AEOLIAN SAND TRANSPORT SYSTEMS – A TERRESTRIAL PERSPECTIVE. N. Lancaster[1] (Desert Research Institute, 2215 Raggio Parkway, Reno, NV 89512, USA; nick@dri.edu.

Sand dunes of different types are a key component of all aeolian sand transport systems. Their dynamics and morphology, as well as their response to the effects of external forces, such as changes in climate, cannot be considered in isolation from the dynamics of the sand transport system of which they are a part.

Aeolian sediment transport systems, in which sand is moved by wind from source areas via transport pathways to depositional sinks (e.g. dune fields, sand seas), have been identified at regional- and local-scales in many deserts using a combination of wind and remote sensing data [1]. Principles of sediment budgets show that accumulation of sand is the product of spatial changes in transport rates and/or temporal changes in sediment concentration [2]. Following principles of conservation of sediment mass, sand seas and dune fields accumulate downwind of source zones wherever sand transport rates decrease as a result of regional and/or local changes in wind speed and directional variability, so that the influx of sand exceeds outflux. Reductions in sand transport rates may be a result of topographic or regional climatic factors, so that many sand seas and dune fields occur in areas of low total or net sand transport and/or in topographic lows.

The dynamics of eolian sediment transport systems on any time scale are determined by the relations between the supply, availability, and mobility of sediment of a size suitable for transport by wind [3]. Sediment supply is the emplacement of sediment that serves as a source of material for the eolian sediment transport system. Sediment availability is the susceptibility of a sediment surface to entrainment of material by wind; and sediment mobility can be described by potential sand transport rates (or wind speed as a proxy). The relationships between the controls of sediment dynamics can be used to define the state of the system and how it varies through time. These key variables may be affected by changes in climate, including variations in the magnitude and frequency of winds capable of transporting sediment, so enabling the response of sand transport systems to climate and other external changes to be assessed and modeled. In many cases, periods of sediment input are relatively short compared to the much longer episodes of reworking and stability and even depletion of the sand body (Fig. 1) [4].

Terrestrial sand seas contain large volumes of sand (10's to 100's of cubic km) and have accumulated episodically during the Quaternary Era. Their construction has therefore been determined by climatic, tectonic, and sea level changes that have affected sand supply, availability, and mobility, as well as the preservation and inheritance of deposits and landforms from prior episodes of aeolian construction. Given that the reconstitution time (time to completely rework a sediment body) increases exponentially with sediment volume, the legacy of past climatic conditions therefore plays a major role in determining the present morphology and distribution of many areas of dunes [5]. One effect of climate change is the development of multiple generations of dunes, which in many sand seas are manifested by clear spatial patterning of dune types (often with sharp transitions between dune types), dune size and spacing, crest orientation, and sediment characteristics (Fig. 2). Different dune morphological units were most likely formed at different times in a specific wind regime [6].

Despite significant conceptual and methodological advances, many aspects of the dynamics of aeolian sand transport systems remain difficult to resolve. One example is the identification of the source(s) of sediment for many large-scale systems. In many cases, the input of sediment may no longer be active, so that it is not possible to physically trace the transport pathway from source to sink. Mineralogical information (determined from field or remote sensing studies) can offer insights [7, 8]. Remote sensing and climate data may however give a false impression of the regional nature of aeolian sediment transport. In Australia, for example, dune patterns suggest a continent-wide system of dunes, yet mineralogical data suggest that many dunes are sourced locally and inter-basin transport does not occur [9, 10]. High spectral resolution remote sensing data can provide valuable data to identify distant and local sediment sources [11].

Assessment and modeling of the sand budgets of sand seas and dunefields remains uncertain in many areas. The potential for using climate models and reanalysis data to understand regional winds and sand transport patterns is considerable and can follow methods established to understand dust generation areas in the Sahara [12] and martian dune fields [13].

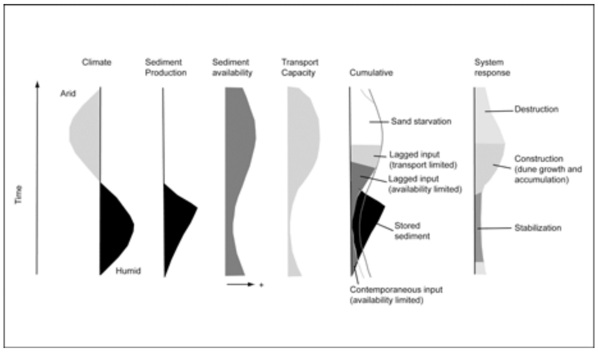

Fig. 1: Conceptual diagram of changes in sediment state over time [4**].**

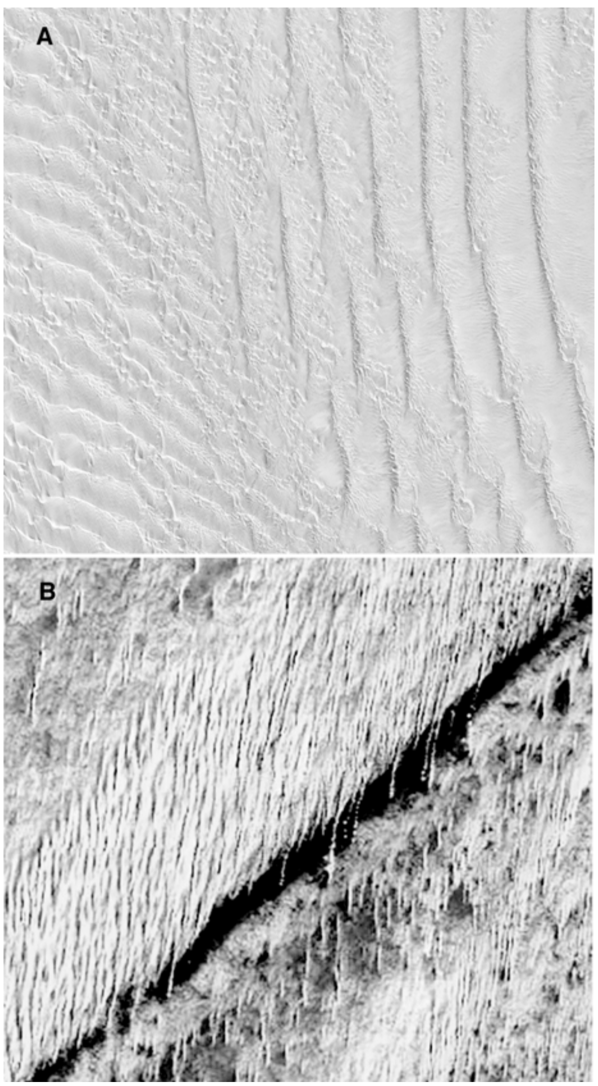

Fig 2: Examples of dune generations: (A) juxtaposition and superposition of compound crescentic and complex linear dunes, Namib Sand Sea; and (B) superimposition of modern N-S oriented linear dunes on NE-SW oriented late Pleistocene linear dunes, Azefal Sand Sea, Mauritania.

References

1. Fryberger, S.G. and T.S. Ahlbrandt (1979) Z. für Geomorphologie, 23, 440-460.
2. Kocurek, G. and K.G. Havholm, (1993) in Siliciclastic Sequence Stratigraphy, AAPG, 393-409.
3. Kocurek, G. and N. Lancaster, Sedimentology, 46, 505 - 515.
4. Kocurek, G. (1998), in Quaternary Deserts and Climatic Change, 327-338.
5. Lancaster, N. (1999) in A.S. Goudie, I. Livingstone, and S. Stokes, Eds, 49 – 70.
6. Ewing, R., C., G. Kocurek, and Lake.L.W., (2006) ESPL, 31, 1176-1191.
7. Ramsey, M.S., et al., (1999). GSA Bulletin, 111, 646-662.
8. Muhs, D.R., (2004), Geomorphology, 59, 247-269.
9. Wasson, R.J., et al. (1988) Australian Geographer, 19, 89-104.
10. Pell, S.D., I.S. Williams, and A.R. Chivas (1997), Sedimentary Geology, 109, 233-260.
11. Scheidt, S., M. Ramsey, and N. Lancaster (in press) Remote Sensing of Environment.
12. Washington, R., et al. (2006). GRL,33(L09401).
13. Fenton, L.K. (2005) JGR, 110 (E110004).