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3D visualization of liquefaction-induced dune collapse in the Navajo Sandstone, Utah, USA

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The eolian Navajo Sandstone outcrop on the Canyon Overlook Trail in Zion National Park in Southern Utah is dissected by modern erosion in a way which reveals a great deal of the three-dimensional architecture of a major soft-sediment deformation event. The feature is bounded below by a well-developed interdune complex made up of two superimposed carbonate lenses, above by an irregular truncational surface, and incorporates 3 – 10 m of sandstone over an approximately 2 km area. The material above the deformed interval is undeformed cross-bedded sandstone, with crossbeds downlapping onto the surface of truncation. The stratigraphic confinement of deformation and the irregularity of the upper bounding surface suggests a deformation process which created topography, which was in turn covered by the next upwind dune before it could be eroded flat. The deformed material itself is laterally segmented by a stacked succession of shear surfaces, which all strike approximately perpendicular to the paleo-wind direction and dip at decreasing angles in the down paleo-wind direction. These factors point to the collapse of a major dune into the downwind interdune area, likely initiated by liquefaction in the interdune complex. The foundering of the dune's toe into the liquefied area created a powerful lateral stress field which did not extend significantly into the subsurface.

The dune collapse process has been used in the past to describe other soft-sediment deformation features in the Navajo Sandstone, but this site provides a wealth of physical details which were not previously associated with dune collapse. Shear surfaces originate in the interdune deposit as slip between laminae, then the cohesive muds provided support as they were thrust upward to angles of up to 50 degrees. The margins of the site also contain important paleoenvironmental indicators. Dinosaur tracks are exposed both at the extreme upwind and downwind margins of the interdune deposit in and slightly above the deformed interval. In addition, a smaller liquefaction feature is visible in the deposit just below the interdune deposit, far enough away from the main feature to suggest that it is a separate event, not directly caused by the dune collapse. It may have been an earlier episode, or was initiated by the same trigger, but it illustrates the susceptibility of this particular interdune to liquefaction. Details such as the confinement of deformation between irregular bounding surfaces, development of major shear planes, and nearby indicators of liquefaction may be used as new and more robust criteria for the recognition of dune collapse features in other localities and deposits.