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SHORT COMMUNICATIONS

A DECADE OF SURFACE CHANGE ON A NAMIB LINEAR DUNE

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ABSTRACT

Survey data from return visits to a linear dune in the Namib Desert provide information about change in dune form over a decade. The data demonstrate that, although change on these large features is slow, there is none the less considerable movement over this time-scale. The dunes are therefore confirmed to be currently active and not Pleistocene relics.

KEY WORDS Aeolian geomorphology Sand dune Linear dune Namib Desert , DERU

INTRODUCTION

A previous paper reported data from a 4-year study of the dynamics of a 'complex' linear dune in the Namib sand sea in Namibia (Livingstone, 1989). For that study, data were in the form of weekly measurements of dune surface elevation on two parallel cross-profiles using steel posts (erosion pins) whose positions were fixed using a theodolite survey. That study provided information about the surface response of the dune to a seasonally bimodal wind regime. In particular, it showed that the crest of the dune moved laterally back and forth approximately 15 m each year, but that at the end of an annual cycle the dune had returned to its original position. The base (or plinth) of the dune was essentially fixed.

Two recent return visits to the site in July 1991 and September 1992 provided an opportunity to re-survey the cross-profiles of the dune, and thereby generate information about longer-term change on these dunes. This paper reports the results of these latest surveys.

THE SURVEYS

The study dune lies at the northern fringe of the Namib sand sea in Namibia on a 'complex' linear dune with a north–south trend (Figure 1). For this study, four cross-profiles were surveyed: two parallel cross-profiles 20 m apart at the site established in October 1980, which provided the data reported in Livingstone (1989) (rows A and B on study site 1 located in Figure 1); and two parallel cross-profiles, also 20 m apart, at another site approximately 0·8 km further south on the same dune established in August 1982 (rows 0 and 20 on study site 2 located in Figure 1). At site 1, the dune is approximately 350 m wide and 50 m high, while at site 2 it is approximately 550 m wide and 70 m high.

The cross-profiles were resurveyed in 1991 and 1992 using a clinometer and a tape. Constraints of time meant that only study site 1 was surveyed in 1992. Fortunately, a sufficient number of steel posts remained in

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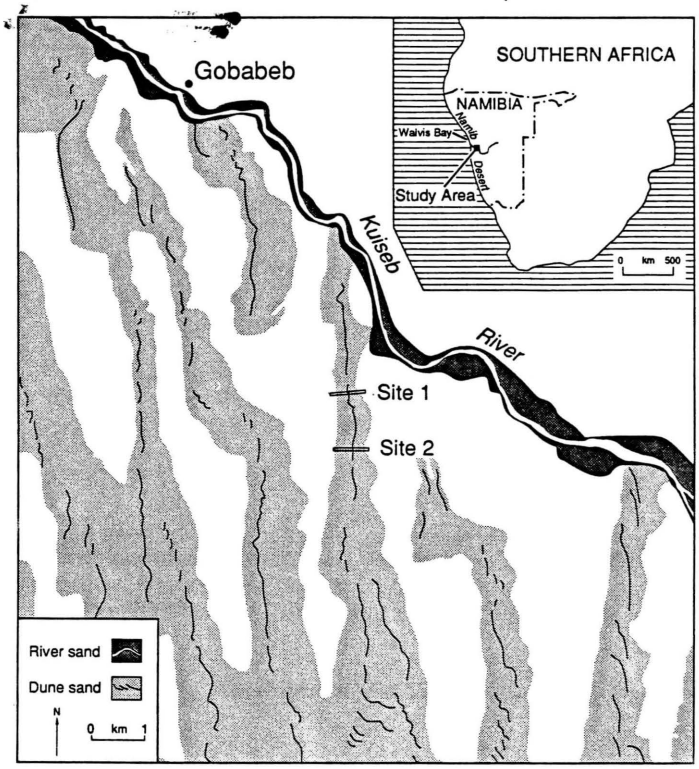

Figure 1. Location of the four cross-section survey lines, two at study site 1 and two at study site 2, on a 'complex' linear dune in the northern Namib sand sea

place from the earlier study, especially on the lower slopes of the dune, to enable the 1991/92 surveys to be related directly to the past work. As a consequence, it was possible to be certain that the positions of the four profiles measured in 1991/92 were exactly the same as those measured in 1981/82. Because the clinometer-and-tape method is not as accurate as the theodolite survey, some adjustment was made to the 1991/92 survey data to bring them in line with known elevations fixed by the steel posts.

The cross-profiles for the four sites are plotted in Figure 2. Surveys for 1981 and 1991 were taken from the same week of the calendar year (15 July 1981 and 14–15 July 1991) in order to avoid, as far as possible, the effects of seasonality in the cycle of erosion and deposition. The initial survey at site 2 was undertaken in August 1982, while the most recent survey of site 1 was undertaken on 30 September 1992.

From Figure 2 it is clear that considerable change has taken place in the past decade. At both sites the dune has changed from having a single main crest to being double-crested. However, although the cross-profiles give the impression of two parallel ridges of equal height, in three dimensions these were the sides of a bowl-shaped structure. In all four cases, the maximum height of the dune has been reduced, and there is some (more equivocal) evidence of sand accumulation on the upper east flank of the dune.

IMPLICATIONS

Activity and equilibrium

The clearest implication of the results is that these are active dunes. Although change of dune form, as distinct from the bulk transport of sand, is necessarily slow on dunes as big as these, the surveys show that considerable change of form is occurring at the time-scale of a decade. It has often been argued that large linear dunes such as these are inactive relics of stronger wind regimes during the Pleistocene (Besler, 1980; Glennie, 1970). The data presented here do not refute a possible origin in the Pleistocene, nor can it be denied

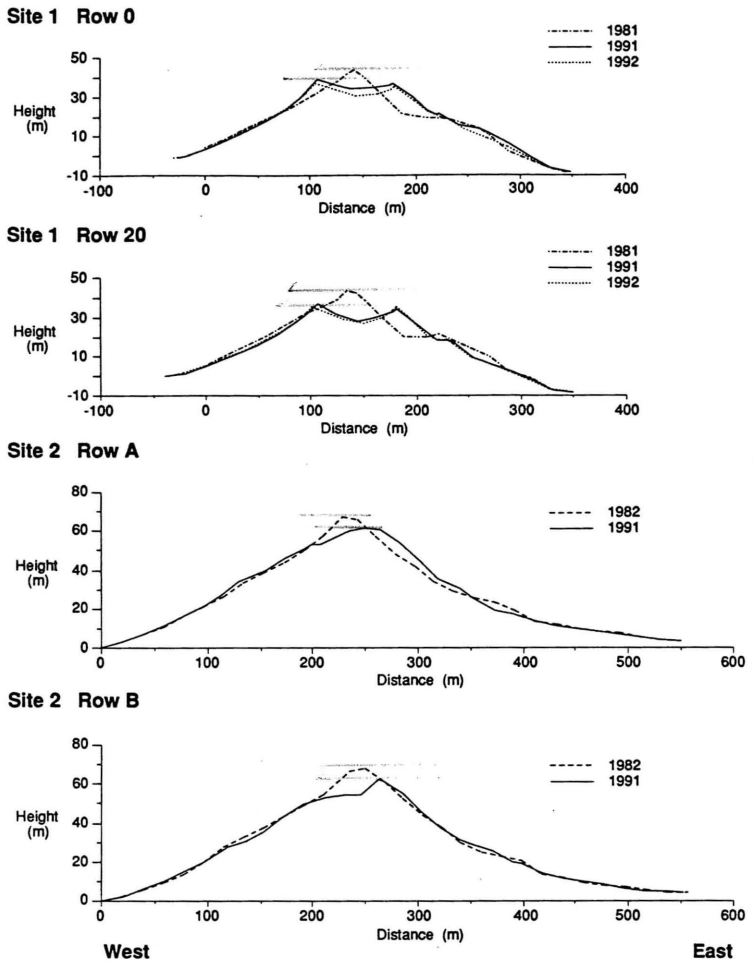

Figure 2. Cross-profiles for the four survey lines in pairs at two sites. Dune crest trend is approximately north–south so cross-profiles are aligned roughly east–west

that the Namib dunes are probably very long-lived, but there is no evidence here to suggest that the dunes are entirely passive in the present regime.

Earlier work showed an annual cycle of crestal movement of the Namib study dune (Livingstone, 1989). The later surveys show that there is a longer-term trend of progressive as well as cyclic change. There is a considerable debate still to be developed about what constitutes an 'active' dune (Livingstone and Thomas, 1993), and the distinction is sometimes drawn between *dune-forming* and *dune-maintaining* activity. These Namib linear dunes are clearly not in a simple dynamic equilibrium in which a stable morphology is maintained by a constant process–form feedback mechanism: considerable change of form has occurred in the past decade. The change that is occurring appears to represent migration of secondary features on the surface of a stable but active 'complex' linear dune.

Wilkinson (1988) recently argued for a two-phase origin in which the Namib linear dunes were formed in a late-Pleistocene southerly wind regime, but are today being remodelled into transverse dunes by easterly winds. We might therefore be witnessing the relaxation time as the dune moves to a new equilibrium form, but were this the case some westward movement of the plinth ought to be discernable over a decade. Overall, the plinth position and alignment of the dune have not changed. There is therefore no evidence of the lateral shift of the base in these highly active forms, which has been reported for linear dunes in northwest China by Hesp *et al.* (1989) and interpolated for dunes in the Strzelecki Desert of Australia by Rubin (1990).

Bowls

At both survey sites bowl-shaped structures had developed at the dune crest by 1991 where previously (1980–1984) there had been simple crests. These bowls are common on the complex linear dunes of the northern Namib sand sea (Besler, 1976/77). It is suggested that the more easterly crest in these forms is a remnant of a secondary transverse feature developed on the dune's east flank. Secondary, transverse dune elements are also common on the east flank of linear dunes in this part of the Namib sand sea (Besler, 1976/77; Lancaster, 1983a, 1983b). Like the main crests, they are pushed eastward away from the main dune crest by westerly winds in summer, and westward towards the main crest by easterly winds in winter (Livingstone, 1987). The easterly winds tend to be high magnitude, low frequency events which move considerable volumes of sand in relatively short periods of time. Often the work of several months of westerly winds is reversed in just a few days by the easterly winds. In a season (or a series of seasons) of particularly strong east winds, it might be that a secondary ridge would be pushed towards the main crest, eventually creating the bowls now evident.

This can only be speculation, and highlights the disadvantage of 'snap-shot' surveys rather than a continuous record. The surveys say nothing about the intermediate forms that developed at these sites between the survey dates, nor do they tell us anything directly of the processes by which this form was created. It is interesting, however, that the double-crested profiles at site 1 survived the year from 1991 to 1992.

CONCLUSION

This 10-year record confirms that there is considerable surface change taking place on the Namib linear sand dunes, and that they cannot therefore be regarded simply as Pleistocene relics.

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REFERENCES

Besler, H. 1976/77. 'Untersuchungen in der Dünen-Namib (Südwestafrika)', *Journal of the South West Africa Scientific Society*, **31**, 33–64.

Besler, H. 1980. 'Die Dünen-Namib: Entstehung und Dynamik eines Ergs', *Stuttgarter Geographische Studien*, **96.**

Glennie, K. W. 1970. *Desert Sedimentary Environments*, Developments in Sedimentology, **14**, Elsevier, Amsterdam.

Hesp, P., Hyde, R., Hesp, V. and Zhengyu, Q. 1989. 'Longitudinal dunes can move sideways'. *Earth Surface Processes and Landforms*, **14**, 447–451.

Lancaster, N. 1983a. 'Controls of dune morphology in the Namib sand sea', in Brookfield, M. E. and Ahlbrandt, T. S. (Eds), *Eolian Sediments and Processes*, Developments in Sedimentology, **38**, Elsevier, Amsterdam, 261–289.

Lancaster, N. 1983b. 'Linear dunes of the Namib sand sea', *Zeitschrift für Geomorphologie, Supplementband*, **45**, 27–49.

Livingstone, I. 1987. 'Photographic evidence of seasonal change in a secondary form on a 'complex' linear dune', *Madoqua*, **15**, 237–241.

Livingstone, I. 1989. 'Monitoring surface change on a Namib linear dune', *Earth Surface Processes and Landforms*, **14**, 317–332.

Livingstone, I. and Thomas, D. S. G. 1993. 'Modes of linear dune activity and their palaeoenvironmental significance: an evaluation with reference to southern African examples', in Pye, K. (Ed.), *The Dynamics and Environmental Context of Aeolian Sedimentary Systems*, Geological Society, Special Publication, **72**, 91–101.

Rubin, D. M. 1990. 'Lateral migration of linear dunes in the Strzelecki Desert, Australia', *Earth Surface Processes and Landforms*, **15**, 1–14.

Wilkinson, M. J. 1988. 'Linear dunes in the central Namib Desert: theoretical and chronological perspectives from wind streaks. in Dardis, G. F. and Moon, B. P. (Eds), *Geomorphological Studies in Southern Africa*, Balkema, Rotterdam, 85–113.