科学家在实验模型中探索沙丘雪崩声音的奥秘

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The bone-shakingly low bass notes that bellow during sand dune avalanches have captured the attention of explorers from Marco Polo to Darwin.

Likewise, people playing in sand dunes have found that pushing sand in different ways gives various notes: Scooting on your rump down a dune, pushing the sand downhill with your feet, triggers a low booming noise around 50 to 300 hertz (the low end of a piano scale). Pushing the sand around by hand or walking on so-called "squeaking beaches" yields higher-pitched squeals reminiscent of birds chirping or balloons rubbing together.

The causes of these sounds have eluded scientiests for more than a century.

Now a group of researchers, led by physicist Stéphane Douady of the University of Paris VII: Deins Diderot, report that they have performed the first replication of these sand dune sounds in a lab.

The new study, published in the July 7th issue of Physical Review Letters, suggests that in singing sands, grains on the surface of an avalanche bounce up and down in unison, collectively acting much like the diaphragm of a stereo speaker. (In contrast, normal sand dunes make a noisy, rustling sound when their sands slide.)

"The grains are all jumping up and down at different moments," said Douady, about non-singing dunes. "That's enough to cancel the whole vibration."

Previous studies indicated that in natural avalanches on singing dunes, the sand grains' size is linked to the frequency of sound it puts out: To make the booming sound, the grains have to be similarly sized, well-rounded—but not overly polished—dry and free of dust.

Douady's team brought singing sand from a dune in Morocco back to their lab in Paris.

"What was really exciting was that when we found this singing dune, none of the explanations I had imagined before were working," Douady said. "So we really had to come up with something original."

The researchers built a donut-shaped channel, about a meter in diameter, complete with a motorized paddle to push the sand in circles.

Using this apparatus, they made controlled mini-avalanches, varying speed and pile sizes, to find out when the sands would sing soprano, tenor or bass.

According to the group's findings, both the velocity with which the sand is pushed and the depth of the avalanche control pitch. Surprisingly, they report that it takes a layer of sand only a few grains thick to produce the loud sounds recorded in the field—up to 110 decibels, close to the pain threshold of 120 decibels.

To pump out this volume of sound, the grains in the avalanche must move in synchrony. This self-organization, the researchers said, can happen spontaneously when the surface grains bounce along the microscopic hills and valleys of the sand layers below.

Physicist Bruno Andreotti, also at University of Paris VII, says Douady's work is "a beautiful lab

experiment," but he disagrees about which part of the dune is making the sound.

While Douady and colleagues contend it is a thin layer of the sliding sand, Andreotti sticks by his previous work, which suggests the collisions in the avalanche set a much larger area of the dune vibrating, and this greater section emits the sound.

Mechanical engineer Melany Hunt at Caltech argues that the entire dune plays an important part. For one thing, she said, the dunes' sound "is sustained even when it doesn't look like any grains are moving.

"If you ever came out to the dunes with us, there's no way you would think that the grain size and simple sand shearing is responsible for the tone," Hunt said. "You get the sensation that the whole thing is moving and vibrating."

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