Palaeont. afr., **32**, 33-37 (1995)

FOSSIL EGGS AND CENOZOIC CONTINENTAL BIOSTRATIGRAPHY OF NAMIBIA

by

Brigitte Senut[1] and Martin Pickford[1, 2]

[1]*Laboratoire de Paléontologie du Muséum National d'Histoire Naturelle, 8, rue Buffon, 75005, Paris, France*
[2]*Collège de France, 11, Place Marcellin Berthelot, Paris France*

ABSTRACT

One kind of aepyornithoid and six kinds of struthious eggshells have been found in Cenozoic deposits of Namibia. Field evidence indicates that the six struthious egg types are time successive, and they thus form a useful basis for determining the relative stratigraphic positions of sites at which they occur. Their placement in the geological time scale has been partly tied down by reference to the biostratigraphic position of mammals that occur in association with them.

INTRODUCTION

Fossil eggshells have been found at more than 70 localities in Namibia. Most of them occur in aeolianite successions of the Namib Sand Sea which crops out extensively in the coastal fringe of Namibia as far inland as 100 km.

Fragments of fossilised 'ostrich' eggs have been known to occur in the region for a long time, but it was only in the 1970's and 1980's that geologists W. Shaw, I. Corbett, J. Teller and J. Ward and ecologist M. Seeley collected specimens for study (Ward and Corbett, 1990). At the invitation of NAMDEB (formerly CDM (Pty) Ltd, the Namibia Palaeontology Expedition has carried out research on the eggs in the hope of learning something about them, since the surface morphology of most of the specimens was clearly different from that of modern ostriches (Corbett, 1989).

Initial estimates of a lower Miocene age for the aeolianites at Rooilepel (Pickford, *in* Corbett, 1989) were based on the presence of incisors of *Parapedetes namaquensis* (initially mis-identified as *Paraphiomys pigotti* on account of the overall similarities in size and morphology of the incisors of these two taxa). Subsequent work by the Namibia Palaeontology Expedition on abundant micromammals associated with the eggshells has confirmed this age estimate (Senut *et al.*, 1994) and has shown that aeolianites were accumulating in the region at intervals throughout the Miocene and subsequent periods, albeit with stratigraphic gaps represented by super bounding surfaces, non-deposition and erosion.

Sauer (1966) had previously described eggshell fragments form a borehole at Beisebvlakte (Etosha), northern Namibia, as belonging to *"Struthio" oshanai*. He estimated a Pliocene age for the species. In the early 1980's, J.D. Ward discovered eggshells of *"S." oshanai* in Tsondab Sandstone at the Elim Gullies, northeast of Sesriem, on the eastern fringe of the Namib sand sea. These fragments were from the base of the aeolianite succession, and a Pliocene age for the specimens seemed unlikely. Further eggshell specimens were found at Schmidtfeld by W. Shaw, at Kolmanskop and Grillental by I. Corbett and later by the authors, at Kahari and Narabeb by M. Seeley, at Nutab and West Pan by J. Teller and J. Ward and at Tjirundo by J. Ward. Prospecting by M. Pickford, R. Swart and J. Gold in the Tsauchab (Sesriem) area in 1992, resulted in the discovery of several more eggshell sites. In 1992, aepyornithoid eggs were found at Elisabethfeld by B. Senut and other members of the Namibia Palaeontology Expedition (Senut *et al.*, 1995). Abundant aepyornithoid eggshells with pores deposed in parallel slit like furrows were found *in situ* in the Kamberg area in 1994 by J. Ward and the authors. From this wide scatter of sites it became evident that fossil eggshells would probably be found throughout the Namib Sand Sea. Such has indeed been the case, these and subsequent surveys having discovered over 70 localities (Pickford and Dauphin, 1993; Pickford *et al* 1993; Senut *et al.*, 1994, in press). Some sites are extremely rich in eggshells (thousands of specimens) while others may be poorly endowed with them. Only a few outcrops of aeolianite are devoid of eggshells.

Thus, in Namibia, fragments of struthious eggs are proving to be ideal for biostratigraphy. They are abundant and widely distributed, their morphology changed through geological time in a way which has now been securely documented, and the species to which they belong is easily determined in the field.

DISTRIBUTION OF FOSSIL EGGSHELLS IN NAMIBIA

Thus far, eggshell fragments have been discovered at more than 70 localities in Namibia (Table 1) (Figure 1), and the number of sites is sure to increase as new areas are prospected. An important point is that several of the localities at which eggshells have been collected have also yielded fossil mammals, which permit the ages of the strata to be determined within reasonable limits. It is clear that the Namib sites span much of the Neogene period.

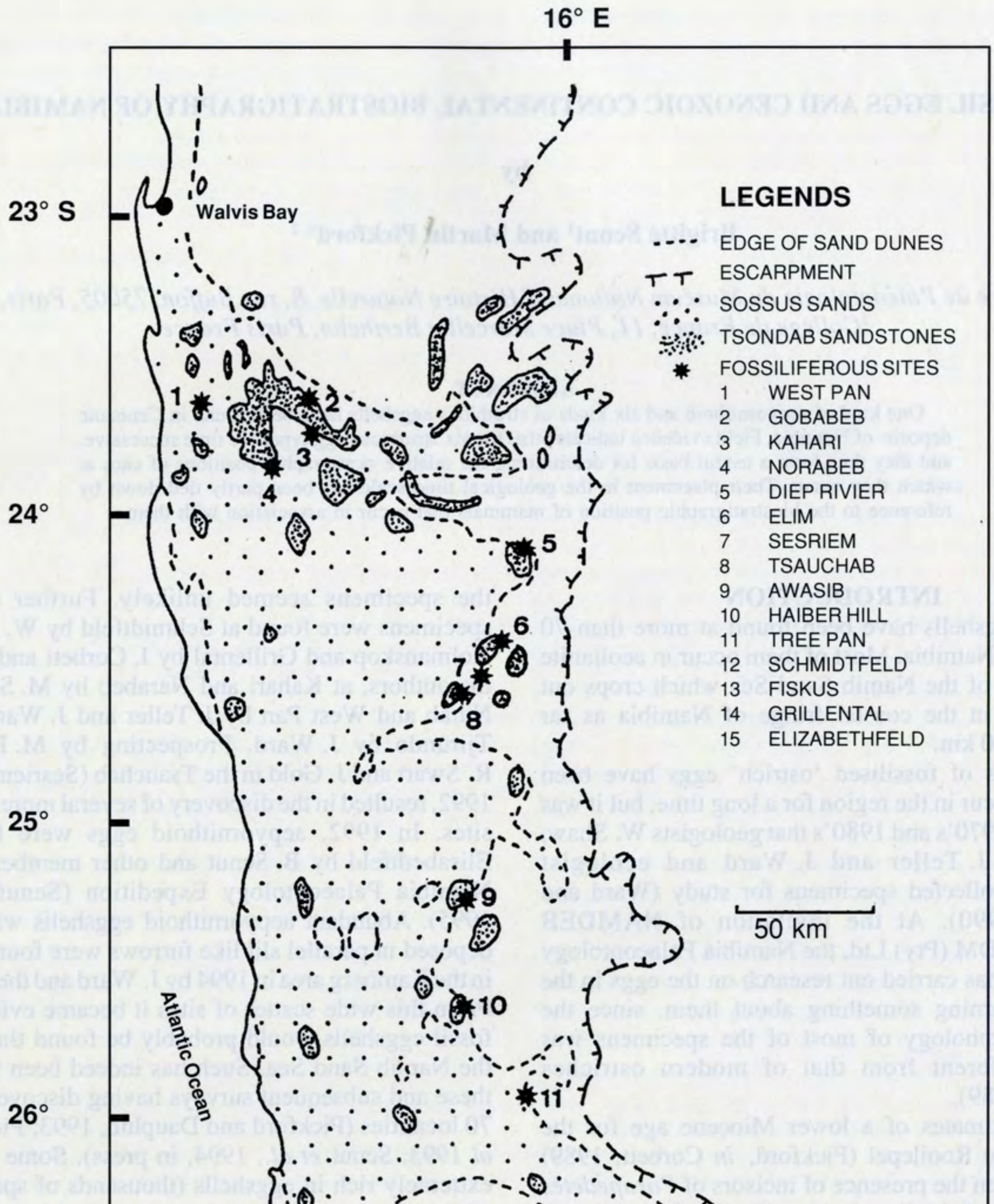


Figure 1: Locality map of the Central Namib showing the disposition of sites which have yielded struthious eggshells

Despite the large number of sites, the diversity of eggshells is low: six of the struthious morphology and one of aepyornithoid structure. Futhermore, where two or more struthious egg types occur in a sequence of aeolianites, they always occur in the same order, but never in the same horizon. On this basis, Pickford *et al.* (1993, 1995); Senut *et al.* (1994) proposed a biostratigraphic ordering of the egg types, even though a complete sequence in superposition had not yet been located. Subsequent surveys in the 120 metre thick

TABLE 1

List of fossil eggshell localities in Namibia.

Aep = Aepyornithoid; D.c. = *Diamantornis corbetti;* D.1. = *Diamantornis laini;* D.w. = *Diamantornis wardi*; N.o. = *Namornis oshanai*; S.c. = *Struthio camelus*; S.d. = *Struthio daberasensis;* ??? = species unidentified

LOCALITIES	SPECIES	AGE
Awasib (Cairn 1, 8-9 km N waterhole)	N.o.	Middle Miocene
Awasib (Cairn 2, 8-9 km N waterhole)	D.c.	Middle Miocene
Awasib (8-9 km N waterhole, low cliffs)	D.w.	Lower Middle Miocene
Awasib (8-9 km N waterhole, mid cliffs)	D.1.	Upper Miocene
Awasib (8-9 km N waterhole, upper cliffs)	S.d.	Post-Miocene
Awasib (8-9 km N waterhole, loose sand)	S.c.	Quaternary
Awasib (10.5 km NNE of waterhole)	D.w.	Middle Miocene
Awasib (9 km NW of waterhole, dune elbow)	S.d.	Post-Miocene
Awasib (8 km W of waterhole, inselberg)	D.w.	Middle Miocene
Buntfeldschuh (loose sand)	S.c.	Quaternary
Daberas (Main aeolianite)	S.d.	Post-Miocene
Daberas (near inselberg)	S.d	Post-Miocene
Daberas (Acheulean deflation surface)	S.c	Quaternary
Diep Rivier (aeolianite)	N.o.	Middle Miocene
Diep Rivier (deflation surface)	S.d.	Post-Miocene
Elbow Dune (9.5 SE of Tree Pan)	D.w.	Middle Miocene
Elbow Dune (loose sand)	S.c.	Quaternary
Elim Gullies (aeolianite)	N.o.	Middle Miocene
Elim (deflation surface)	S.d.	Post-Miocene
Elim (loose sands)	S.c.	Quaternary
Russell's Perch (E-Bay, aeolianite)	S.c.	Quaternary
Elisabethfeld	Aep	Lower Miocene
Etosha (subcrop Beisebvlakte)	N.o.	Middle Miocene
Fiskus (aeolianite)	S.d.	Post-Miocene
Fiskus (green clays)	Aep	Lower Miocene
Gamsberg Pass (conical aeolianite hill)	?Aep	Unknown
Gobabeb (aeolianite)	Aep	Unknown
GP Pan East (aeolianite)	D.w.	Middle Miocene
GP Pan North (aeolianite)	D.w.	Middle Miocene
GP Pan (loose sand)	S.c.	Quaternary
Grillental (green clay)	Aep	Lower Miocene
Haiber Hill (6 km SW)	D.w.	Middle Miocene
Haiber Hill (8 km SW, lower aeolianite)	D.1.	Upper Middle Miocene
Haiber Hill (8 km SW, upper aeolianite)	S.d.	Post-Miocene
Haiber Hill (8.5 km SW)	D.1.	Upper Middle Miocene
Haiber Hill (13.5 km SW)	S.c.	Quaternary
Kahari (8 km S Gobabeb)	S.c.	Quaternary
Kamberg cliff (loose sands)	S.d.	Post-Miocene
Kamberg Mesa	Aep	Lower Miocene
Karingarab (lower aeolianite)	D.c.	Middle Miocene
Karingarab (middle aeolianite)	D.w.	Middle Miocene
Kolmanskop (aeolianite)	S.d.	Post-Miocene
Narabeb (40 km S Gobabeb)	D.w.	Middle Miocene
Nutab (13 km E Gobabeb)	???	Unknown
Obib Gorge (aeolianite)	S.d.	Post-Miocene
Obib (Acheulean deflation surface)	S.c.	Quaternary
Obib (lateral valley aeolianite)	S.d.	Post-Miocene
Rooilepel Depression (Basal aeolianite)	D.c.	Miocene
Rooilepel Depression (middle aeolianite)	D.w.	Middle Miocene
Rooilepel Depression (upper aeolianite)	D.1.	Upper Middle Miocene
Rooilepel (mobile sands)	S.c.	Quaternary
Rooilepel West (aeolianite)	D.w.	Middle Miocene
Rooilepel West (mobile sands)	S.c.	Quaternary
Sesriem (MSA deflation surface)	S.c.	Quaternary
Sesriem North of Windmill (MSA surface)	S.c.	Quaternary
Sesriem North of Airstrip (aeolianite)	D.w.	Middle Miocene
Schmidtfeld (aeolianite)	D.w.	Middle Miocene
Target Pan (aeolianite)	D.1.	Upper Middle Miocene
Target Pan (loose sand)	S.c.	Quaternary
Tjirundo (Omaruru, river silts)	S.c.	Quaternary
Tree Pan (0.5 km E of pan)	D.1.	Upper Middle Miocene
Tree Pan (0.5 km S of pan)	D.1.	Upper Middle Miocene
Tsauchab (aeolianite)	D.1.	Upper Middle Miocene
Tsauchab (upper eaolianite)	S.d.	Post-Miocene
Tsauchab (Acheulean deflation surface)	S.c.	Quaternary
Tsauchab 3 (aeolianite)	S.d.	Post-Miocene
Tsauchab Valley (south)	D.w.	Middle Miocene
Vreemdelingspoort (aeolianite cliffs)	D.w.	Middle Miocene
Vreemdelingspoort (fossil dune, lower)	D.c.	Middle Miocene
Vreemdelingspoort (fossil dune, upper)	D.w.	Middle Miocene
West Pan	D.c.	Middle Miocene
West Pan (50 km S Rooibank)	S.d.	Post-Miocene
Zebra Hill (aeolianite)	Aep	Lower Miocene
Zebra Hill (loose sand)	S.d.	Post-Miocene

aeolianite succession 8-9 km north of Awasib Waterhole during September 1994, by the authors resulted in the discovery of a complete succession of egg types, confirming the preliminary succession worked out on the basis of partial sequences. The order of the various species is given in Table 2, from (1) oldest to (6) youngest.

PHYLOGENY OF EGGSHELL TYPES AND REPLACEMENT OF AVIAN LINEAGES

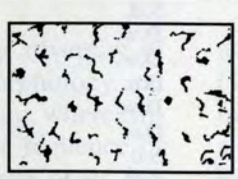
Based on the distribution of the eggshell types in the field, it is evident that only one type of bird laying struthious eggs occurred in the region during any one geological period. Detailed studies of the surface morphology and microstructure of these eggs suggest that *Namornis* probably gave rise to *Diamantornis* and that the three species of *Diamantornis* were derived one from the other in a time successive anagenetic pathway. This lineage gave rise to birds laying *Struthio*-like eggs sometime during the late Miocene, after which eggs of more modern *"Struthio"* type occur in the fossil record. Eggs of *S.daberasensis* may have given rise to *S.camelus* types. This is of interest in view of the usually accepted scenario that *S.camelus* originated in Asia and then migrated to Africa. The new discoveries in the Namib Desert suggest an alternative hypothesis, in which *Struthio* already existed in Africa during the Pliocene and that the extant ostrich is a descendent of this lineage. Further work is needed to confirm this hypothesis.

Aepyornithoid eggshells have been found in Namibia at several sites of pre-Miocene to lower Miocene age (Kamberg, Elisabethfeld) and in surface context in several places (Table 1) which might be younger than lower Miocene, but further work needs to be done to determine their stratigraphic range.

SUMMARY AND CONCLUSION

The recovery of seven kinds of large fossil eggs in the Neogene of Namibia is remarkable, not only for the

TABLE 2
Age, stratigraphic order and surface morphology of struthious eggshells from the Namib Sand Sea, Namibia

Species	Surface Structure of Eggs	Age
(6) *Struthio camelus*		Early Pleistocene to Present
(5) *Struthio daberasensis*		Pliocene (ca 7-2 Ma)
(4) *Diamantornis laini*		Upper Miocene (ca 11-8 Ma)
(3) *Diamantornis wardi*		Middle Miocene (12-11 Ma)
(2) *Diamantornis corbetti*		Middle Miocene (ca 13-12 Ma)
(1) *Namornis oshanai*		Middle Miocene

diversity of eggshell structures encountered but also for their potential for relative dating. Among the six struthious egg types (Table 2) none have ever been found togther in the same stratigraphic interval, indicating that only one bird species producing struthious eggs lived in the Namib at any one geological period. Furthermore, where two or more egg types have been found in superposition, they have always been found in the same order.

At Awasib Cliffs, all six egg types occur in the following stratigraphic order. In the lower slopes leading up to the cliffs, the species *Namornis oshanai* and *Diamantornis corbetti* occur in superposition. At the base of the cliffs, the species *Diamantornis wardi* is found. In the middle section of the cliffs, the species *Diamantornis laini* is very common, while in the uppermost aeolianites at the cliff tops and in sloping ground beyond, the species *Struthio daberasenis* occurs. Finally, in loose sands, eggshells of the modern ostrich, *Struthio camelus* are found.

Fossil struthious eggshells are thus proving to be of great use for correlating strata in the Namib Sand Sea. At several sites, associated mammals have been found, which have yielded information concerning the ages of the various species (Tables 1, 2).

ACKNOWLEDGEMENTS

We thank NAMDEB (formerly CDM (Pty) Ltd) (M. Lain, J. Ward, 'S' Spaggiari) for access to the Sperrgebiet and for funding and logistic support to carry out the survey there. Access to Awasib in the Namib-Naukluft Park was possible due to the courtesy of P. Bridgeford (Nature Conservation). The opportunity to survey at Vreemdelingspoort was provided by Namib Rand (L. Clapham). Thanks are due to Professors Y. Coppens (Collège de France) and P. Taquet (Institut de Paléontologie), Y. Maire and N. Weil (Mission de Coopération et Affaires Culturelles, Windhoek), Dr. B. Hoal (Geological Survey of Namibia) for funds and logistic support. Research permission was provided by the National Monuments Council of Namibia (G. Hoveka and A. Vogt). Help from Société des Amis du Musée de l'Homme (Paris & Antenne Méditerranée) is greatly acknowledged.

REFERENCES

CORBETT, I.B. 1989. *The sedimentology of diamondiferous deflation deposits within the Sperrgebiet, Namibia*. Unpublished PhD thesis, University of Cape Town, Cape Town.

PICKFORD, M. & DAUPHIN, Y. 1993. *Diamantornis wardi* nov. gen., nov. sp., giant extinct bird from Rooilepel, Lower Miocene, Namibia. *C. R. Acad. Sci. Paris* **316,** 1643-1650.

---------, SENUT, B. & DAUPHIN, Y. 1993. Chronologie du Néogène continental de Namibie: apport des oeufs fossiles. *Paléovox* **2,** 66-67.

--------- 1995. Biostratigraphy of the Tsondab Sandstone Group (Namibia) based on gigantic avian eggshells. *Geobios*. **28**(1), 85-98.

SAUER, E.F.F. 1966. Fossil eggshell fragments of a giant struthious bird (*Struthio oshanai* sp. nov.) from Etosha Pan, South West Africa. *Cimbebasia* **14,** 1-51.

SENUT, B., PICKFORD, M. & DAUPHIN, Y. 1995. Découverte d'oeufs de type "Aepyornithoïde" dans le Miocène inférieur de Namibie. *C. R. Acad. Sci. Paris*, 319, Sér. IIa, **320,** 71-76.

SENUT, B., PICKFORD, M. & MEIN, P. In press. Les falaises d'Awasib: une coupe-type pour le Cénozoïque continental de Namibie. *C. R. Acad. Sci. Paris*.

SENUT, B., PICKFORD, M. & WARD, J.D. 1994. Biostratigraphie de éolianites néogènes du Sud de la Sperrgebiet (Désert de Namib, Namibie). *C. R. Acad. Sci. Paris* **318,** 1001-1007.

WARD, J.D. & CORBETT, I. 1990. Towards an age for the Namib. **In:** Seely, M. Ed., *Namib Ecology: 25 years of Namib Research*. Transv. Mus. Monogr. Pretoria, Transvaal Museum, **7,** 17-26.