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Networks dunes in southeastern Tengger Deseert: morphology, sediment, and dynamics

Ha Si┼ China Center of Desert Research at Beijing Normal University, Beijing, P.R.China, 100875 (*E-mail:* hsed@bnu.edu.cn)
┼ Key Laboratory of Environmental Change and Natural Disaster, the Ministry of Education of China, Beijing Normal University, Beijing, P.R.China, 100875

Introduction

Networks dunes, which are one of the commonest dune types in world desert, are characterized by network pattern resulted from the intersection of longitudinal and transverse elements. In contrast to other major dunes such as transverse (Howard *et al,* 1978;), longitudinal(Tsoar,1983;Livingstone,1986) and star dunes(Lancaster,1989), whose mechanism and advance are well known ,the networks dunes still pose many unanswered questions. In present reseach, the systematical field measurements on the networks dunes at southeastern Tengger Desert conducted in order to understand its morphology and dynamics. They included: measurements of wind direction and velocity for the regional wind regime and of surface airflow especially secondary wind currents as the result of the interaction of primary wind with the dune forms, analysis of grain size and sorting of surface sediment and spatial variation, identification of aeolian cross stratification types in natural exposure and trenching part.

Figure 1. Oblique view of networks dunes in southeastern Tengger Desert

Dunes morphology and morphometry

Networks dunes at the southeastern fringe of the Tengger Desert consist of SW-NE trending main ridges and nearly vertical secondary ridges(SE-NW orientation). Main ridges' slopes on both sides are asymmetric, northwest-facing slopes are long and gently(6-12°), southeast-facing slopes are short and steep(28-32°), dune height varies between 3-20m,and interdune depressions are less noticeable, with a spacing ranging from 30m to170m. Their secondary ridges are superimposed on the windward slope of the main ridges, both the east and west-facing slopes are gentle in lower part(4-14°)but steep in upper part(19-30°), slipface are not well developed and restricted to upper portion of the ridges, 1-6m in height and 20-70m in spacing. According to analytical data, there is significant correlation between the heights and the spacing of their respective primary and secondary ridges (Ha Si,1995). From the comparisons of aerial photographs of three different periods since 1950s, it can be seen that over the past 40 years the shapes of networks dunes in the region, as a whole, remained stable. From this it follows that the networks dunes in the region are in dynamic equilibrium with modern wind regime and sand supply.

Regional and surface wind flow over the dunes

Networks dunes in the southeastern Tengger Desert are formed under the low-energy and bidirectional wind regime. Both the prevailing wind direction and annual and seasonal resultant sand transport directions(fig.1)are perpendicular or oblique at a larger angle (>50°) to main ridge crest line (235°, 55°) but are oblique to the secondary ridge (155°, 335°) at a smaller angle (<40°). According to dune forms and wind regime. The annual resultant sand transport direction in the study area is perpendicular to the primary ridges and oblique to the secondary ridges with a small angle. Primary ridges are transverse dunes, while secondary ridges are longitudinal dunes. Viewed from the spatial assemblage, the secondary ridges are superimposed on the windward slopes of the primary ridge, therefore the networks dune can be regarded as complex transverse dune.

Surface airflow over the dune is the main factors controlling the erosion deposition patterns and the morphology of sand dunes. The main and secondary ridges of the networks dunes have different surface airflow patterns although they are in the same regional wind conditions. This shows that they have different mechanism of movement. The primary ridges are under the influence of transverse airflow, which occurs separation after crossing the dune crest and causes sand deposition there due to sharp reduction in wind velocity (fig. 3a), finally forms the large scale slip face and leads to the sand dune migration in the prevailing wind direction or resultant sand transport direction. Hence, the primary ridges possess the dynamical characteristics of transverse dunes. The secondary ridges are under the influences of oblique airflow(fig3.b,fig3.c), which occurs attached deflection on the lee slope and forms longitudinal airflow parallel to the dune crest line, in such case, the sand eroded from the windward slop is not deposited all on the lee slope (except for the upper narrow long zone) but continuous to move along the dune crest line direction with the deflected wind. Since the wind velocity over the lee slope increases with the decreasing incident angle of the primary wind, coupling with the lower threshold velocity for sand movement on a down sloping surface than on a flat surface, wind erosion takes place on the lee slope of the secondary ridges and finally leads to extension of the ridges. However, the crest lines of the secondary ridges also have lateral shifts due to the alternating influences of bidiectional winds. The wind erosion caused by oblique winds on both sides of the sand dunes and the dune extension are the crucial elements for elucidating the dynamical processes of longitudinal dune movement and this has been demonstrated by the field observations and experiments (Tsoar,1983;Livingstone,1986).Thus the secondary ridges have the dynamical characteristics of longitudinal dunes.

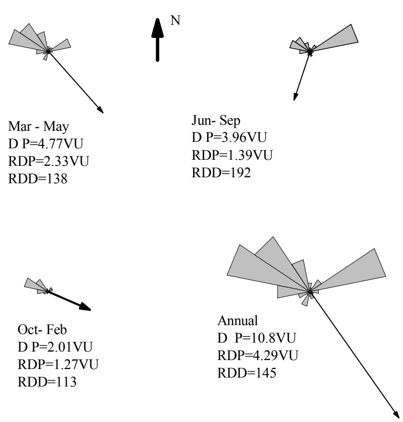
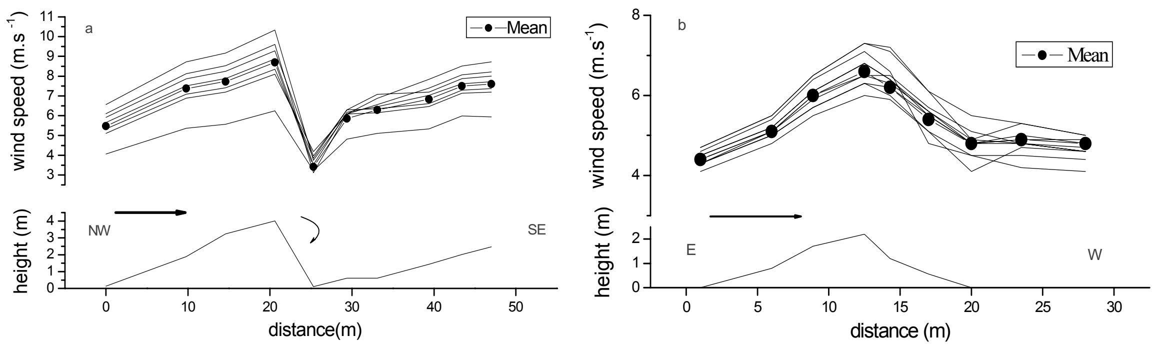


Figure 2 Annual and seasonal sand rose in the study area



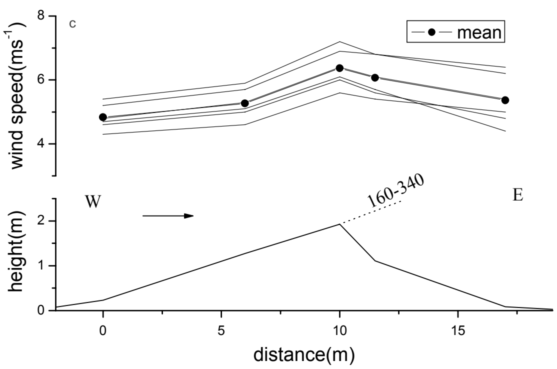


Figure 3. Wind velocity variation over the networks dune surface, (a) main ridge in NW wind, (b) secondary ridge in ENE wind, and (c) secondary ridge in NW wind

Internal structure

Internal structures of sand dunes are the direct evidences of dune deposition and development processes. There is a good correspondence between the external form, internal structures and the surface processes of the primary and secondary ridges of the dunes. The sedimentary structure dominated by the monoclonal high angle tabular cross-bedding of the main ridge is the typical transverse dune feature formed under the influences of unidirectional winds. From this it follows that primary ridges are formed under the influences of dominant wind (northwest wind). The bipolar azimuths and bimodal dip distribution tabular-wedge cross strata with a chevron-like pattern of the secondary ridges is the typical structure of longitudinal dunes. The alternating reactivation surfaces existed in the secondary ridges representing third-order bounding surface their inclination indicate the extent of erosion between two deposition events; low-angle climbing ripple lamination and upper concave divergent bedding are mainly caused by the deflection of oblique wind over the lee slope. Therefore, the secondary ridges are formed under the alternating influences of dominant wind (northwest wind) and subdominant wind (northeast wind) and they maintain their morphology under the effects of bidirectional oblique winds. The second order bounding surface separated the main ridge deposits from the secondary ridge deposits shows that the secondary ridges are the secondary dunes formed on the basis of main ridges. From this one might conclude that the networks dunes are initiated and developed as a result of the modification of transverse dunes as they extend or migrated into area of seasonally varied bidirectional wind regime through a series of form-flow interactions.

Conclusion

Networks dunes are very common in the deserts of the world but have been seldom researched. Through the studies on the regional wind, surface airflow of the dune field, and internal structure of networks dunes. It was suggested that the main ridges of the networks dunes were formed by the prevailing northwest winds, while the secondary ridges were formed by the alternating actions of the prevailing wind secondary wind (northeast wind) on the basis of the primary ridges. Viewed from morphodynamic types, they belong to the complex dunes formed by longitudinal dunes superimposed on the transverse dunes.

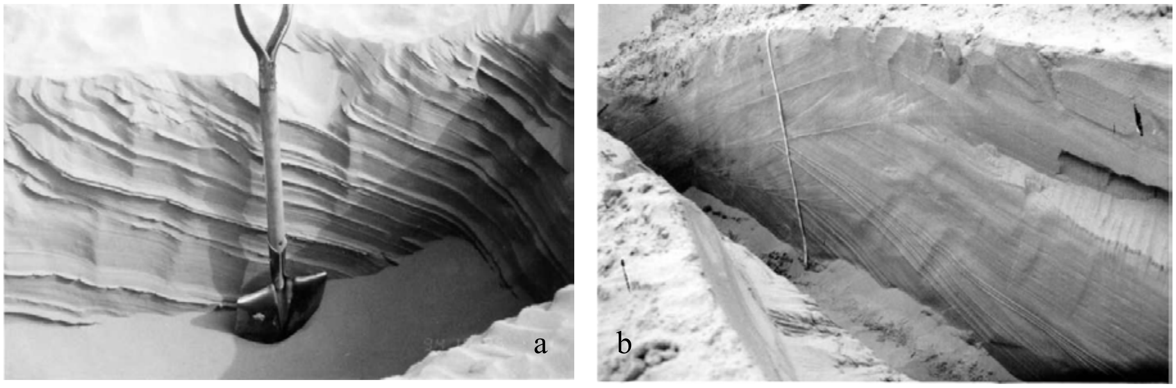


Figure 4 Sedimentary structure of networks dunes,(a) primary ridge□and (b)secondary ridge

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