

SHEAR STRUCTURES WITHIN SOFT-SEDIMENT DEFORMATION FEATURES IN THE EARLY JURASSIC NAVAJO SANDSTONE

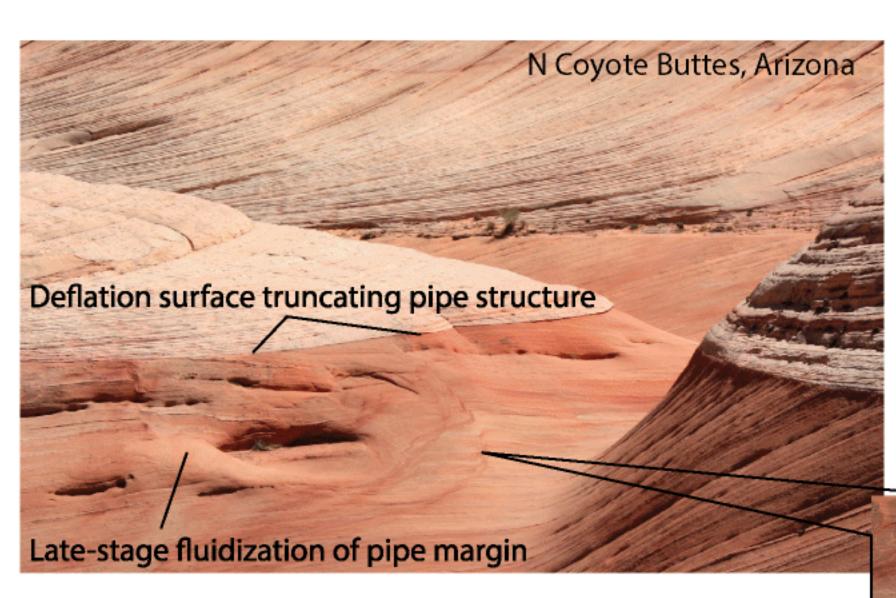
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Abstract

Soft-sediment deformation features in outcrops of the early Jurassic Navajo Sandstone commonly display shear structures, at a variety of scales. These typically appear as planar zones of structureless sand that truncate primary features and are accentuated by overturned foresets, rip-ups, and other displacements of pre-existing architectural elements. In some cases, it is apparent that shear stress was accommodated by more cryptic movement along foresets.

The origin of the shear forces producing these structures is sometimes the evident consequence of larger-scale dynamics within the deformation event, driven by gravity or hydraulic pressure, after seismic destabilization (liquefaction) has occurred. In many cases, however, it is difficult to postulate coherent mechanisms within the context of current theory and established physical constraints.

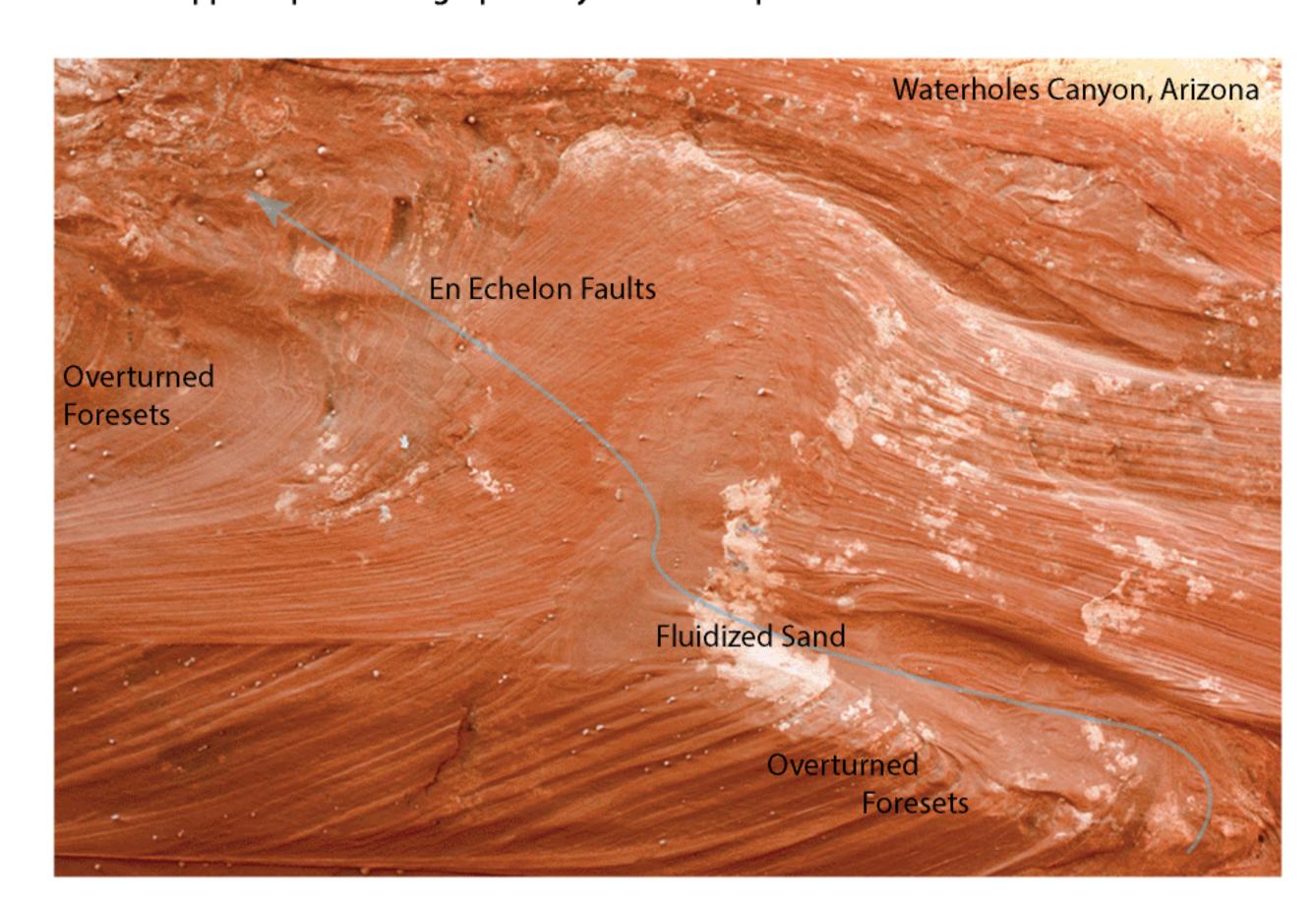
Identifying these interpretive challenges is a necessary first step in developing more broadly applicable models. To this end, photodocumentation of shear structure diversity is here provided, along with a corresponding array of interpreted dynamics and emerging enigmas.



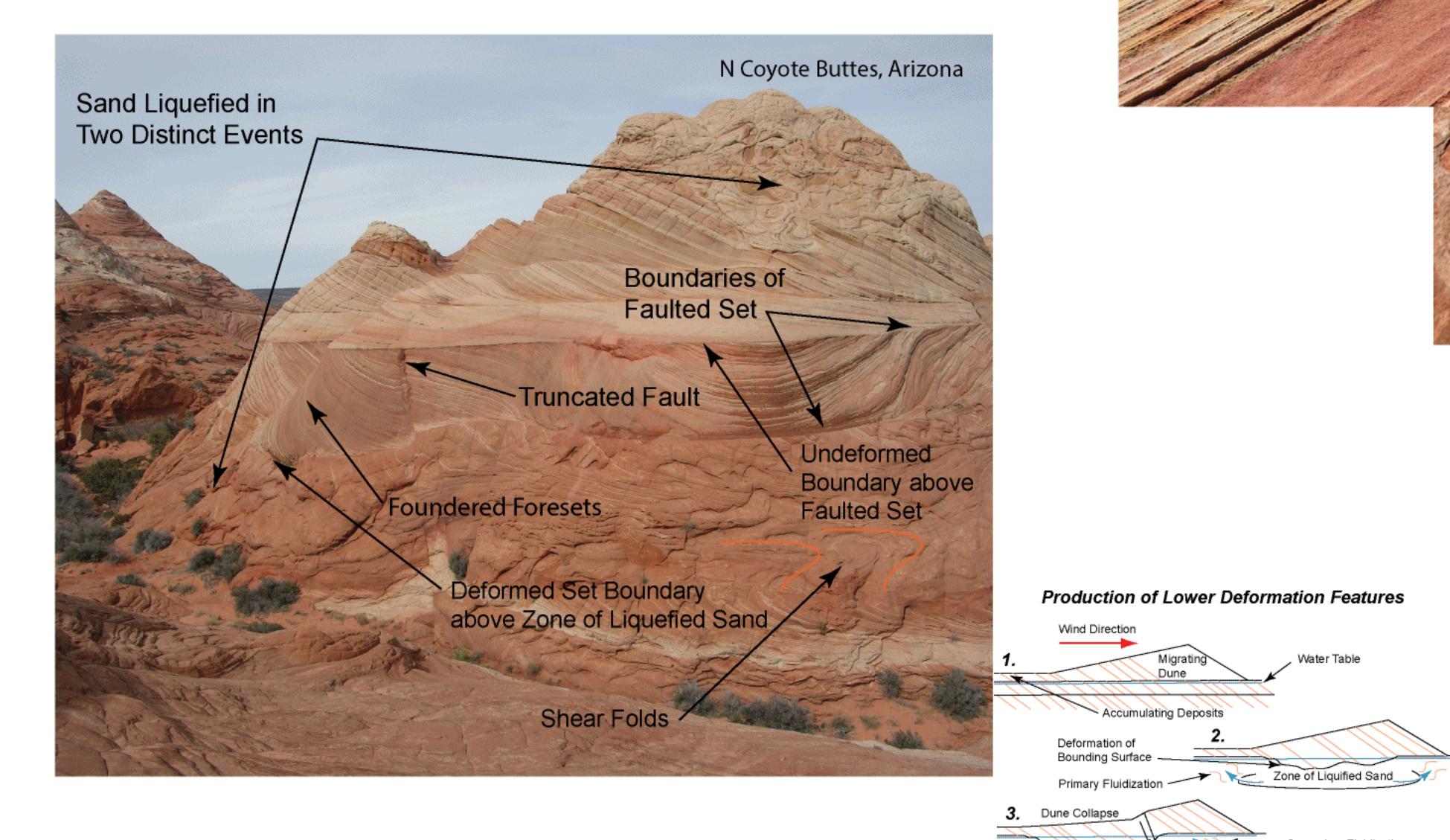
Faults generated by fluid escape:

Above: Concentric ring faults with increasing downward displacement toward the center of a fluid-escape pipe. Dilation of the sand framework within the pipe during fluid escape was followed by progressive collapse within that cylindrical structure.

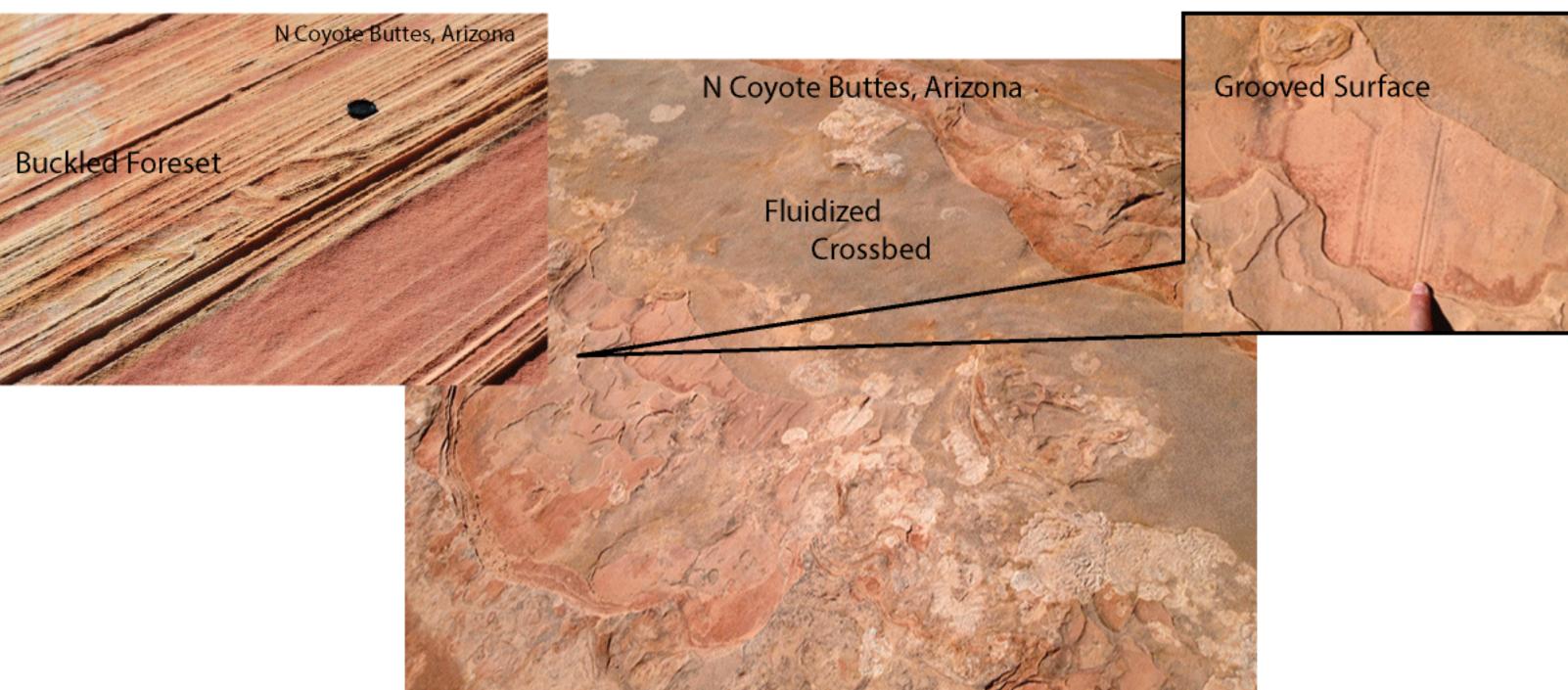
Below: En echelon faults produced by hydraulic fracturing of a permeability barrier, a thick succession of climbing wind ripple deposits along a pathway of fluid escape



Faults and shear folds generated by dune foundering



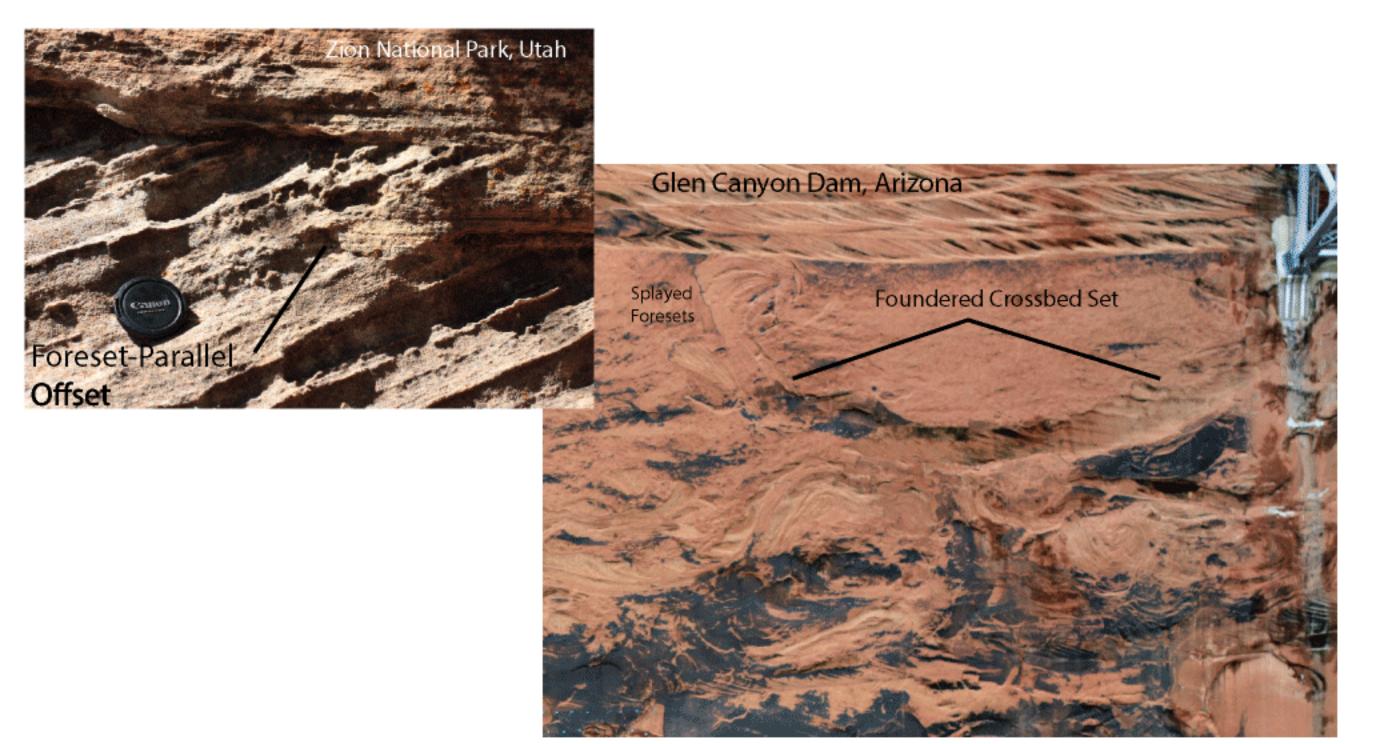


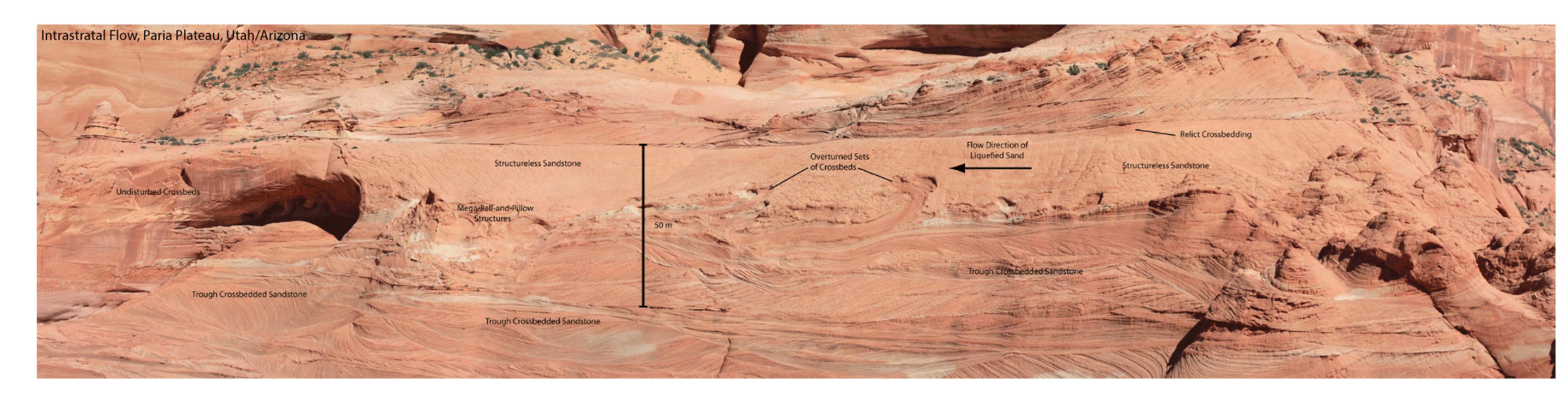


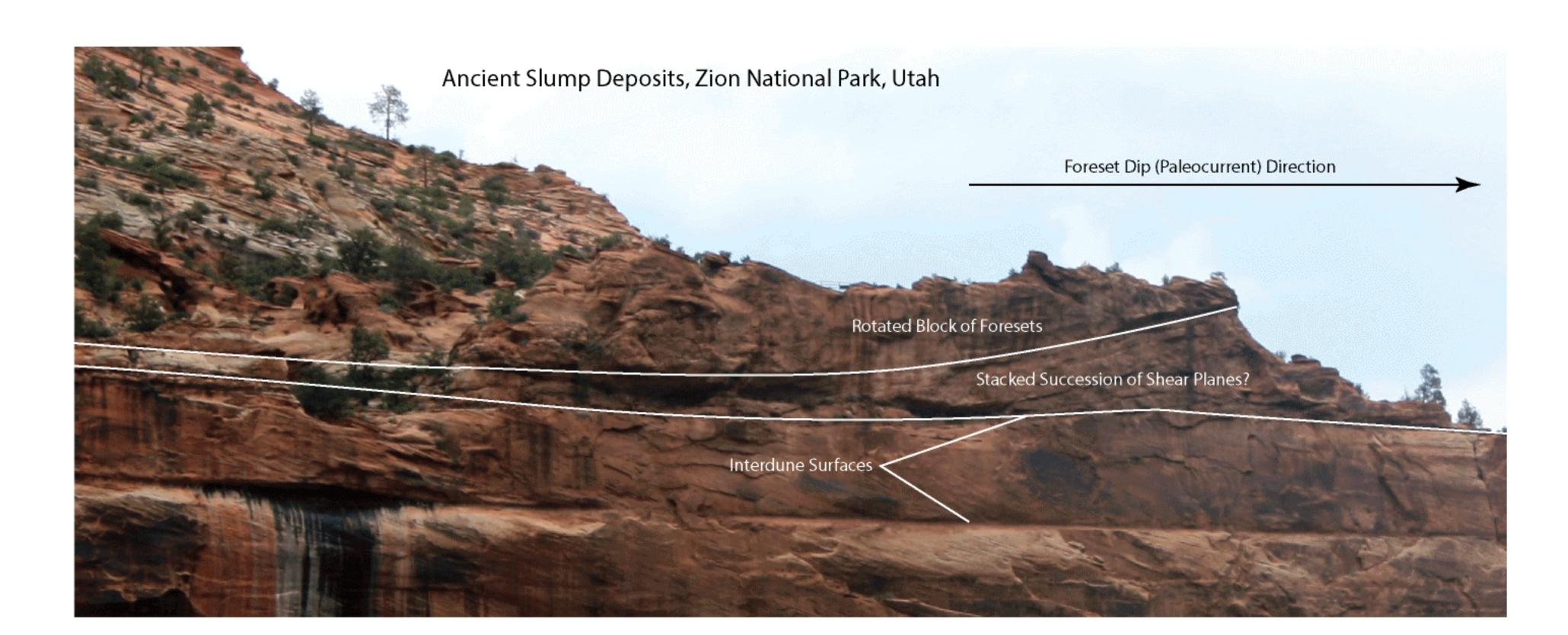
Bedding-plane-parallel shear structures

Left: Direct evidence of differential movement along bedding planes is provided by buckled crossbeds and dip-parallel grooves on foresets. This type of stress release occurred down the lee slopes of active dunes, driven by gravity, and in the subsurface, where differential stresses were generated by seismic loading, followed by liquefaction and the redistribution of static loads.

Right: Indirect evidence of shear along bedding planes is provided by patterns of strain in crossbed sets deformed in the subsurface. The example from Zion National Park displays shear strain produced by lee slope failure of an active dune. The Glen Canyon example shows accommodation of curvature by shear along foresets in a foundered crossbed set.







Deflation of Collapsed Dune

Enigmatic Shear Structures

Above: The "Relict Crossbedding" at the top of the thick zone of massive sandstone, exposed at the western edge of the Paria Plateau, indicates that the flow of fluidized sediment that sheared upward entire crossbed sets developed in the subsurface, not as a slope-generated mass flow. The mechanism for generating such large-scale lateral movement is not apparent.

Left: Even though the landslide context of the deformation complex exposed along the Zion Overlook Trail is established by preserved paleotopography and a variety of strain features aligned with foreset-dip-parallel stresses, distinctions between thrusted sheets of cohesive interdune deposits (right) and stacked successions of shear planes are difficult in many places.

Below: Crudely bedded zones at the top of the deformation complex exposed in Cave Lakes Canyon are even more difficult to decipher. Here, the original sedimentary architecture is complexly trough-crossbedded and no definitive relationships between deformation morphologies and contemporary topography have yet been established. Perhaps robust criteria, independent of broader architectural considerations, will be established by detailed comparisons to sites where comparable morphologies occur in a well-constrained context of deformation dynamics.

