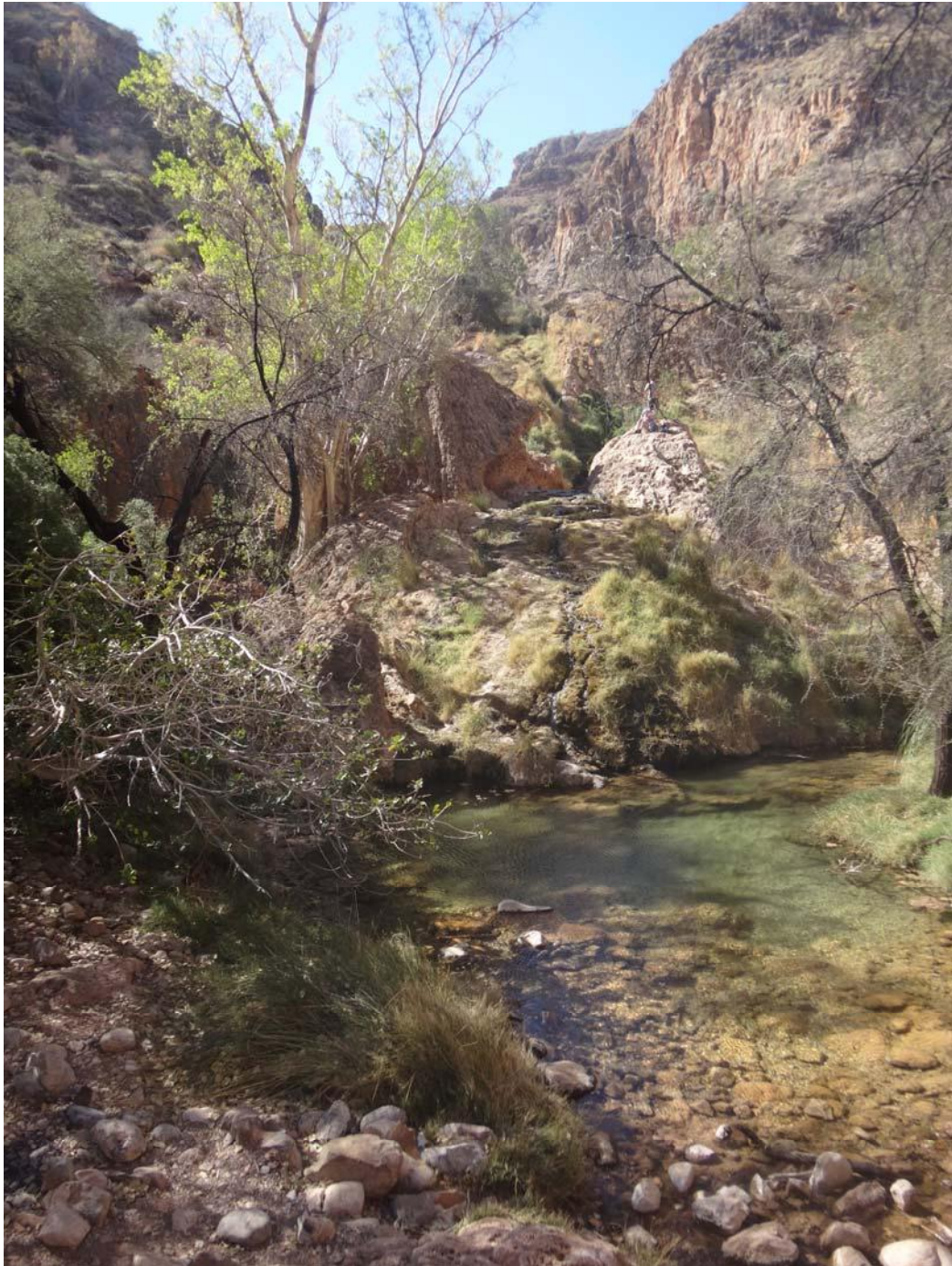


Figure 16. Barrage tufas and pools upstream from Naukluft Park Headquarters, Namibia.



Figure 17. Plant impressions in tufa upstream from Naukluft Park Headquarters (Waterkloof Walking Circuit) comprising leaf and stalk elements of *Phragmites* and other plants.



Figure 18. Dense concentration of fossil reeds preserved in tufa, close to the Naukluft Park Headquarters, Namibia.



Figure 19. The land snail, *Dorcasia*, in the Naukluft Mountains. A) fossils in dense tufa near the Naukluft Park Headquarters (black arrows), B) extant specimens (diameters of shells ca 2 cm).

Discussion

The Naukluft Mountains contain many examples of cascade and barrage tufas (Marker, 1988; Viles *et al.* 2007). Most of them contain plant remains, but there are some with molluscs (Naukluft: *Dorcasia*, *Bulinus*; Remhoogte: *Dorcasia*) and one outcrop (Blässkopf) yielded fossil micromammals. The latter discovery is important because it provides evidence concerning the age of deposition of the tufa, as well as data concerning the palaeoclimate at the time of formation of the tufa lobes.

A preliminary estimate of the age of the Blässkopf tufa on the basis of the micromammals (*Otomys*, *Rhabdomys*) is middle to late Pleistocene. The record of *Otomys* cf. *irroratus* is interesting because the species does not occur at present in Namibia (Taylor & Kumiral, 2001) but it has been

identified in archaeological contexts at Zebrarivier Cave, Central Namibia (Avery, 1984). This species is a « wetland » inhabitant, which is reflected in its common name, the « vlei rat ». Thus its presence at Blässkopf would indicate increased humidity, either due to an increase in rainfall, or to a decrease in evapotranspiration related to a cooler climate than that of today (Lim *et al.* 2016).

Rhabdomys (the four-striped grass mouse) is a widespread genus in Namibia, South Africa, Angola, Botswana and East Africa (Skinner & Chimimba, 2005; Du Toit *et al.* 2016). It survives in grassland ranging from mesic to xeric conditions.

The Thoms (Brandfontein) Cascade Tufa, not far from Blässkopf, yielded Middle Stone Age lithic implements *in situ* in tufa, indicating a late Pleistocene age for the

deposits. This evidence agrees with the age of deposition of some of the tufas in Kaokoland (Mocke, 2014; Pickford, 2019; Pickford *et al.* 2016) and elsewhere in Namibia (Korn & Martin, 1955; Brook *et al.* 1999; Pickford & Senut, 2010) and in Southern Africa in general (Peabody, 1954; Butzer *et al.* 1978; Marker, 1988).

Many of these researchers interpreted their results in terms of palaeoclimatic changes, usually inferring the existence of more humid climates at the time of tufa deposition (Heine, 1998; Schneider, 2008) and drier climates during periods when tufa deposition diminished or ceased altogether. Pickford (2019) considered that the presence of cold underground waters would lead to an acceleration of tufa deposition, because

calcium carbonate is more soluble in cold water than warm water. Cold phreatic waters more readily dissolve carbonates in limestones and dolomites than warm waters do, and then, upon reaching the warmer surface conditions at resurgences and springs, the lime-rich cold waters deposit some of the dissolved carbonate as tufa as they warm up, with little or no evaporation of the water being implicated. If so, then maximum tufa deposition would occur during periods of cooler climate, and not necessarily during periods of more humid climates.

It is evident that a more detailed survey of the Naukluft Tufas would yield useful evidence concerning the Pleistocene-Holocene palaeoclimates of the region.

Conclusions

A brief survey of some of the Naukluft Tufas in 2019 resulted in the discovery of many fossiliferous sites. Palaeobotanical remains are ubiquitous, as is often the case in tufas all over the world. *Phragmites* is common, as are stalks of *Cyperus*, and mats and domes of moss tufa. Occasional dicotyledon leaves are also encountered. Land snails (*Dorcasia*) and freshwater gastropods (*Bulinus*) were found at two localities, both taxa being common in the Naukluft today. Micromammals were recovered from Blässkopf. Detailed studies of the remains are

underway, but it is evident that most of the fossils belong to extant taxa (rodents, shrews, sengis) on which basis it is inferred that the deposits accumulated during the late Pleistocene or Holocene. Finally, Middle Stone Age implements were found embedded in tufa at Thoms, not far from Blässkopf, on which basis a late Pleistocene age can be inferred for part of this tufa complex.

The results of the brief survey of Naukluft tufas indicate that more detailed research is warranted.

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