LANDSCAPE RESPONSES TO EARTHQUAKE-INDUCED LIQUEFACTION IN AN ANCIENT DESERT DUNE ENVIRONMENT: SOFT-SEDIMENT DEFORMATION FEATURES OF THE EARLY JURASSIC NAVAJO SANDSTONE

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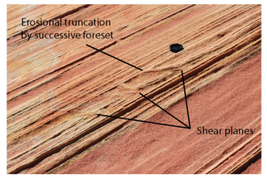
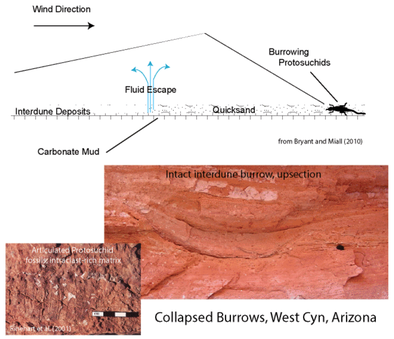
1. Slope Failure

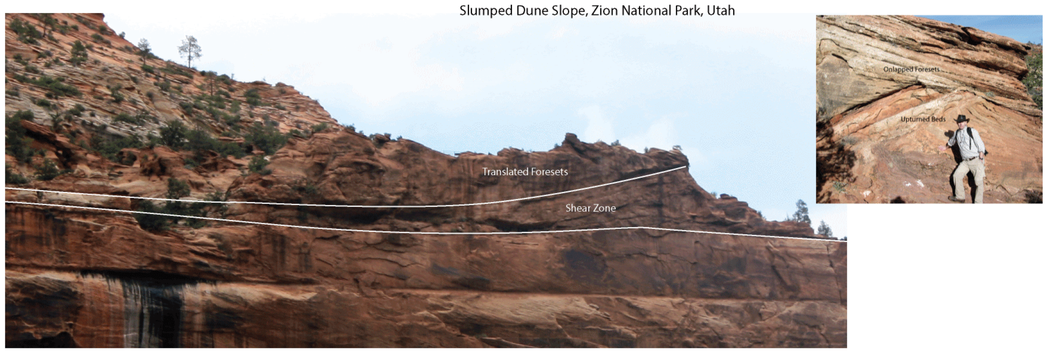
Buckled Foreset, N Coyote Buttes, Arizona





Collapsed Burrows, West Cyn, Arizona

Slumped Dune Slope, Zion National Park, Utah



Abstract

Modern environments provide many keys to interpreting ancient deposits; but ancient deposits themselves preserve records of a broader range of environmental conditions and event characteristics than are currently observable on Earth. In contrast to the paucity of earthquake records from modern dunefields, for example, innumerable liquefaction events are represented in the outcrop architecture of the early Jurassic Navajo Sandstone, on the Colorado Plateau. A minor percentage of these preserve distinct indications of topographic changes. These changes occurred as a result of seismic shaking, structural failure of subsurface sediments, and hydraulic dynamics driven by the equilibration of transient fluid pressures. They include minor slipface slumps, as are commonly seen on modern dunes in wet climates, and sand blows similar to those documented from clay-capped sands in various modern earthquake zones; but they range into much more exotic features, including: kilometer-scale dune collapse complexes; quicksand kill zones; 20 m depressions formed by surface subsidence; and voluminous sediment outflows.

The contrast between the richness of this ancient record and the sparse documentation from modern dune environments certainly reflects differing environmental conditions; however, differences in the observational perspectives - both physical and temporal - available on modern versus ancient deposits may also be important. Perhaps a broader range of features is yet to be discovered in the rare cross-sections available from modern dunefields – or from the freshly emerging documentation of extra-terrestrial sections. In support of this continuing exploration, a sampling of Navajo Sandstone outcrop architectures, representing earthquake-induced modification of desert dune landscapes, is presented here.

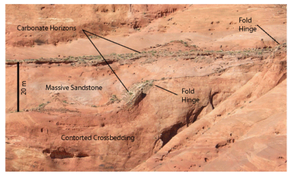
References

Bryant, G. C. and Miall, A. D, 2010, Diverse products of near-surface sediment mobilization in an ancient eolianite: Outcrop features of the Early Jurassic Navajo Sandstone. Basin Research, 22: 578-590.

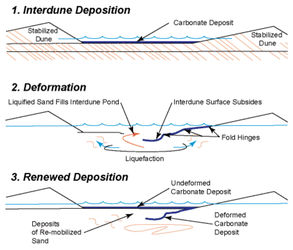
Bryant, G. C., Monegato, G. and Miall, A. D., 2013, An example of liquefaction-induced interdune sedimentation from the early Jurassic Navajo Sandstone, USA. Sedimentary Geology, 297: 50-62.

Rinehart, L.F., Heckert, A.B., Bryant, G., Lucas, S.G., and Cushman, R. 2001. Protosuchid crocodylomorphs from the Lower Jurassic Navajo Sandstone of north-central Arizona. Mesa Southwest Museum Bulletin, 8: 25-31.

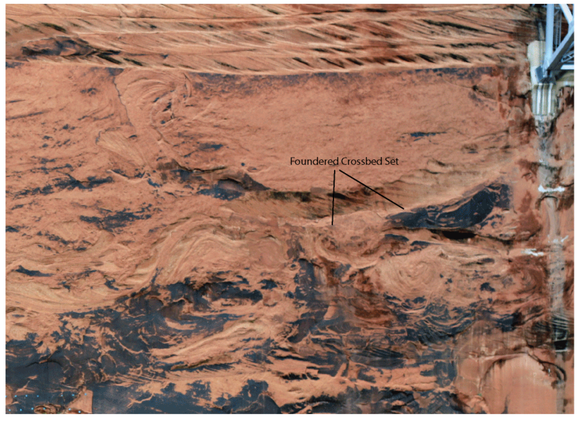
2. Subsidence



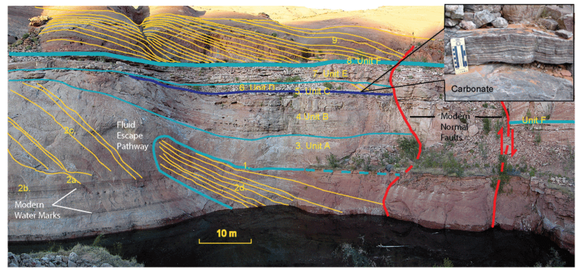
Interdune Subsidence, Navajo Canyon, Arizona



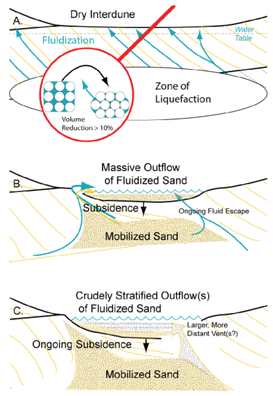
Interdune Subsidence, Glen Canyon Dam, Arizona



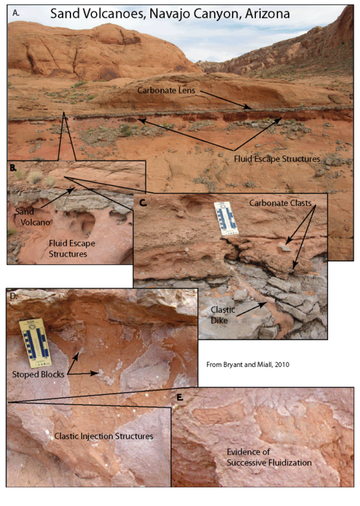
Subsidence Basin, filled with a mixed succession of interdune sediment
West Canyon, Utah. Figures are from Bryant, Monegato, and Miall (2013)



1. Depositional surface conforming to underlying structure.
2. Foresets variously: a. contorted; b. effaced; c. oversteepened to 45 degrees; and d. flattened to as little as 10 degrees.
3. Initial mass flow deposit.
4. Successive mass flow deposits.
5. Lacustrine carbonate over finely bedded sandstone.
6. Eolian dune deposit.
7. Succession of sandstone and mudstone deposits.
8. Extensive, capping beds of sandstone and mudstone,
9. Large-scale dune foresets, dipping 27 degrees, to the SE.



3. Sediment Eruption



Large-Scale Sediment Eruption, Glen Canyon Dam, Arizona