Timing of landscape development and calcrete genesis in northern Namaqualand, South Africa

M. Pickford[a], V. Eisenmann[b] and B. Senut[b]

***Hipparion namaquense* from Areb, high Namaqualand, dates from the early Pliocene (*c.* 6–4 Myr ago). Its discovery in strata below 15 metres of calcrete provides biochronological control on some of the more recent geological and palaeoclimatological events in Northern Cape Province.**

Until recently, there have been few chronological controls on the timing of landscape development in the high interior of southern Africa. For this reason, estimates of the ages of geomorphological events have tended to vary widely, with many authors suggesting that the sub-Kalahari Basement erosion surface dates from the Cretaceous,[1,2] whereas others consider this surface to have undergone modifications as recently as the Pliocene.[3] Netterberg[4,5] considered that the so-called Kalahari limestone of eastern Namibia and nearby areas of Botswana and South Africa comprise important regional lithostratigraphic marker horizons that may be of value for establishing regional geochronologies.[6] If so, then the determination of the age of the calcretes in northern Namaqualand may be of use in a wider, Kalahari, context.

Evidence from Bosluis Pan indicates that fluviatile activity occurred in the Koa Valley during the Middle Miocene, followed by a period of aeolian deposition and calcrete genesis of unknown age.[7–9] At Areb, in granitic sands underlying a 15-metre-thick series of calcretes, several teeth of *Hipparion namaquense* were found in the early 1930s.[10] Comparison of these specimens with material from other parts of Africa indicate that they date from the early Pliocene some 6–4 Myr ago. The northern Namaqualand calcretes at Areb are thus younger than basal Pliocene, and it is likely that those at Bosluis Pan and elsewhere in the region are also relatively young.

Palaeontology, local geological context and biochronology

The site of Areb, 40 km east of Springbok [29° 30′ 52.3″ S : 18° 14′ 50.3″ E (WGS 84 datum)] yielded a set of associated lower teeth that comprise the holotype of *Notohipparion namaquense* Haughton, 1932. Near the farmhouse at Areb there are two hand-dug pits some 18 metres deep, which pass through about 15 metres of calcrete before terminating in clay and granitic grits overlying granite. It was from the granitic grits that the teeth are reported to have come. The altitude of the surface at the wells is close to 980 metres (Fig. 1). Thus, the *Hipparion* teeth came from about 964 metres above sea level. The fossil sample (South African Museum No. 9982) consists of fairly worn, lower left P_2–M_1 and M_3 and lower right P_4–M_2 from a single individual.[10] For an equid the teeth are not very hypsodont. Even though the crowns of the P_3–M_2 are lower than 30 mm, the enamel pattern is still clearly discernible (Fig. 2). The double knot is not caballine, but only caballoid. Small ectostylids are visible on the right P_4 and on the M_1 and M_2.

In South Africa, the *Hipparion* from E Quarry at Langebaanweg has similar caballoid enamel patterns but no ectostylids. Nor are there ectostylids in the caballine and certainly much younger *Hipparion baardi* from Baard's Quarry.[11,12] There is, however, a premolar series with caballine enamel pattern and small ectostylids found between E and C quarries at Langebaanweg, which was referred to *Hipparion* cf. *namaquense* by Hooijer.[13] From this evidence it appears that *H. namaquense* from Areb is probably younger than the *Hipparion* from E Quarry but older than *H. baardi,* and it is possibly somewhat older than the specimen found between E and C quarries. In East Africa, cheek teeth with similar morphology occur in sites aged 6–4 Myr.[14]

Geomorphology and discussion

The Areb fossil site lies slightly uphill from a gap between two steep hills, to the north the hill on which the farmstead of Areb is located, to the south the hill known as Bakenskop (Fig. 1), which ascend to 1125 and 1040 metres, respectively. These hills comprise part of a ring of high ridges that encloses a flat area between 980 and 1020 metres a.s.l. (above sea level). The present-day drainage cuts from south to north through this ring of hills, indicating that they are residuals above a wider erosion surface, the Post African I surface of Partridge & Maud,[15] which locally lay at *c.* 964 metres a.s.l. In Namaqualand this erosion surface has been buried by extensive sheets of calcrete and wind-blown sands[16] to a depth of at least 16 metres. The clay and granitic grits that underlie the calcretes at Areb are of basal Pliocene age (*c.* 6–4 Myr). Further to the east, at Bosluis Pan, a comparable sequence of strata fills the ancient Koa Valley,[9] but in this case the basal clays and silts are Middle Miocene (*c.* 16 Ma).

Climatic change was probably a major factor in causing the switch from an erosional to an accumulation regime in northern Namaqualand after the early Pliocene. It is unlikely that crustal warping related to the Griqualand-Transvaal Axis of Partridge & Maud[15] has played any significant role in local tectonics since the early Pliocene because play along this axis would most likely have increased relief between Areb and the Orange River to the north, which would have thereby enhanced erosional tendencies rather than reducing them.

Taken together, the evidence from Bosluis Pan and Areb underscores the fact that much of the interior of Namaqualand inland from the Great Escarpment has been extremely stable from a geomorphological point of view for the past 16 million years and has as a consequence undergone very little erosion. The exceptionally slow rates of erosion in high Namaqualand contrast with erosion rates of up to 15 metres per million years calculated for the Namib coastal strip and the Otavi Mountains, Namibia and the Kwihabe Hills, Botswana (M.P. and B.S. in prep.).

Even though Areb lies well south of the Kalahari Basin, the geological and palaeoclimatic events that took place there may provide evidence concerning the timing of the onset of arid conditions in the subcontinent.[5] Pickford[3] has already suggested that northwestern Kalahari (Kwihabe and Koanaka) was more humid during the Pliocene than it was during the Pleistocene (the Pliocene was a period of cavern formation, whereas the Pleistocene saw the infilling of caves with aeolian sands and fossils). Calcretes in the Koanaka and Kwihabe region, northwestern Botswana, accumulated at the same time as the cave breccias, which are of early Pleistocene age. In the Kamberg

[a]Laboratoire de Paléontologie, URA 8569 du CNRS, 8, rue Buffon, 75005, Paris, and Chaire de Paléoanthropologie, Collège de France, 75005, Paris, France.
E-mail: pickford@mnhn.fr

[b]Laboratoire de Paléontologie, URA 8569 du CNRS, 8, rue Buffon, 75005, Paris.

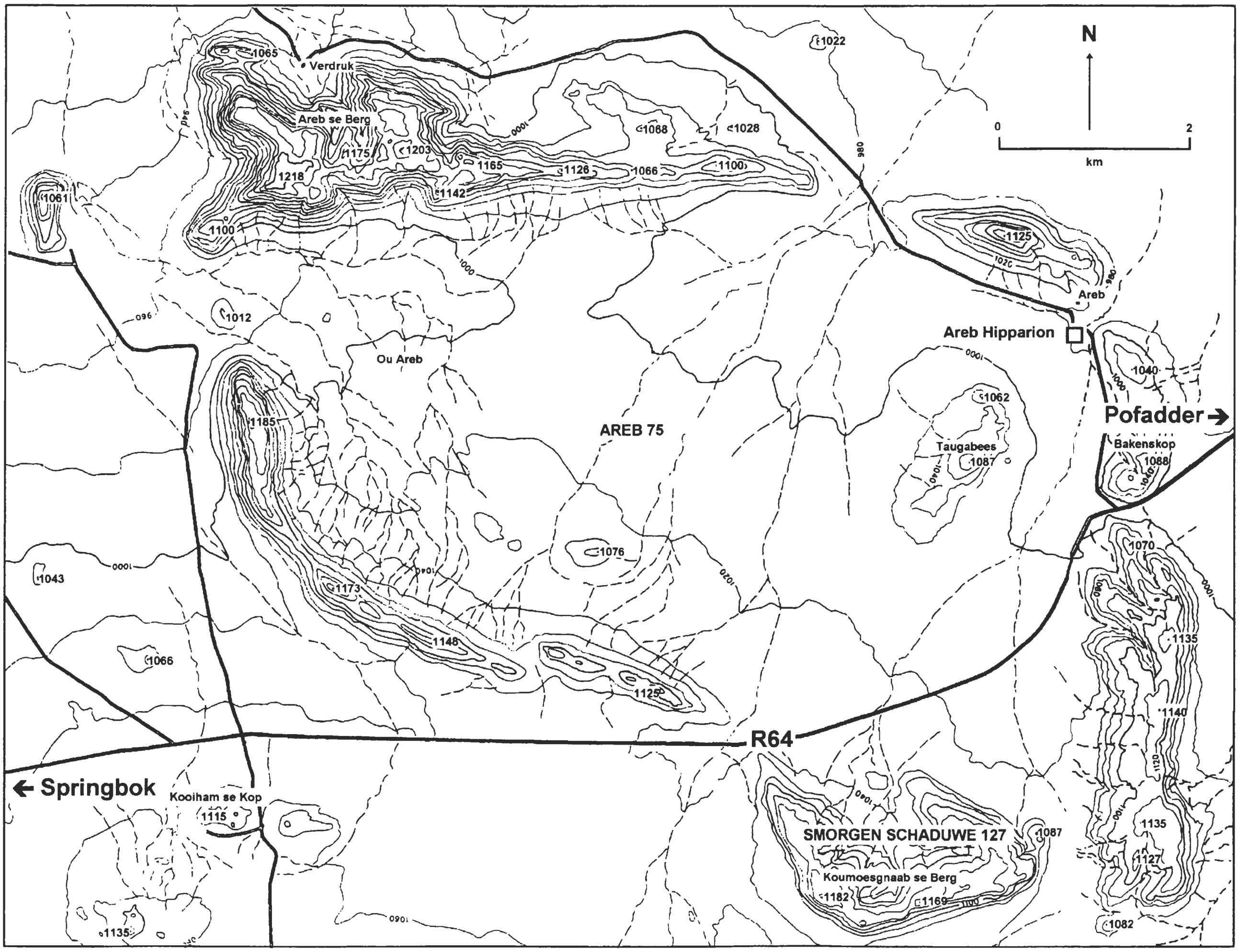

Fig. 1. Topography of the Areb Hills, northern Namaqualand, and location of the Areb *Hipparion* locality.

region of the Namib Desert and elsewhere in the coastal plain of Namibia and coastal Namaqualand, South Africa, all the dated calcretes are of Pleistocene to Holocene age (M.P. and B.S. in prep.). The Areb occurrence lends additional weight to the conclusion that most if not all southern African calcretes are relatively young, the fossils from the site proving that, locally at least, they must be younger than early Pliocene. Red sands at Bosluis Pan yield modern ostrich shells[17] as well as Middle Stone Age tools.

Conclusions

The Areb locality, even though it has yielded only a few fossils, is important because it provides chronological constraints for certain geological and palaeoclimatic events that took place in Namaqualand. The widespread calcretes of northern Namaqualand are likely to date from post-Pliocene times. At Areb more than 15 metres of calcrete has accumulated, and this has had the effect of evening out the landscape which during the early Pliocene was more deeply incised than it is now. Much of the planar landscape in northern Namaqualand is underlain by similar calcrete sheets that cover much of the region, and are in their turn overlain by red wind-blown sands of latest Pleistocene to Holocene age.

The main topographic relief in the region, including the Areb Hills, consists of ridges and mountains that lie above the African surface. The Areb fossil locality is associated with a drainage network which altitudinally was probably related to the Post African I surface, which must therefore have been actively eroding until the early Pliocene. The cause of the change from an erosional to an aggradational regime in the region is not yet known, but it was probably due in the main to climatic change from relatively humid before to arid later. The postulated climatic change occurred some time near the Pliocene-Pleistocene boundary.

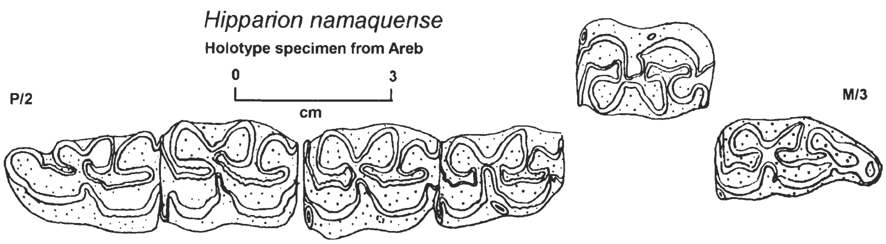

Fig. 2. Occlusal view of part of the holotype of *Hipparion namaquense* from Areb, Namaqualand, Northern Cape Province (after Haughton[10]).

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1 Passarge S. (1904). *Die Kalahari*. Dietrich Reimer, Berlin.
2. Thomas D. and Shaw P. (1990). The deposition and development of the Kalahari Group sediments, central southern Africa. *J. Afr. Earth Sci.* **10**, 187–197
3. Pickford M. (1990). Some fossiliferous Plio-Pleistocene cave systems of Ngamiland, Botswana. *Botswana Notes and Records* **22**, 1–15.
4. Netterberg F. (1969). Ages of calcretes in southern Africa. *S. Afr. Archaeol. Bull.* **24**, 88–92.
5. Netterberg F. (1978). Dating and correlation of calcretes and other pedocretes. *Trans. Geol. Soc. S. Afr.* **81**, 379–391.
6. Deacon J. and Lancaster N. (1988). *Late Quaternary Palaeoenvironments of Southern Africa*. Oxford Science Publications, Oxford.
7 De Wit M.C.J. (1990). Palaeoenvironmental interpretation of Tertiary sediments at Bosluis Pan, Namaqualand. In *Palaeoecology of Africa*, **21**, ed. K. Heine, pp. 101–118.
8. De Wit M.C.J. (1993). *Cainozoic evolution of drainage systems in the north-western Cape*. Ph.D. thesis, University of Cape Town.
9. Senut B., Pickford M., De Wit M., Ward J., Spaggiari R. and Morales J. (1996). Biochronology of sediments at Bosluis Pan, Northern Cape Province, South Africa. *S. Afr. J. Sci.* **92**, 249–251
10. Haughton S.H. (1932). The fossil Equidae of South Africa. *Ann. S. Afr. Mus.* **28**, 407–427.
11. Hendey Q.B. (1978). The age of the fossils from Baard's Quarry, Langebaanweg, South Africa. *Ann. S. Afr. Mus.* **75**, 215–247
12. Hendey Q.B. (1983). Southern African late Tertiary vertebrates. In *Southern African Prehistory and Palaeoenvironments*, ed. R.G. Klein, pp. 81–106. Balkema, Rotterdam.
13. Hooijer D.A. (1976). The late Pliocene Equidae of Langebaanweg, Cape Province, South Africa. *Zool. Verhandel.* **148**, 1–39.
14. Eisenmann V. (1994). Equidae of the Albertine Rift Valley, Uganda. In *Geology and Palaeobiology of the Albertine Rift Valley, Uganda-Zaire*. Vol. 2 : *Palaeobiology*, eds B. Senut and M. Pickford. CIFEG Occas. Publ. **1994-29**, 289–308.
15. Partridge T.C. and Maud R.R. (1987). Geomorphic evolution of southern Africa since the Mesozoic. *S. Afr. J. Geol.* **90**, 179–208.
16. Le Roux J.S. (1992). Linear dunes near the Orange River: origin, mineralogy and climate. *S. Afr. Geogr. J.* **74**, 3–7.
17. Mourer-Chauviré C., Senut B., Pickford M., Mein P. and Dauphin Y. (1996). Ostrich legs, eggs and phylogenies. *S. Afr. J. Sci.* **92**, 492–495.