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Pleistocene large mammal bone breccia in calc-tufa, northern Kaokoland, Kunene Region, Namibia

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Abstract :- On account of the abundant plant, invertebrate and vertebrate fossils that they contain, the cascade tufa occurrences of the Kunene Region, Namibia, comprise an important source of information about past climates of the late Tertiary and Quaternary. Most of the vertebrate fossils thus far encountered in the tufas consist of microfauna, the remains of medium and large mammals being sporadic and rare. The discovery of a rich concentration of large mammal skeletal remains at Ozombindi, northern Kaokoland, is unusual, in that there are few if any small mammals associated with the bone-bearing lenses, which consist of vast quantities of fossil limb bones and jaws of zebras, large bovids, hyaenids and possibly rhinocerotids. The Ozombindi occurrence is interpreted to represent a natural trap that formed in cascade tufas during the early Pleistocene, into which animals fell but were unable to get out. Skeletal remains of many hundreds of individuals are preserved in an inextricable jumble of bones piled one upon the other in three dimensions. The aim of this article is to put on record the presence of the Ozombindi bone breccia, and to provide preliminary estimates as to its age and palaeoclimatic significance. Taphonomic studies will throw much light on the formation of this unique (for Namibia) concentration of fossil bones.

Key words :- Large mammals, Pleistocene, cascade tufa, bone breccia, natural trap, palaeoclimate

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Introduction

Field surveys carried out in Kaokoland, Namibia, during the past decade have recorded the presence of many examples of cascade tufas in the region between Sesfontein and Opuwo (Mocke, 2014; Pickford, 2019; Pickford *et al*. 2016a). Most of the occurrences have yielded plant fossils and invertebrate shells as well as abundant microfaunal remains and occasional large mammal bones and teeth. Some of the tufa deposits contain stone tools of Middle Stone Age and Late Stone Age aspect (Pickford, 2019, 2020).

Preliminary estimates of the age of the cascade tufa deposition in Kaokoland revolve around the Pliocene and Pleistocene, with hints that some of the older tufa lobes (mostly obscured by younger lobes) might be late Miocene. So far, though, the oldest fossils found in Kaokoland invite a mid-Pliocene correlation for a few of the older lobes, but the bulk of them are of Pleistocene age. Only a few of the tufa lobes are still actively precipitating carbonates, and these at an extremely reduced rate compared to the widespread and relatively rapid rates of deposition that occurred in the past.

The available evidence indicates that at times during the Pliocene and Pleistocene, the climate in the upland parts of Kaokoland (altitude greater than 1,000 metres) was cooler and more humid than it is today, producing conditions that promoted calcite solution by cold subterranean waters flowing through the dolomitic basement rocks of the aquifers, followed by deposition of calcite as the waters warmed up as they emerged at resurgences and springs or as the lime-charged waters became

turbulent at rapids and waterfalls or flowed gently over moss-covered zones where the phyto-environment altered the eH and pH of the waters, promoting precipitation.

A diversity of landforms resulted from tufa deposition, depending upon the geomorphological setting where precipitation occurred, including barrage tufas in long gently inclined valleys, bastion tufas in steep-backed valleys (Pickford *et al*. in press) and complexes of cascade tufas, conglomerates and calcrete in low-lying areas close to scarps. One such tufa-calcrete-conglomerate complex was recently recognised at Ozombindi (= Monument in the Herero dialect) in northern Kaokoland, 70 km by road northwest of Opuwo (Figs 1-3). The most extraordinary aspect of the Ozombindi complex is the presence of immense quantities of fossil bones of large mammals in the tufa, resembling log-jams in rivers.

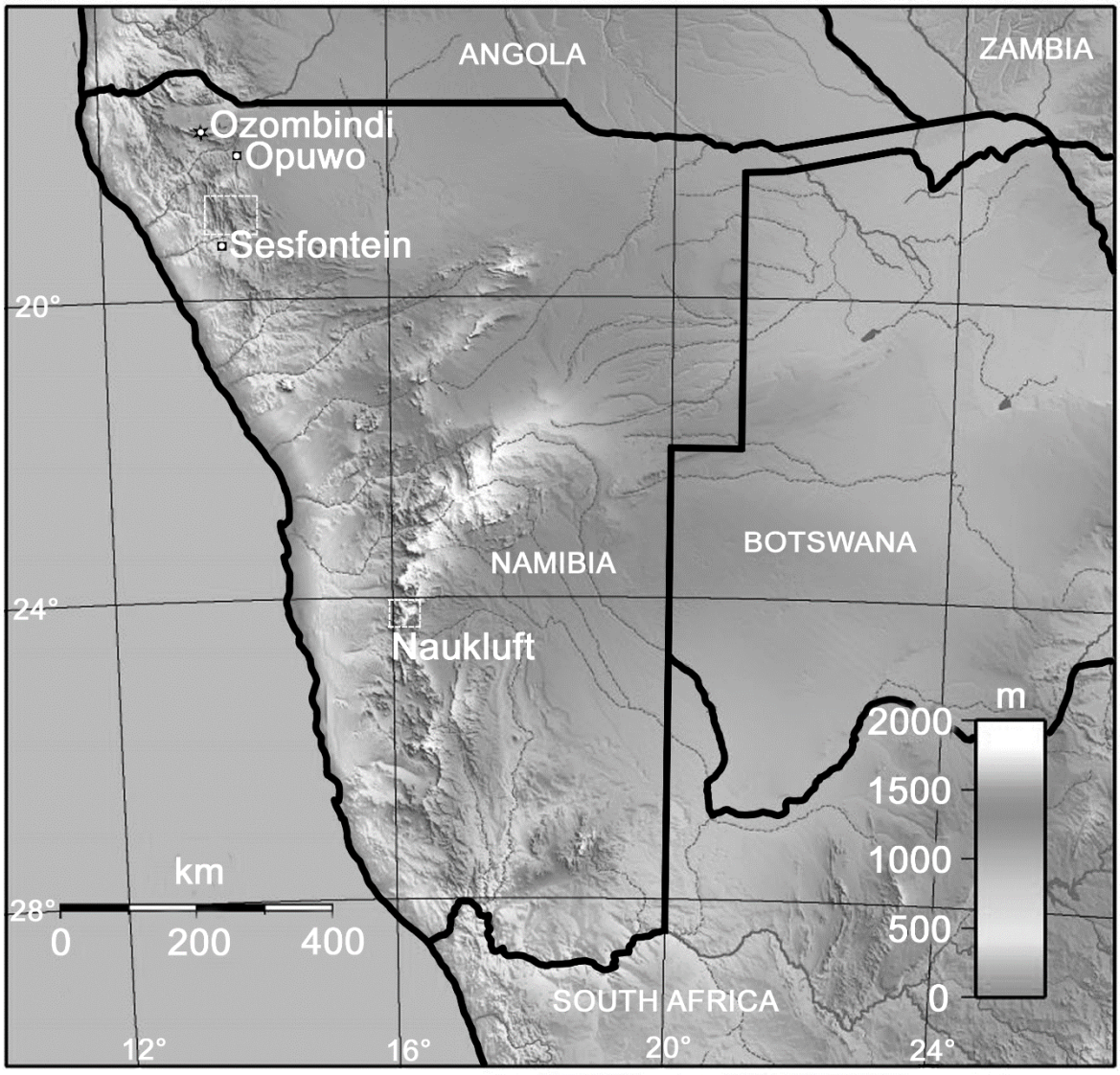


Figure 1. Monochrome Relief Map of Namibia showing the location of the Ozombindi bone breccias in Northern Kaokoland, northwest of Opuwo, relative to the clusters of cascade tufas close to Sesfontein and in the Naukluft Mountains (dotted rectangles : Pickford *et al*. 2016a).

The aim of this contribution is to put on record and to provide a preliminary interpretation of the Ozombindi carbonate complex and its fossils, and to estimate its age.

Discovery of the Ozombindi fossil site

The presence of fossil bones at Ozombindi was brought to the attention of the first author in March, 2022, by Gerrit Schoeman who learned of its existence from Miguel Lefequino, who reportedly noticed the bones while herding his flock of goats in the region. A brief survey of the deposits was carried out by the authors in June, 2022, in order to assess its scientific and socio-cultural potential. It is clear that some breccia blocks containing fossils have already been removed from the site, and that some of the *in situ* fossils have been tampered with, but overall, the occurrence was in good condition.



Figure 2. Ozombindi bluff (centre, left) viewed from the north. Bone breccia occurs at the top of the bluff and along its south-eastern slopes.

Geological setting

The Basement rocks at Ozombindi comprise Neoproterozoic sediments of the Nosib and Otavi groups (Schreiber, 2014) which overlie the Epupa Metamorphic Complex (Fig. 3). Dolomites in the Otavi and Nosib groups are the likely source of the carbonates that precipitated in the cascade tufa and calcrete deposits. Locally these Neoproterozoic rocks form elongated east-west ridges which have been incised by the present-day drainage system. At the downstream ends of valleys cutting through the ridges there are often relatively small patches of tufa, conglomerates and calcrete. The Ozombindi occurrence is one of the larger examples of these deposits, measuring ca 2 km in east-west diameter by 1.5 km north-south diameter, the thickness being variable (up to 30 metres in places) (Figs 4-5).

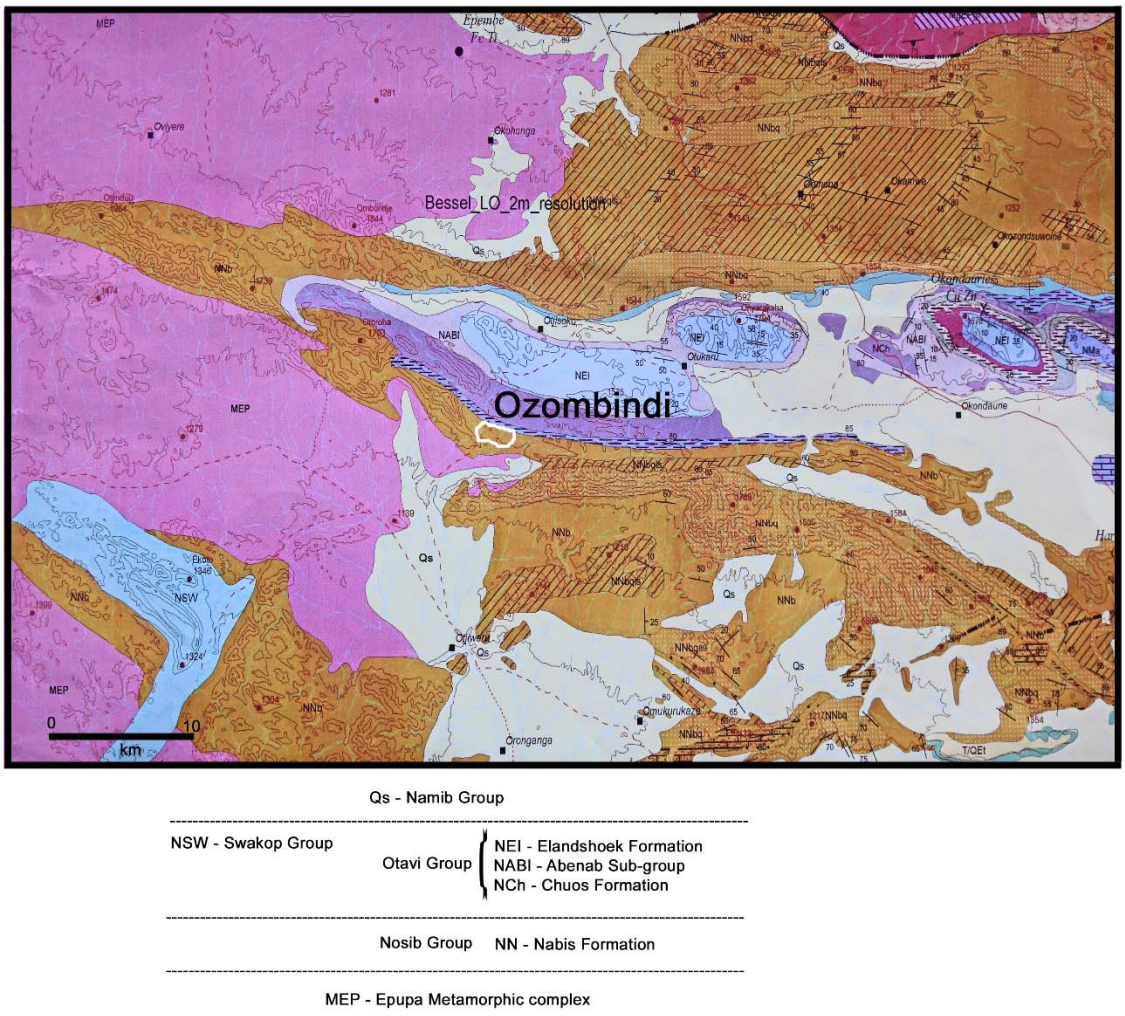


Figure 3. Geological substrate of the Ozombindi calc-tufa and calcrete complex (outlined in white). Base map is an extract from the 1 : 250,000 map sheet, Swartbooisdrif, Sheet 1712. The cascade tufas overlie rocks of the Nosib and Otavi groups.

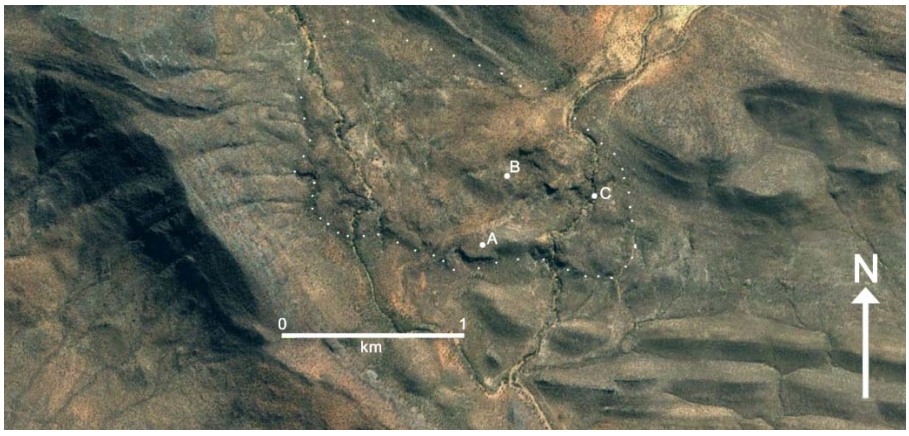


Figure 4. The Ozombindi Cascade tufa complex (white dotted outline – altitude ca 1200-1230 m) comprises several tufa lobes intercalated with calcrete, conglomerate and sands of the Quaternary Namib Group, overlying Basement complex rocks of the Nosib Group. Upstream are rocks of the Otavi Group, the likely source of the carbonates. 'A' is an aven (doline-like pit) in the calcrete plateau 15 metres deep, 'B' is the Ozombindi bone breccia occurrence and 'C' is the Pool Cave area which is rich in fossil plant impressions (Figs 11-12) (image modified from Google Earth).



Figure 5. Two of the flat-topped cascade tufa lobes in the Ozombindi carbonate complex forming cliffs in the landscape beneath high ridges of Basement rocks of the Nosib and Otavi groups. View eastwards from the bone breccia locality.

At the Ozombindi Bluff (altitude 1218 m) there are four discrete patches of bone-bearing deposits separated from each other by gaps of 30-40 metres, but it is not known whether these were once part of a single deposit or whether they represent distinct depositional clusters (Figs 7-9). The uppermost outcrop is an irregular rectangle in outline about 3 m x 3 m in diameter. 20 metres to the southwest there is a second spindle-shaped outcrop about 6 metres in north south extent by 3 metres at its broadest, narrowing to 0.5 m upstream and downstream. On the side of the bluff there is a third outcrop less than a metre long stuck to the side of the cliff, and there is a fourth outcrop a few metres lower down.

The bone-rich deposits consist of masses of fossil bones and teeth piled against each other with little or no sign of clastic sediment, and very little calcite matrix between the specimens. As such the bone-bearing deposit is less soluble than the surrounding calcareous tufa deposits and it forms resistant layers within the tufa complex. The contact zone between the bone breccia and the tufa is sharp. In one of the outcrops the breccia-tufa contact is vertical on one side and in others it is horizontal or shallowly concave beneath, which indicates that the breccias infilled fissures in the tufa, and thus post-date it.



Figure 6. 10 metre diameter aven developed in calcrete (the roof on which the person is standing) and underlying sediment as a result of piping processes (Pickford, 2018). The hole is ca 15 metres deep. Animals often fall into this hole and cannot escape unless they can climb the tree that is growing in it (at the right).



Figure 7. Dense concentration of large mammal limb bones and jaws infilling a former cavity or fissure in cascade tufa at Ozombindi, Kaokoland (outcrop 'B' in Fig. 4). The tufa walls of the fissure are more soluble than the breccia and have thus been dissolved, exposing a sharp contact between the older tufa and the younger breccia.



Figure 8. Spindle-shaped outcrop of bone breccia at Ozombindi, Kaokoland. The outcrop is ca 6 metres long by 3 metres at its broadest. Note the rillenkarren and rinnenkarren in the surrounding cascade tufa.



Figure 9. Bone-rich breccia stuck to the side of a former fissure in cascade tufa at Ozombindi, Kaokoland.

Locally, the tufa itself is deeply eroded and shows classic epikarst features such as clints and grikes, rillenkarren, rinnenkarren, solution cavities etc. (Pickford & Senut, 2010) (Figs 7-9). Close to one of the occurrences, there are deposits of flowstone and stalagmites (Fig. 10) which indicate speleothem activity within cavities or small caves developed in the tufa deposits.



Figure 10. Stalagmitic speleothem infilling an irregular floor of a fissure or small cave in calcareous tufa. At the time of formation this was a gour pool ca 1 metre in diameter. This outcrop is close to the Ozombindi bone breccia occurrences (vertical view from above).



Figure 11. Leaf impression in tufa at the Pool Cave occurrence at Ozombindi 'C' in Fig. 4.



Figure 12. Flowstone tufa encrusting roots and stems of plants at the Pool Cave locality at Ozombindi 'C' in Fig. 4.

Faunal content

It is difficult to identify most of the fossils at Ozombindi because they are still embedded in the calc-tufa and many are incompletely exposed. However, a few post-cranial specimens and isolated teeth or partial dentitions were well enough exposed to yield reliable information. Zebras appear to be dominant in the assemblage, an observation that is borne out by the presence of several teeth in maxillae and mandibles belonging to a species of large zebra, possibly *Equus capensis*. In the upper cheek teeth the protoconule is confluent with the protocone, so it is evident that the remains do not represent the extinct genus *Hipparion* (Fig. 13).

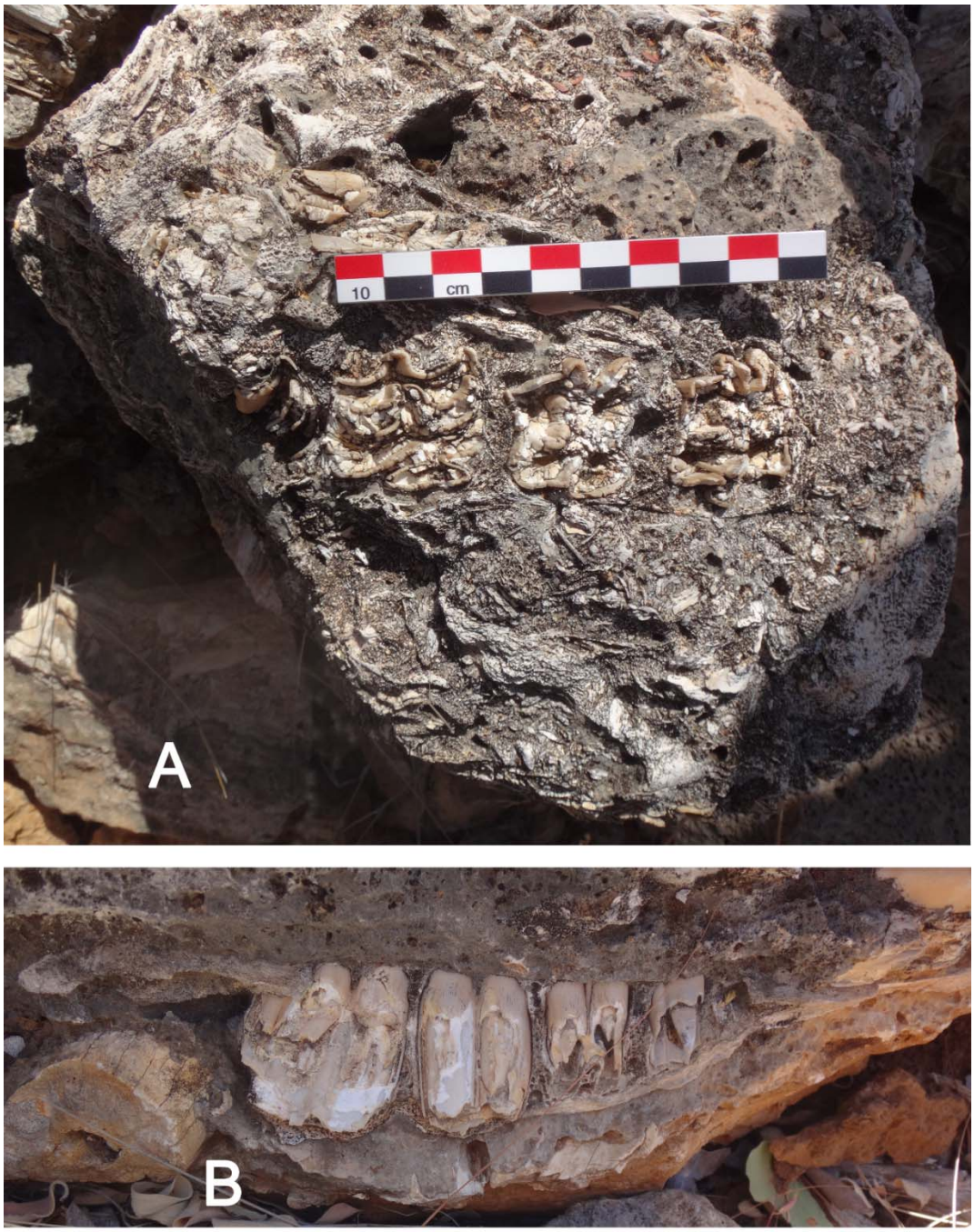


Figure 13. Maxillary (A) and mandibular (B) tooth rows of *Equus* sp. cf *capensis* at Ozombindi, Kaokoland. A) radicular view, B) buccal view.

Second in abundance are the remains of three or four species of bovids ranging in size from large reedbuck to eland (Figs 14, 15). Some of the mandibles agree in dimensions and morphology with the giant reedbuck *Redunca darti* which is an extinct species known from late Pliocene to early Pleistocene sites in southern Africa such as Makapansgat (South Africa) and Ekuma River (Namibia) (Pickford *et al*. 2016b). Other material is provisionally identified as wildebeest and gemsbok, but more detailed comparisons are required before this can be confirmed.

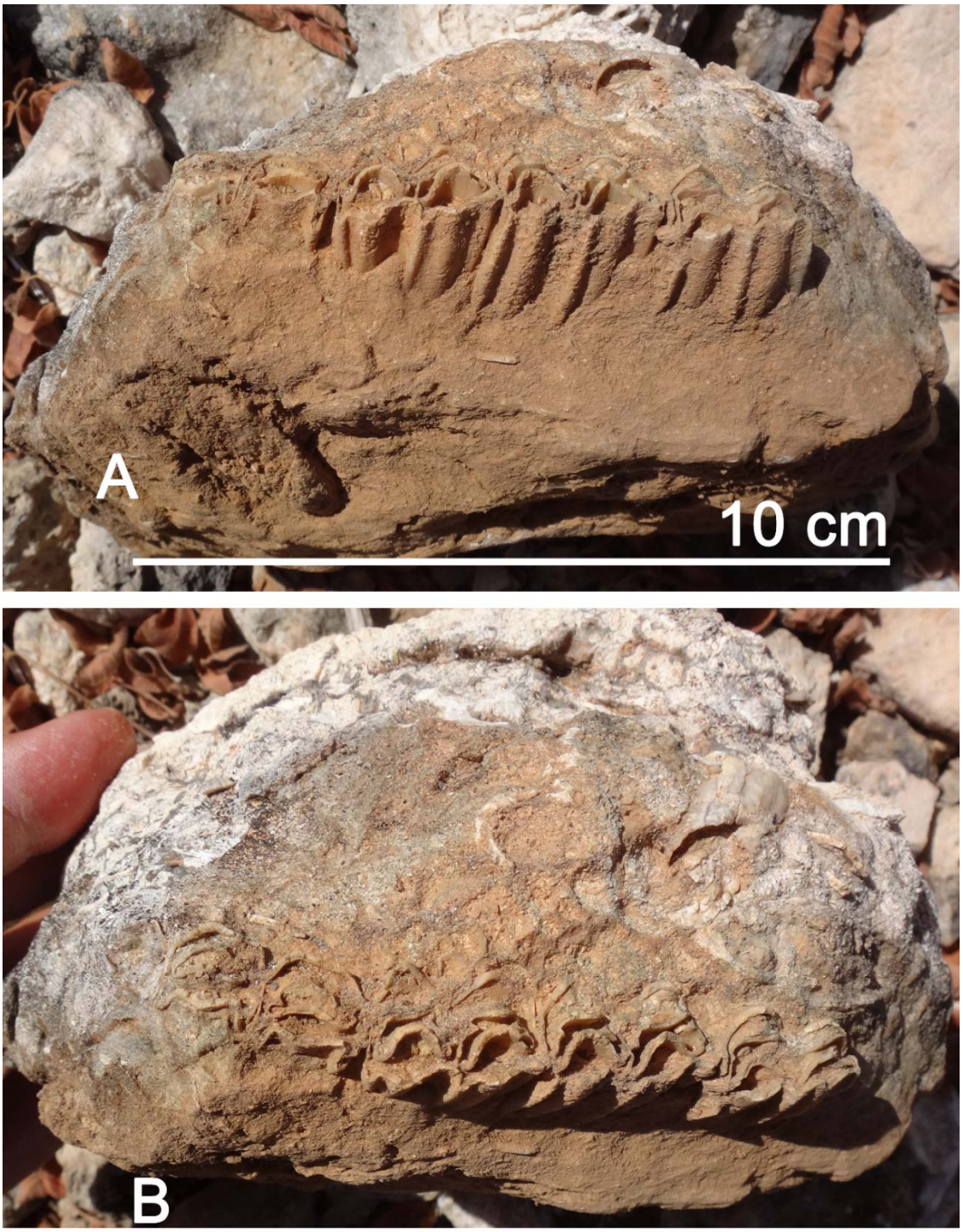


Figure 14. Bovid right upper cheek tooth row from the Ozombindi bone breccia, Kaokoland. A) Oblique bucco-occlusal view, B) occlusal view.



Figure 15. Fossil dentognathic remains of gemsbok-sized Bovidae from Ozombindi, Kaokoland, Namibia. A) right mandible, lingual view, B) left m/3, occlusal view.

Two of the specimens from Ozombindi belong to large carnivores such as hyaenids (Fig. 16), but the teeth are not well-enough exposed to yield confident identifications. In addition, there are fragments of very large limb bones that could represent the remains of rhinocerotids or even elephants.



Figure 16. Stereo occlusal view of a carnassial of a large carnivore, possibly hyaenid, embedded in bone breccia from Ozombindi, Kaokoland (scale divisions in mm).

Age estimate

The presence of the genus *Equus* at Ozombindi means that the deposit in which it occurs is probably younger than 2.33 Ma, the first appearance datum (FAD) of the genus in Africa (Bernor *et al*. 2010). The possible presence of the giant reed buck, *Redunca darti*, at Ozombindi needs to be confirmed, but if it is correct, then it would plead for an age close to

2.3 Ma for the deposits, this species being known mainly from late Pliocene of Makapansgat and Sterkfontein, South Africa (Gentry, 2010) and Ekuma, Namibia (Pickford *et al*. 2016b).

Further work is clearly required before a firm estimate can be made of the age of the Ozombindi bone breccias, but they are in any case likely to be Pleistocene on the basis of the presence of monodactyl horses therein.

Discussion

The discovery of the Ozombindi bone breccia in tufa deposits reveals that much remains to be done to document all the tufa occurrences in the Kaokoland region. Most of the previously recognised tufa occurrences have been mapped in the zone well to the south of Opuwo and relatively close to Sesfontein (Mocke, 2014; Pickford *et al*. 2016a; Pickford, 2019) but the one at Ozombindi is far removed from them, being 70 km by road to the northwest of Opuwo (Fig. 1).

Examination of Google Earth imagery indicates that there is a strong likelihood that there are other outcrops of tufa in the region between Opuwo and the Kunene River, and these should be systematically examined.

Currently available evidence suggests that the Ozombindi bone breccia is of early Pleistocene age, as are many of the other tufa deposits known in Kaokoland and the Naukluft Mountains (Pickford, 2020) as well as in southern Africa at places such as Taung.

The widespread occurrence of tufas in the arid upland parts of Namibia (1200-2000 m altitude) plead for more humid, cooler climatic phases during the Plio-Pleistocene than occur there today. At present, Kaokoland falls within the Mopane Woodland phytochore (White, 1983) but during cooler, more humid phases its vegetation would more likely have corresponded to Miombo woodland or even to wooded savannah.

The Ozombindi bone breccias and related tufa deposits are not only of scientific value, but they are also of interest from a socio-cultural perspective. The bone breccias in particular are visually impressive and if properly managed could comprise a point of attraction for educators and tourists. It is recommended therefore that the occurrences be protected as a natural resource, not to be exploited in such a way as to alter their visual impact. The fact that the surrounding countryside is also visually impressive with its hills, valleys, pools, cliffs, vegetation and wildlife, means that controlled tours including visits to the bone breccias, could be incorporated into a local tourism circuit for students, hikers and adventure seekers.

Conclusions

The discovery of bone breccias at Ozombindi, Kaokoland, so rich as to resemble log-jams in rivers, is important from several points of view – palaeontological, biochrono-logical, palaeoclimatic and potentially socio-cultural. These bone breccias are enclosed in calcareous tufa which precipitated from cool groundwaters emerging at springs and at cascades within the valleys cutting through the Nosib and Otavi Group rocks of the region.

The Ozombindi occurrence is unusual in that most of the bones are of large mammals (zebras, 3-4 bovid species, hyaenids, possibly rhinocerotids) unlike the majority of Kaokoland tufas which are generally rather poor in the remains of large mammals. The bone breccias lack clastic material, being almost entirely organic in content. As such they are more resistant to erosion than the surrounding tufas, which show classic epikarst features such as rinnenkarren, rillenkarren, clints and grikes.

The breccia deposits show sharp contacts with the surrounding tufas wich indicate that they post-date the tufa deposits, and that they thus represent infillings of cavities developed in the tufas. The presence of speleothems in the tufa deposits also indicates the former presence of cavities within them.

Finally, the tufas and their fossil content represent a potentially rich source of information about past faunas, floras and climate of the region.

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