A Database-Informed Investigation of the Signature of Environmental Change in the Aeolian Sedimentary Record

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Abstract

Desert aeolian sedimentary systems are sensitive to changes in a wide range of environmental variables, including climate, sea level, sediment supply and tectonic factors. This research employs a relational database storing literature- and field-derived information on quantitative aspects of aeolian sedimentary architecture to investigate environmental controls on different types of aeolian system, and their deposits through geological time. The Database of Aeolian Sedimentary Architecture (DASA) records the spatiotemporal complexity of >200 case-study examples from modern aeolian systems and preserved successions. The database is applied to develop and constrain a series of quantitative facies and sequence-stratigraphic models that are used to account for response to allogenic forcing mechanisms, as well as autogenic self-organization by dunes of different types. The database and resultant models are used to demonstrate the following: (i) evidence to show that primary allogenic and autogenic controls on preserved aeolian successions are interdependent and interrelated via a series of complex feedback mechanisms; (ii) how a novel sequence stratigraphic framework can be applied to explain how interlinked environmental factors acted to govern the nature of the preserved sedimentary record across multiple scales from basins fill, to architectural elements, to small-scale facies units; (iii) how models can be applied to demonstrate the expected range of stratigraphic architectures for varying classes of aeolian desert system. Quaternary aeolian successions differ markedly in form to counterparts in the ancient record because the former mostly represent partial remnants of stacked sequences that accumulated over

successive arid cycles but which are not yet considered to have been subject to genuinely long-term preservation. By contrast, older successions are principally preserved in basins that undertook long-term subsidence for which each successive sequence is sharply truncated due to erosion to a base level defined by accommodation. Systems preserved via bedform climbing have markedly different stratigraphic expressions to those preserved by “exceptional” mechanisms. Aeolian systems developed in greenhouse climates tend to be better ordered at the scale of facies units in response to monsoonal climates; systems developed in response to icehouse-greenhouse cyclicity tend to be better ordered at the sequence scale in response to longer-term orbital forcing.