

# Onyx travertine in the northeastern Sperrgebiet, Namibia

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**Abstract:** Onyx travertine deposits have long been known to occur in the Trough Namib in the Sperrgebiet, Namibia, but only recently have they been mapped in the Plain Namib. Previous interpretations concluded that the travertines of the Sperrgebiet accumulated in lagoonal settings close to the sea, but the ones in the Plain Namib, some of which lie at altitudes of over 500 above msl, indicate that their genesis had little to do with proximity to the sea, but that they formed where cold lime-charged groundwater emerged at springs, precipitating some of their dissolved lime as they warmed up when they rose towards the land surface and the remainder of the lime at the surface, often as lobes with sloping margins. Most of the Kaukausib and Tsirub travertines are associated with sand, grit and conglomerates, some of which are fossiliferous, thereby providing biochronological controls on the period of accumulation. Based on fossil mammals found in the intercalated calcified sands, some, if not all of the travertine occurrences in the Plain Namib are Plio-Pleistocene. The only known exception is an Eocene occurrence at Eoridge, well south of the Kaukausib Valley.

**Key words:** Onyx travertine; Calcified sand; Calcified grit; Calcrete; Fossil mammals; Termite hives; Pliocene.

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## Introduction

Onyx travertine deposits in the Trough Namib were mapped by Kaiser & Beetz (1926) (map symbol : esi - calcareous sinter) at Grillental, Elisabethfeld, Hexen Kessel, Gamachab and Klinghardtfelder, west of Buntfeldschuh. These travertines were subsequently mentioned by Corbett (1989) and some were correlated to the Neogene marine package sequence of Pether (1986) mainly on the basis of their altitudes above present-day sea level. The Elisabethfeld-Grillental mass, for example, was correlated to the 30 metre marine package, considered to be of Pleistocene age. The Hexen Kessel travertine occurrence is associated with calcified grey sand rich in shells of *Patella* and stone tools (Pickford *et al.* 2018). Initially, based on its altitude, this occurrence was correlated to the 50 metre marine package of Pliocene age (Pether pers. comm. to Pickford & Senut, 2016) but the presence of stone tools in the deposits renders this correlation doubtful, and it is more likely that the deposits are Pleistocene.

Until recently, no travertines were reported from the Plain Namib. Bennett & Kalbskopf (1978) discussed the sequence of terraces in the Tsirub River Valley, a major affluent of the

Kaukausib River in the northeastern corner of the Sperrgebiet. They recognised seven terraces, but found that it was difficult to make correlations between local successions due to rapid lateral and vertical facies changes (colour, lithology) in the calcretes and underlying sheet wash deposits. However, they did mention that some of the calcretes were white, cream or red. Although the authors failed to recognise that the white « calcretes » are in fact travertines of various sorts (onyx, impure limestone, sandy travertine), this appears to be the first reference to the existence of such rock types in the region. Pickford & Senut (1999) mentioned the presence of fossiliferous calcified sand and grit interbedded with travertine deposits near Kaukausib Fontein, possibly of Pliocene age, based on a fossil suid found in the cemented sand, while Pickford (2015) reported the presence of small outcrops of relatively pure onyx travertine in the immediate vicinity of the Eocene fossiliferous limestone at Eoridge, close to the western margins of the Klinghardt Mountains.

The aim of this paper is to document the presence of extensive onyx and related travertine deposits in the Kaukausib and Tsirub

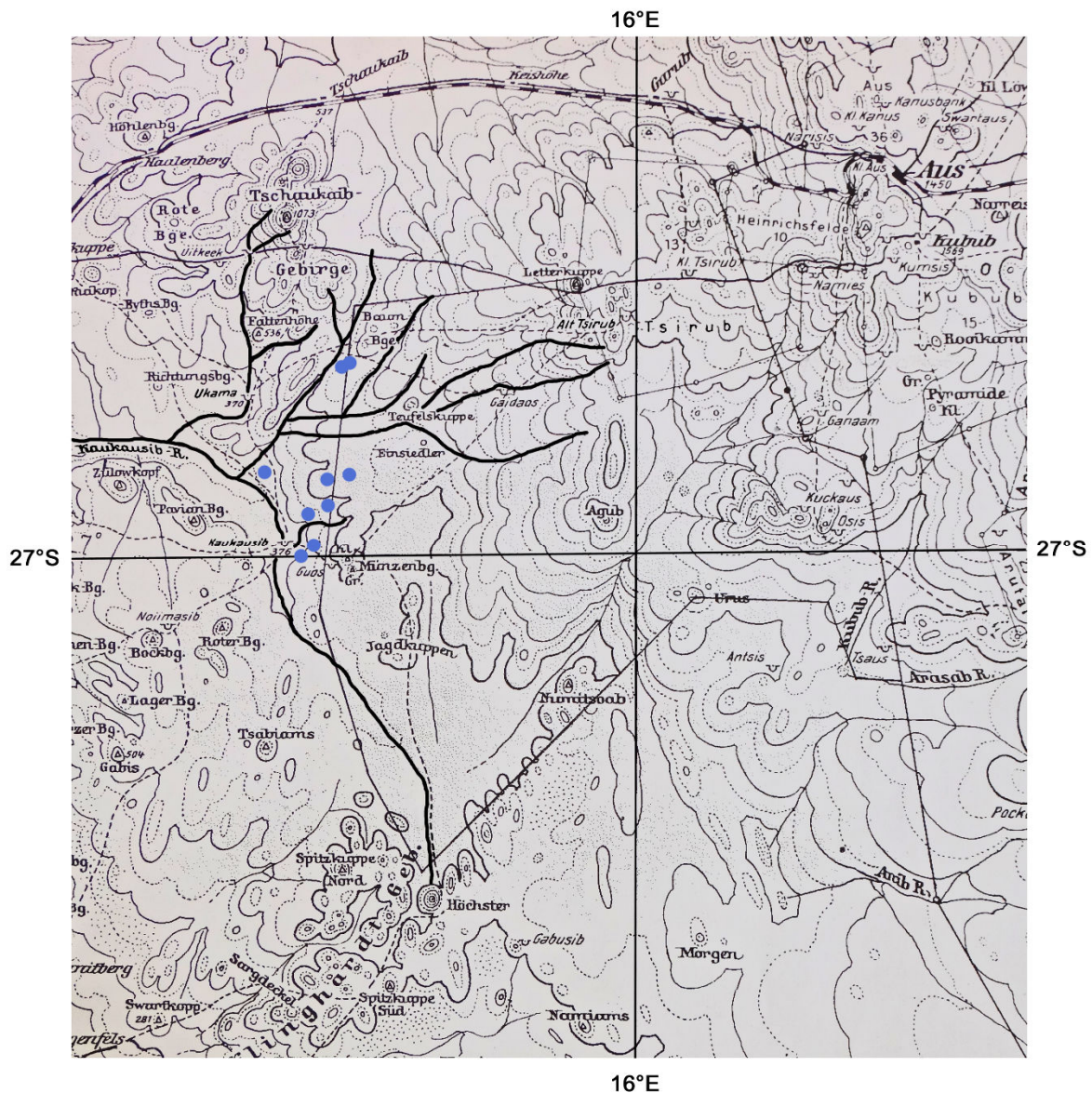
drainages, to discuss their ages based on fossil mammals and to investigate their palaeoclimatic significance. Reference is also made to pedogenic calcrete and calcified scree deposits which overlie silts and sands containing fossilised hives of termites. It is by no means an exhaustive treatise; more in the nature of a preliminary report based on a few days of survey. A great deal of detailed mapping would

be required to resolve the complex stratigraphic relationships in the region, as was implied in the report by Bennett & Kalbskopf (1978). Furthermore, the area surveyed in October, 2018, did not cover the entire region, and examination of satellite imagery suggests that travertine deposits could be more widespread than indicated herein.

### Localisation of the Study Area

The Tsirub drainage network is an affluent of the Kaukausib River in the northeast corner of the Sperrgebiet, Namibia. Its headwaters are in the region of Letterkuppe, southwest of Aus, and it drains generally southwestwards past Teufelskuppe Carbonatite Ridge eventually to

debouch into the Kaukausib River several km downstream from Kaukausib Fontein (Fig. 1). The area in which travertines have been mapped covers an area of ca 15 km east-west by 20 km north-south, but the total area where travertine occurs could be more extensive (Table 1).



**Figure 1.** Northeastern corner of the Sperrgebiet, southwest of Aus, Namibia, highlighting the Kaukausib, Tsirub and Ukama rivers. The blue dots are mapped occurrences of onyx travertine (see Table 1).

**Table 1.** Onyx travertine deposits in the middle reaches of the Kaukausib Drainage and the Tsirub affluent, northeastern Sperrgebiet, Namibia.

Identification	Latitude	Longitude	Altitude	Associated sediments	Fossils
<b>Tsirub Valley</b>					
Travertine 1	26°55'11.9''S	15°43'34.6''E	528 m	Calcified sand/grit	None seen
Travertine 2	26°55'53.3''S	15°42'49.3''E	509 m	Calcified sand/grit	None seen
Travertine 3	26°55'59.8''S	15°42'15.7''E	493 m	Calcified sand/grit	None seen
Travertine 4	26°57'38.7''S	15°40'30.3''E	448 m	Calcified sand/grit	None seen
Travertine 5	26°56'49.1''S	15°41'41.9''E	493 m	Calcified sand/grit	None seen
Travertine 6	26°56'31.2''S	15°42'17.6''E	508 m	Calcified sand/grit	None seen
Travertine 7	26°55'07.9''S	15°37'49.2''E	355 m	Calcified pan silts, sands	None seen
Discordant Hillcock	26°50'23.8''S	15°42'24.6''E	518 m	Calcified sand/grit	Rhinocerotid, termites
Cup Hill	26°50'27.4''S	15°42'04.2''E	510 m	Limestone, calcified sand/grit	Unidentified bone, termites
<b>Kaukausib Valley</b>					
Kaukausib Cliffs	26°59'54.0''S	15°39'32.3''E	416 m	Calcified sand/grit	Bovids, suoids, rodent
Kaukausib East	26°59'58.0''S	15°40'00.0''E	402 m	Calcified grit/conglomerate	None seen

### Geological Context and Formation of Travertines

As Bennett & Kalbskopf (1978) wrote, the Tsirub drainage is the site of extensive sheetwash deposits of the kind that infill all the valleys and depressions between the Klinghardt Mountains and the mountains occurring on the Sperrgebiet Border to the East (Great Escarpment). These deposits form an immense glacia deposit spread like an apron all along the lower edge of the escarpment generally decreasing in altitude westwards towards the coast. The thickness of the ill-sorted sand/grit/conglomerate varies considerably due to the fact that the underlying Basement topography is itself irregular, and also due to erosion of the sheetwash deposits by Pleistocene and Recent fluvial activity in the Tsirub and related drainages (Ukama, Kaukausib). The thickest section of such deposits exposed is about 30 metres, but in places where the basal contact is not visible, it could be greater than this. The deposits thin out to zero metres over Basement highs. There is a discontinuous layer of grey calcrete covering much of the interfluves, and there is a thin but widespread layer of loose red sand obscuring much of the countryside, in some places forming barchans. Bennett & Kalbskopf (1978) wrote that the calcretes have been silicified, but this seems not to be the case as they readily react with weak acid (vinegar).

The Kaukausib, Tsirub and Ukama valleys were thought by Bennett & Kalbskopf (1978) to have developed before end-Miocene times and to have suffered little modification since then,

apart from infilling by «sheetflood» or «streamflood» detritus. Further downstream, the Grillental and associated valleys at Elisabethfeld and Fiskus were downcut during the Oligocene low sea stand (Pickford & Senut, 1999; Pickford, 1998) and were infilled with early Miocene sediments when sea level rose during the Aquitanian/Burdigalian, associated with the 90 metre marine package of Pether (1986). It is likely that the upper reaches of the same hydrographic network had also largely matured by Burdigalian times and that initial infilling of the depressions and valleys was an inland equivalent to the early Miocene deposition at Elisabethfeld and Grillental. Unconformably overlying the early Miocene deposits at Grillental, there are extensive fluvial grits and conglomerates of probable Pliocene age (fossil rhinocerotid, *Ceratotherium* sp.) corresponding to the 50 metre or 30 metre marine package of Pether (1986) and a corresponding deposit likely occurs in the Tsirub area.

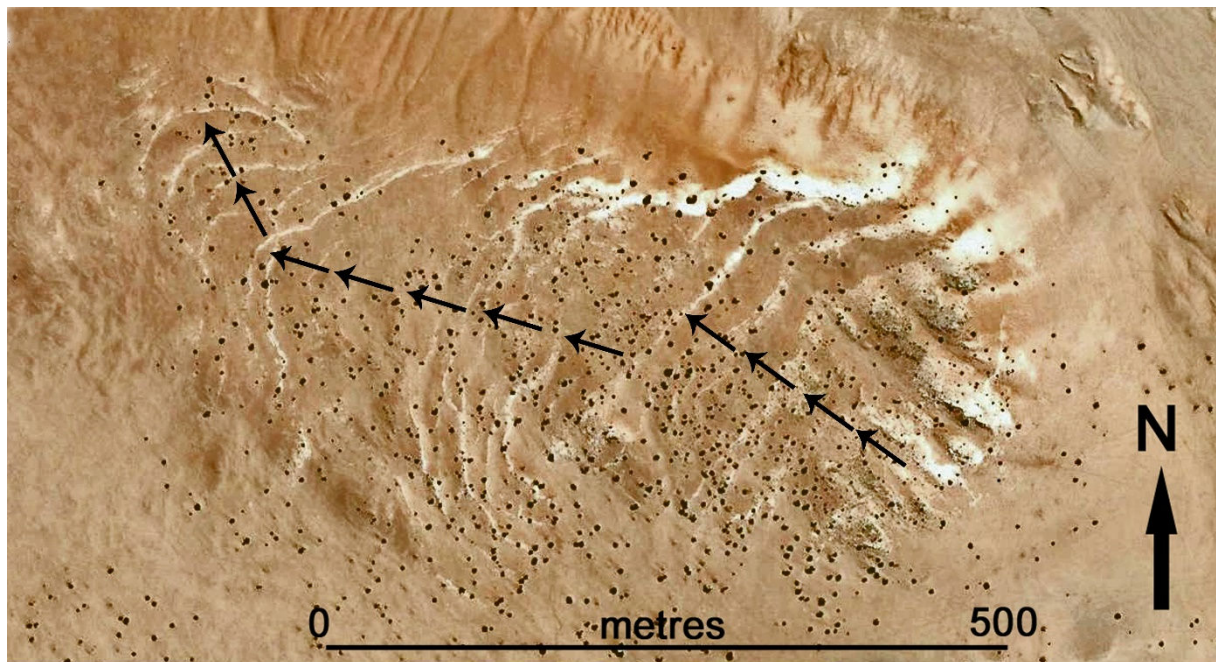
The cut-and-fill history of the Grillental-Kaukausib-Tsirub hydrographic network is therefore complex in detail, but is relatively simple in terms of the geological processes of erosion, transportation and deposition, all responding to rising and falling marine base levels, and affected by the incessant winds that sweep the Sperrgebiet, transporting vast quantities of sand, deflating loose sediment and sandblasting rock outcrops. Also involved are

diagenetic and pedogenic processes, especially calcrete pedogenesis, and other kinds of induration of superficial layers of the land surface (salt crusts in pans for example) even if transient or impermanent.

In numerous places throughout the Tsirub watershed, there are exposures of onyx travertine, limestone and calcified sand/grit (Table 1). Where these are well exposed, the travertine is seen to form centimetre to metre thick layers within the sheetwash deposits, sometimes horizontal to sub-horizontal, but in several cases inclined at angles of up to 45°, with flatter-lying upper and lower extremities.

The Kaukausib Cliffs (Fig. 2) provide the clearest example of inclined travertine lobes, there being 18 or more of them separated from each other by calcified sand and grit. The upper surface of the dome-like structure has been eroded off, leaving a natural horizontal section through the complex exposed over the hilltop. Similar inclined travertine layers occur at Cup Hill and Discordant Hillock in the Tsirub

drainage (Table 1). At Travertine 1 and Cup Hill, the tops of the travertine domes are preserved, with the flanks sloping away in all directions. At Kaukausib Cliffs, six of the travertine lobes exposed along the side of the valley have a sub-horizontal upper part, a steeply inclined middle portion and a sub-horizontal lower part. The style of layering of the travertines indicates that they formed as lobes on sloping ground, where water was seeping out onto the land surface near the tops of slopes and then flowing downhill about 15 metres or so to the local bottoms of the slopes, where the travertine deposits become sub-horizontal. The position of the seepages shifted laterally from time to time, such that the site of travertine deposition also shifted. The travertine layers are seldom more than a metre thick, but where water flow was extended over longer periods travertine up to three metres thick was built up. The clastic layers between successive travertine lobes can be up to tens of metres thick



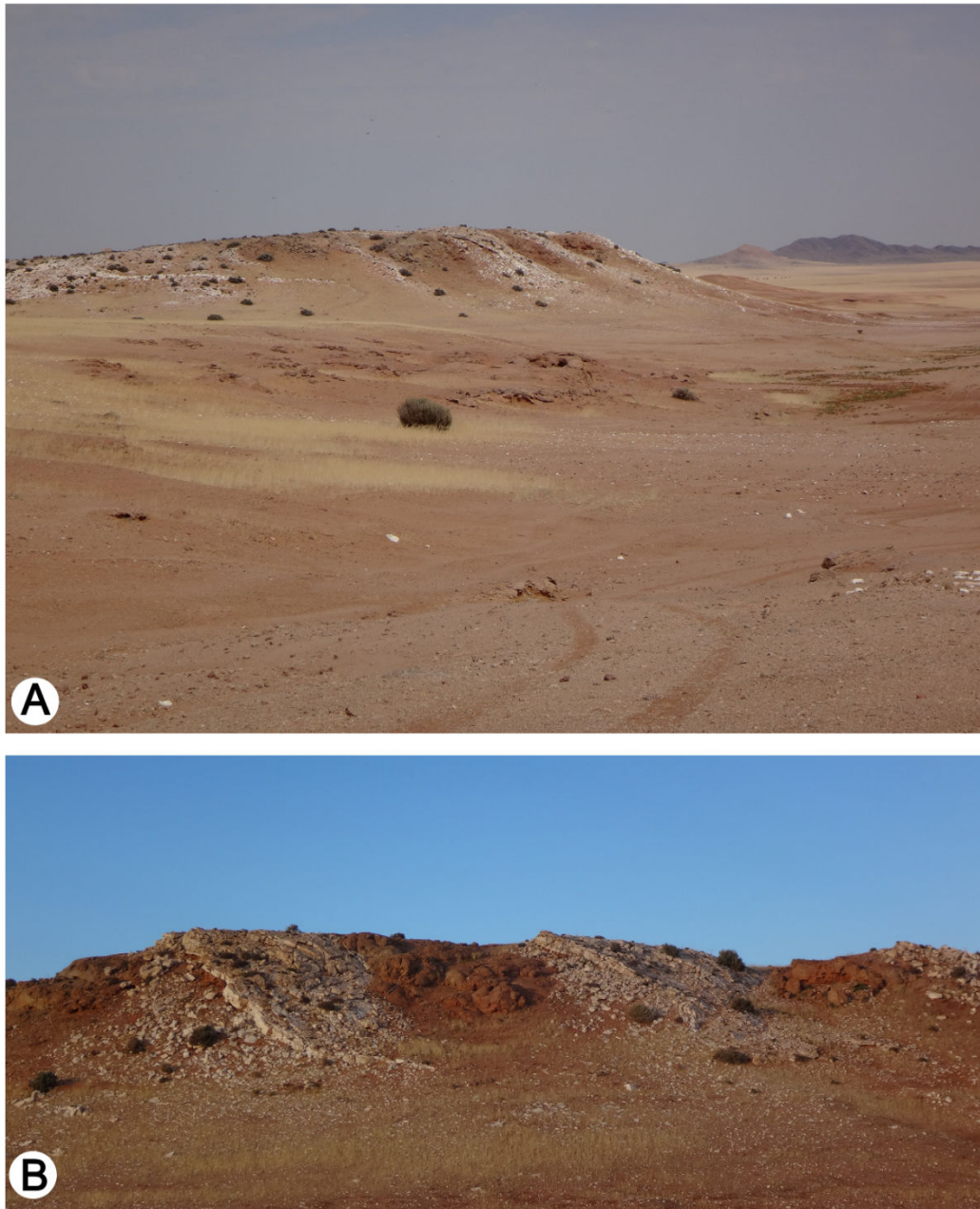
**Figure 2.** The travertine complex at Kaukausib Cliffs on the south bank of the Kaukausib Valley 1.5 km upstream from the currently active spring. Arrows show the main growth trajectories of the travertine lobes and clastic layers. Note the changes in the trajectories, thought to be related to the direction of the prevailing wind which changed over time. Note also the dwindling of travertine activity shown by the last five lobes in the northwest of the complex, prior to the system ceasing to function altogether (image modified from Google Earth).

The 18 or so travertine lobes at Kaukausib Cliffs were built up laterally for a distance of over 500 metres. Water seepage occurred preferentially in the north (broad white layers in

Fig. 2) and this is where the travertine deposits are thickest (one to three metres). Clastic deposition occurred preferentially on the west side of each travertine layer suggesting that the

prevailing wind at the time of deposition was from the East and South-east. During the early and middle phases of travertine deposition, the diameters of the lobes were about 300 metres from northeast to southwest. Towards the end of the life of the spring (the last five or six lobes) clastic sedimentation was preferentially to the north-west of the travertine lobes, indicating a shift in the prevailing wind

patterns to a more southerly wind regime. At the same time the vigour of the travertine deposition was fading with relatively small lobes being built up, only about 100 metres in diameter. The last lobe is fractured into two or three small areas only 20 to 50 metres in diameter, after which travertine deposition ceased.



**Figure 3.** Kaukausib Travertine Cliffs, Namibia. A) view from the south showing five of the sloping travertine layers interbedded with red sands and grit, B) view westwards showing three sloping layers of travertine with the basal part flattening out, intercalated with red sands.

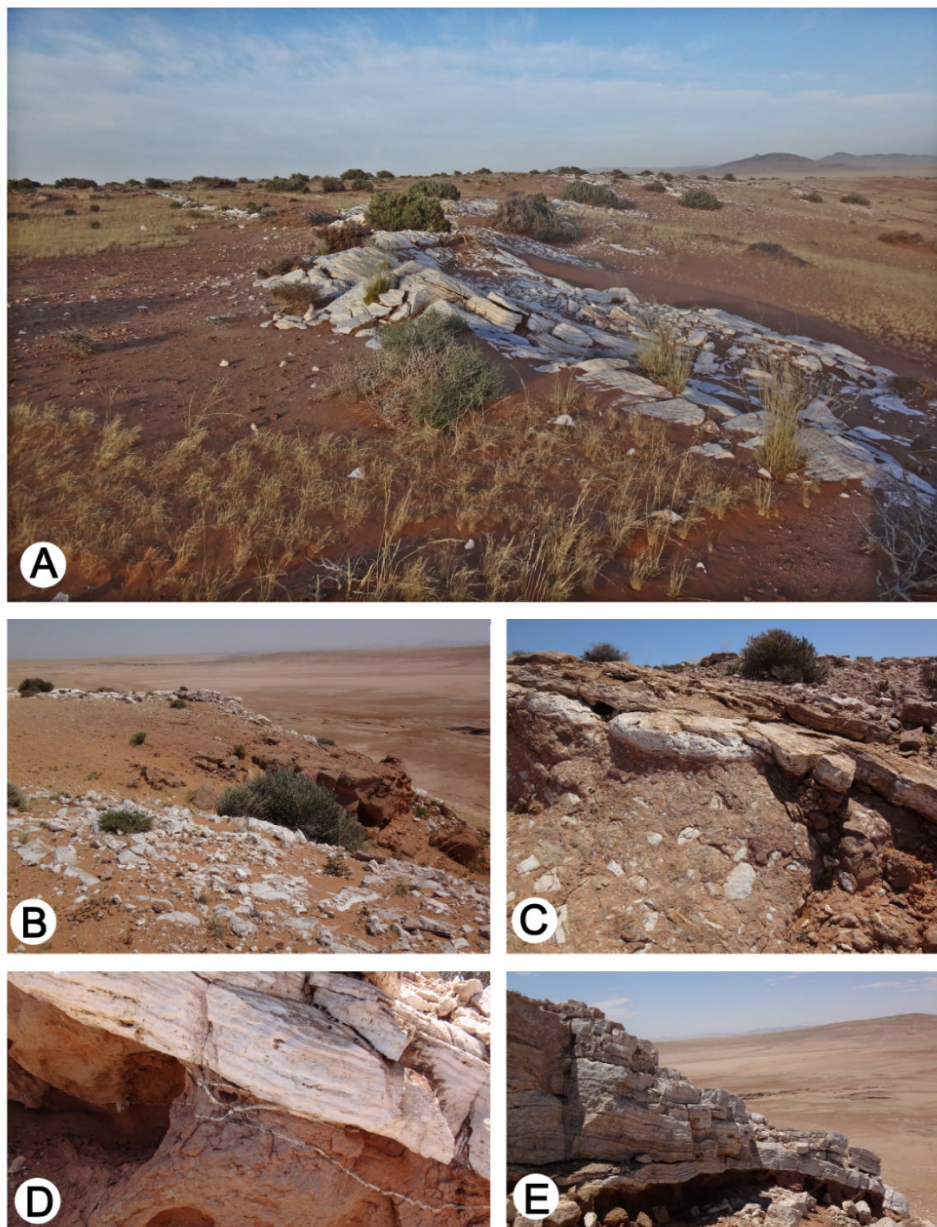
The formation of the Kaukausib Travertine Complex appears to have been influenced by the climatic regime prevalent at the time. When

the prevailing wind was from the East or Southeast, travertine deposition was at its greatest, suggesting a through flow of immense

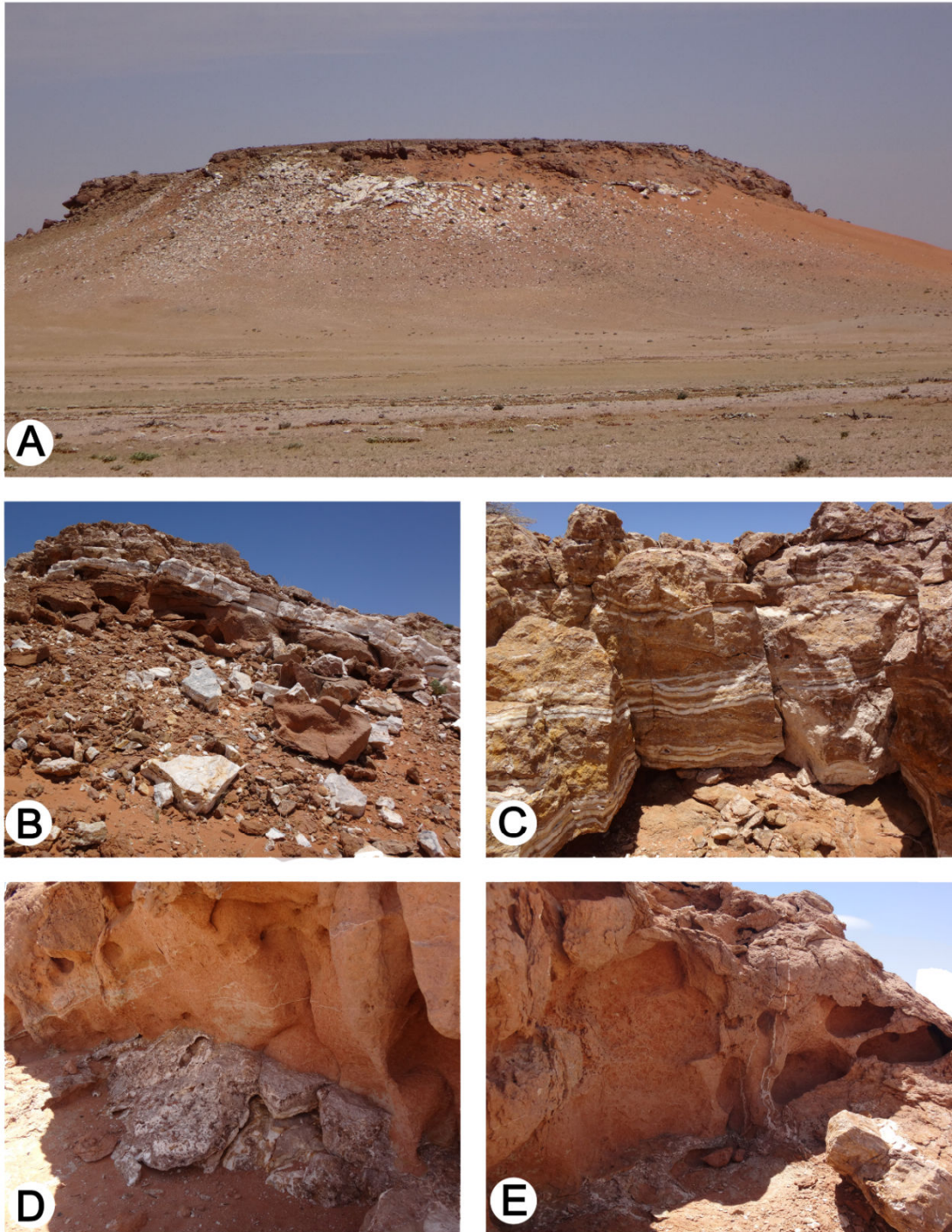
quantities of groundwater rich in carbonates seeping towards the surface. When the wind regime shifted to one with a greater component of South Wind, the quantities of groundwater seeping to the surface decreased dramatically, and after laying down five or six small lobes, travertine build-up died out completely. This suggests that the change in the wind regime was caused by a regional climatic change that either led to decreased groundwater volumes, or to a reduction in carbonate content in the

groundwater (warmer groundwater for example).

Where natural sections are exposed such as at Kaukausib Cliffs, Cup Hill and Discordant Hillock, thin veins of travertine can be observed criss-crossing the clastic sediments exposed in the sides of the hills. These were the channels via which the lime-charged groundwaters seeped to the surface, depositing thin veins of travertine as they warmed up on approaching the land surface (Figs 3, 4).



**Figure 4.** Kaukausib Travertine Cliffs, Namibia. A) Upper surface of the complex showing travertine layers extending over the landscape, separated from each other by red sandstone layers, B) two thick sloping layers of travertine separated by a 5 metre-thick red sandstone (the small pile of blocks in the centre of the image is rich in vertebrate remains), C) grey-red sand containing abundant blocks of eroded travertine, overlain by a sloping travertine layer and more red sandstone, D) detail of travertine veins traversing red sandstone and feeding upwards to the sloping travertine layer above, E) thinly bedded travertine and sandy travertine overlying red sandstone.



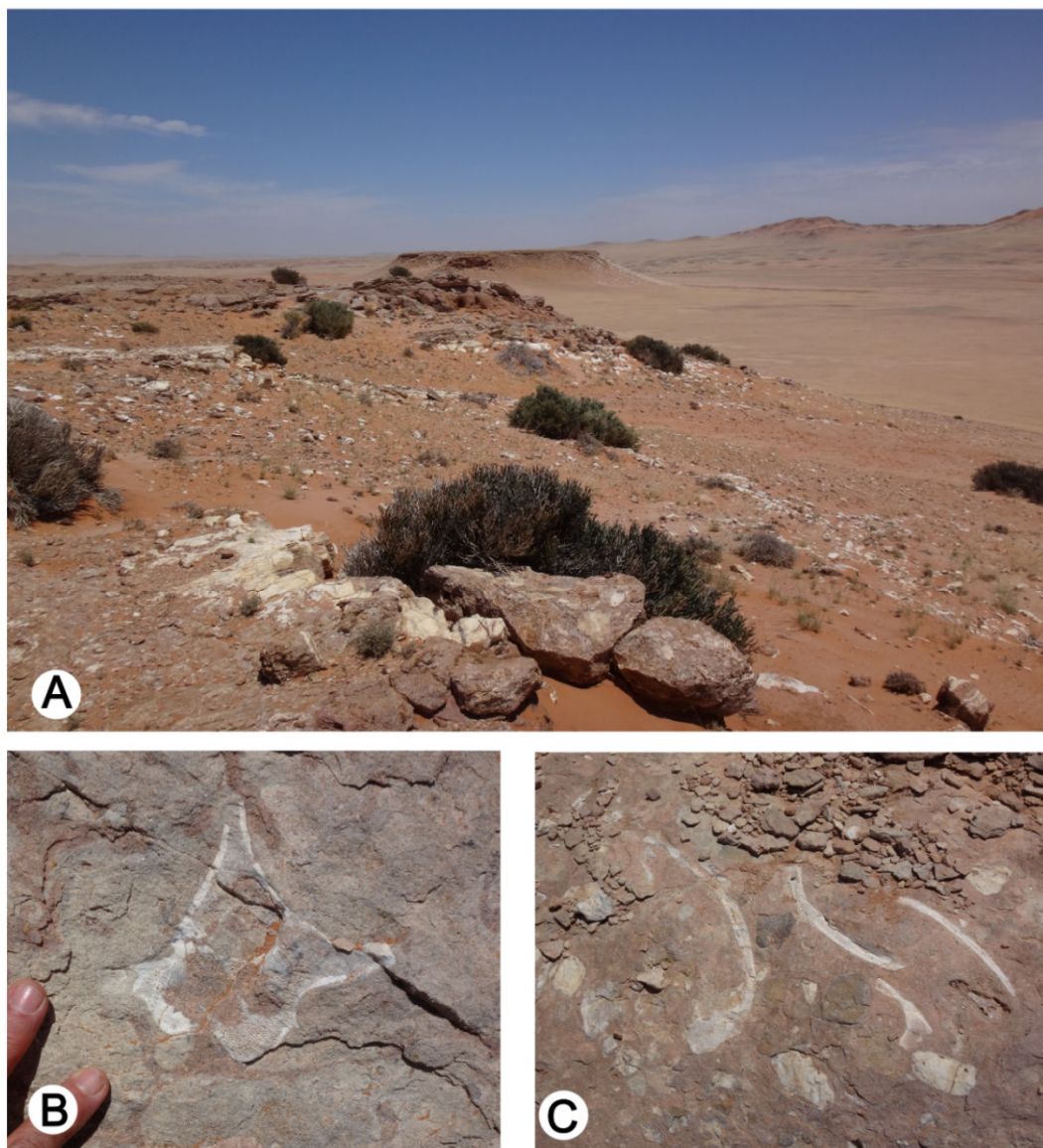
**Figure 5.** Travertine and sandstone at Cup Hill, Tsirub Valley, Namibia. A) view of hill from the north showing the sloping white band of travertine interbedded with red sandstone and the dark brown impure limestone horizon at the summit, B) sloping layer of travertine interbedded with red sandstone, C) interbedded thin layers of travertine and sand, D) apex of dome of travertine overlain by red sandstone, E) thin veins of travertine traversing red sandstone.

The layers of travertine which accumulated at the surface show many of the classic features of onyx travertine, such as varicoloured layering (predominantly white alternating with grey to brown layers), reniform and botryoidal structures, onion-skin textures, and thin lenses

of heavily calcified sand and silt. At the southern end of the small bluff comprising Travertine 2 (Table 1) impure travertine has been intensively brecciated, but elsewhere it shows well-developed botryoidal structures and varicoloured banding. At Cup Hill (Fig. 5), a

large hollow in the south side of the cliffs has exposed a dome of travertine at least three metres across and half a metre tall (the sides and base are obscured under cemented red sand, so the whole structure could be appreciably larger). The surface of the dome shows characteristic botryoidal structures, superficially rather like cauliflower heads.

In many places the travertine has merely cemented the clastic deposits through which the groundwater was percolating, but occasionally it produced small patches and lenses of pure travertine as witness of the process of calcification. These deposits are not to be confused with calcretes, which are pedogenic in origin.



**Figure 6.** Discordant Hillock in the Tsirub Valley, Namibia. A) view southwestwards of the top of the hillock with its travertine band interbedded with red sandstone (Cup Hill in the background), B) large mammal vertebra in grey-red sandstone, C) large mammal ribs in grey-red sandstone.

Most of the outcrops show that penecontemporaneous erosion of travertine was a common occurrence, with chunks of travertine caught up in subjacent clastic deposits as well as being recemented by continuing travertine deposition (Figs 4, 6). Under the circumstances,

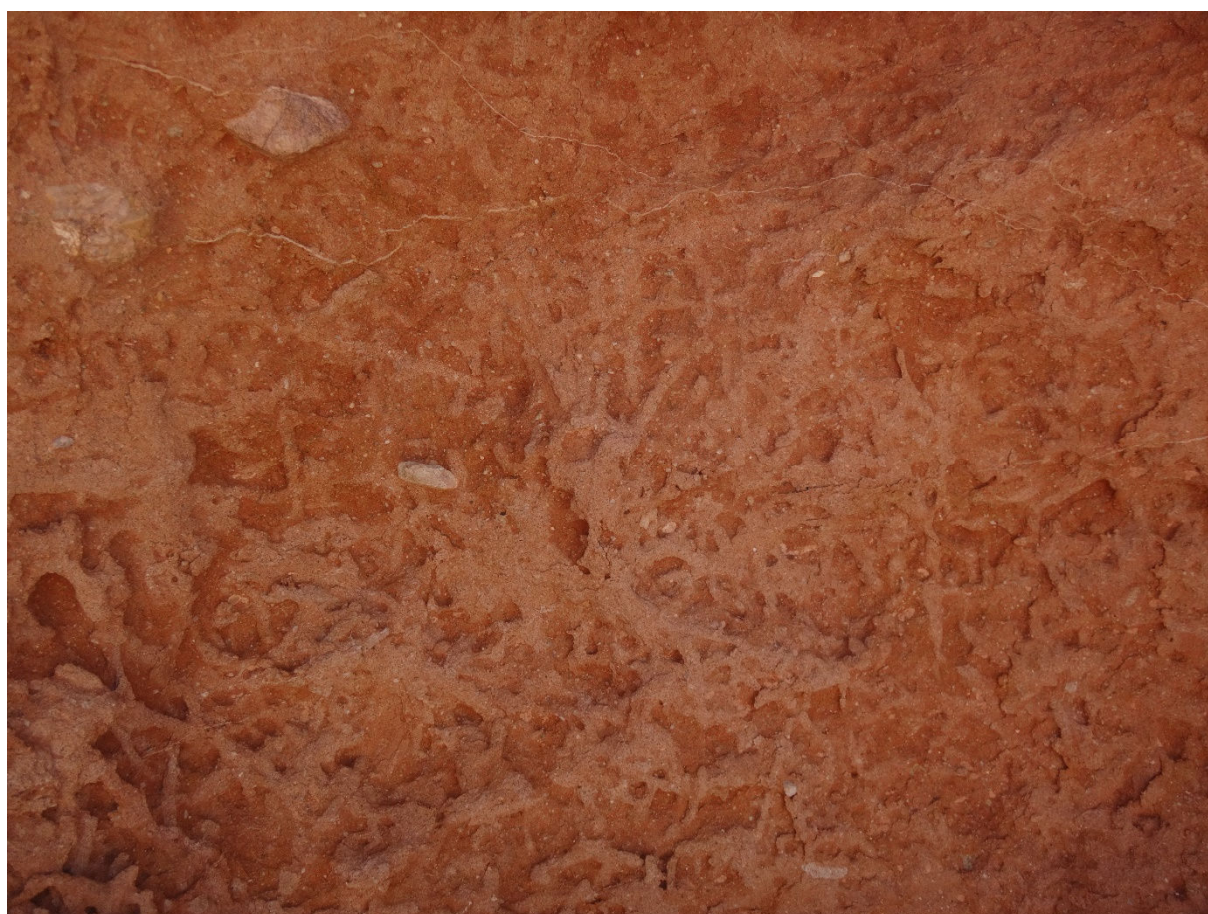
it would be difficult to reconstruct a highly detailed sedimentological history of the region, even though the major processes involved can be ascertained with a reasonable degree of precision.



## Palaeontology

The Tsirub « sheetwash » deposits are generally variegated reddish brown and are comprised of poorly sorted sand, grit and angular conglomerates, in many places showing pervasive evidence of the activity of plant roots and termite foraging tunnels (Fig. 7). The upper surfaces of the deposits are sometimes partly to substantially affected by calcrete pedogenesis. The form of the termite tunnels and some possible hive structures suggest that the termites responsible for the bioturbation were probably

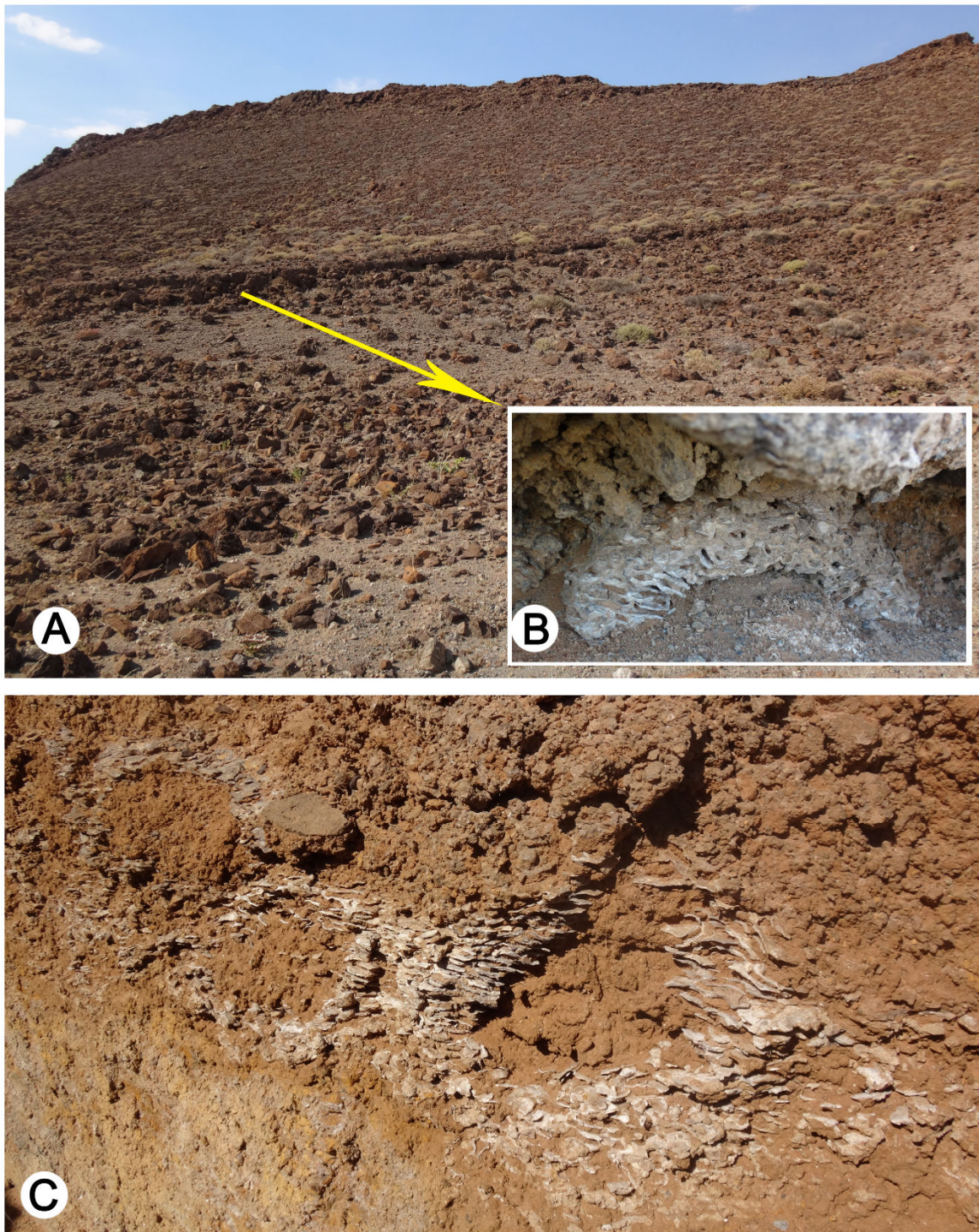
*Macrotermes* (mound-building termites) or a related group. *Hodotermes* (Harvester Termites) seem not to have left any traces in these deposits, but their hives (*Namajenga mwichwa* Pickford, 2008) are present in the nearby area of Teufelskuppe (26°52'11.0''S : 15°46'03.7''E : 631 m) where they occur in the silty layers beneath the calcreted slope scree fringing the hill, probably of Plio-Pleistocene age (Fig. 8).



**Figure 7.** Bioturbated red sandstone at Cup Hill, Tsirub Valley, Namibia. These traces are likely a mixed assemblage of rhizolites and termite foraging tunnels, possible of *Macrotermes*. Note the thin travertine veins in the upper half of the image

A second occurrence of fossilised hives of *Hodotermes* (*Namajenga mwichwa*) is at Keishöhe Carbonatite complex 35 km north of Teufelskuppe, and two km south of the Aus-Lüderitz road (26°36'06.4''S : 15°52'08.6''E : 678 m). Here a cluster of eight hypogean hives

is exposed in a prospecting trench in the southwestern outcrop, and there are probably others still buried in undisturbed ground (Fig. 8). The polycalate nature of the hives is a distinguishing feature of the harvester termite, *Hodotermes*



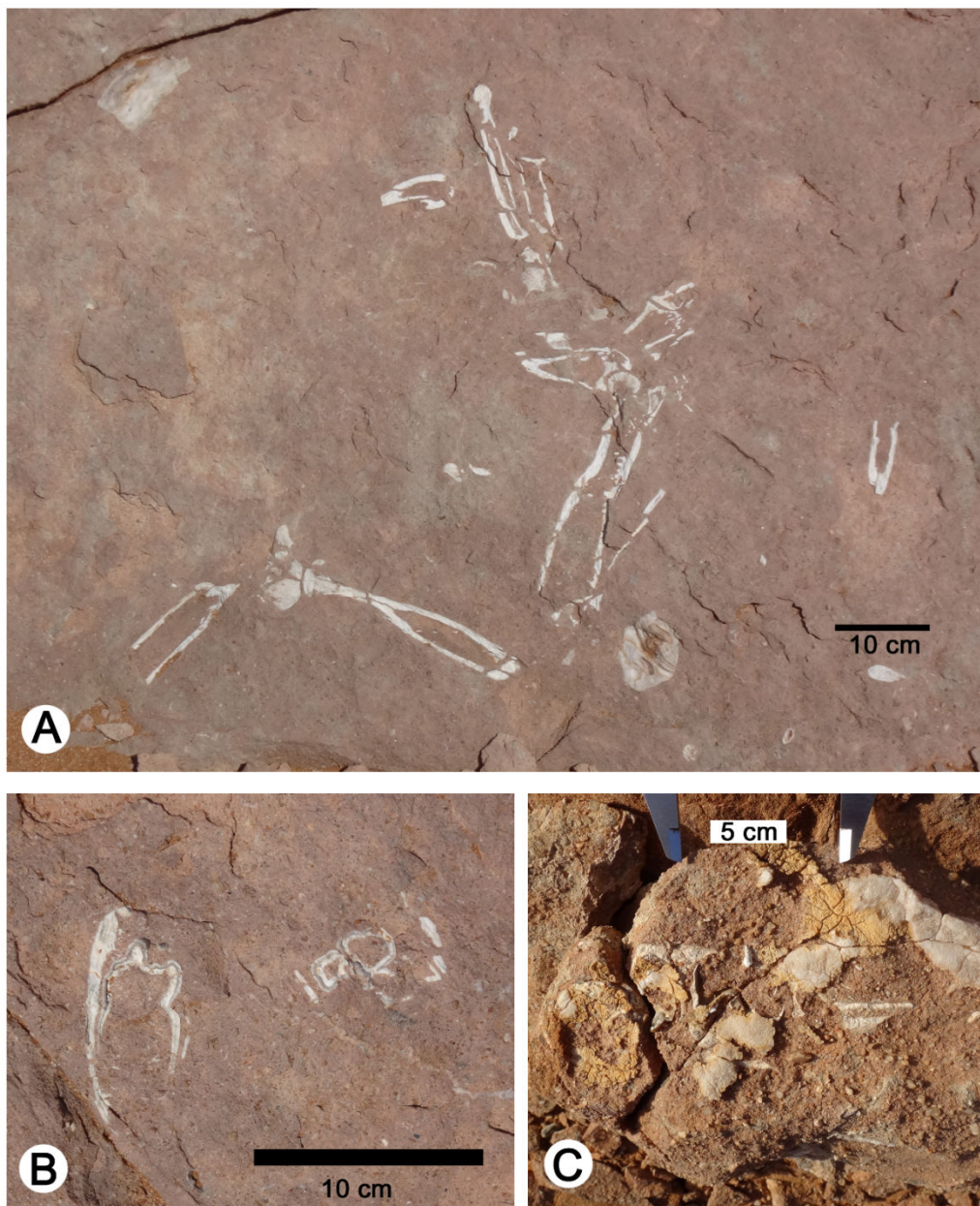
**Figure 8.** Fossilised hives (*Namajenga mwichwa*) of the harvester termite (*Hodotermes*) in the Sperrgebiet, Namibia. A) and B) at Teufelskuppe, beneath the cemented scree (base of yellow arrow), C) at Keishöhe, exposed in a prospecting trench. The hives are between 40 and 50 cm in diameter. Note the hypogeal polycalate Keishöhe occurrence showing four of the eight hives exposed.

The termite evidence, if correctly interpreted, would indicate that the so-called sheetwash deposits of the Tsiarub Valley contain evidence of the activity of *Macrotermes*, suggesting that the deposits accumulated under a savannah

palaeoclimatic regime, similar to the Outjo region today, whereas the younger layers with *Hodotermes* hives would have been deposited under a more arid, steppic palaeoenvironment, but not hyper-arid desert (Pickford, 2006).

The cemented grey sands sandwiched between travertine layers in the Kaukausib Cliffs yield bones and teeth of small to large mammals. One such locality contains a partial skeleton with articulated elements of a bovid the size of a Gemsbok (*Oryx gazella*) (Fig. 9). A second locality contains the jaws of a large suid, possibly *Notochoerus capensis* or a similar-

sized animal (Pickford & Senut, 1999) (Fig. 9). If the identification is valid, then it is inferred that the deposits accumulated during the middle Pliocene. A jaw of a springhaas (*Pedetes*) was noted at one outcrop. A lower third molar the size of a Springbok (*Antidorcas* sp.) was also found.



**Figure 9.** Fossil mammal remains in red sandstone at Kaukausib Travertine Cliffs, Namibia. A) partial skeleton of a bovid the size of a Gemsbok (*Oryx gazella*), B) suiform teeth, C) suiform mandible with two teeth (scales as indicated on images).

A similar occurrence of large mammal bones occurs in grey cemented sandstone at Discordant Hillock in the Tsirub drainage (Fig. 6). Exposed are half a dozen ribs, a vertebra, a long bone (radius) and several bone fragments

and a mandible with parts of two teeth of a rhinoceros (possibly *Diceros* sp. : to be confirmed). Nearby the mesa known informally as Cup Hill is capped by a limestone layer

which contains small unidentifiable bone fragments.

It is evident that further palaeontological research is warranted in the Tsirub Drainage in order to determine more precisely which fossil

mammals are preserved in the cemented sands, and thereby to estimate a more precise age for the period of sedimentation and travertine activity in the Tsirub region.

### Conclusion and Discussion

The Tsirub hydrographic network and the middle reaches of the Kaukausib Valley contain extensive exposures of onyx travertine and related types of lime-rich sediments which are intercalated with clastic sediments ranging from poorly sorted silts, through sands, grits and conglomerates. Two fossil occurrences have been recognised which yield large mammal bones probably of Pliocene age. The identifications of the mammals are preliminary and need to be verified after the fossils have been extracted from the exceptionally hard cemented sandstone in which they occur. The sands and grits in the Tsirub drainage are rich in bioturbation traces, probably of plants roots and termites suggestive of a savannah palaeo-environmental setting.

Younger (Plio-Pleistocene) cemented scree deposits on the flanks of Teufelskuppe and

Keishöhe (two carbonatite complexes) overlie a metre-thick layer of silt and sand in which calcified termite hives of the harvester termite, *Hodotermes*, are preserved. The latter taxon suggests a steppic palaeoenvironment under a summer rainfall climatic regime. Today the Tsirub area lies within the winter rainfall belt, but it is close to the boundary zone where rainfall occurs during both winter and summer. At the time that *Hodotermes* lived in the area it was not hyper-arid, like it is today, but was likely to have been somewhat more humid, probably steppe rather than savannah.

It is concluded that the travertine deposits in the Tsirub and Kaukausib hydrographic network probably accumulated during the Pliocene when the climate was likely more humid than it is today, and under a summer rainfall regime.

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