Seismic Evidence for Resonance Layer in Booming Sand Dunes

NATHALIE M. VRIEND *, MELANY L. HUNT * AND ROBERT W. CLAYTON †

* Division of Engineering and Applied Science
M/C 104-44
California Institute of Technology
Pasadena, California 91125, USA
nmvriend@caltech.edu

† Division of Geological and Planetary Science
M/C 170-25
California Institute of Technology
Pasadena, California 91125, USA

"Booming sand dunes" are large desert dunes that emit a loud droning, low-frequency sound during an avalanche of sand on the leeward face of a dune. The monotone sound (70-105 Hz) may continue for up to a minute after initiation, even after all visible motion has ceased. The source of the booming sound has long been a mystery and no accepted scientific explanation has been proposed yet.

Seismic refraction experiments conducted with a closely-spaced 48 channel system show a shallow ($<$ 10 m) subsurface layering inside the dune with significant velocity contrasts between the individual layers. The seismic body wave velocities in the top three layers of sand (240 m/s, 360 m/s and 460 m/s) are very close to the acoustic velocity in air (355 m/s) while at the same time the surface waves are highly attenuated. The seismic velocity changes cannot be explained by increasing confined pressure but must be provided by a seasonally changing physical structure. From the seismic survey it is further noted that the layering narrows towards the foothill. During the sustained boom, the frequency rises slightly (from 85 Hertz to 95 Hertz) as the source due to the avalanche proceeds downwards. This observation was deduced from analyzing the booming emission on all 48 geophones in conjunction with a high-quality air microphone.

The multi-layer internal structure of the dune provides a resonance cavity that amplifies particular frequencies and creates the loud booming sound. The resonance and its interaction with the air is modeled with finite-difference simulations.