structures of the many Wade's rule clusters of the heavier group 13 to 15 elements.

Over the past decade, we and others have shown that the remarkable stability of alkali metal salts of Ga, In, and Tl clusters must in part originate from the large coulombic energy attained through intimate packing of the surrounding cations with cluster anions (*8*). Some of these polyanions follow Wade's rule (such as the octahedral Ga_6^{8-} and the tetrahedral In_4^{8-}), whereas many others are hypoelectronic by this criterion (for example, In_{11}^{8-} and Tl_{13}^{11-}) and form new deltahedral configurations (*2*). No aluminum analogs have been found, however; in fact, Al forms alkali-metal compounds only with Li.

The above results suggest indirectly that potential M_2Al_4 or $M'Al_4M$ salts will not be stable in the solid state. First, the clusters of the heavier group 13 elements appear to be stable as simple salts only when many alkali metal cations surround each cluster, thus preventing additional bond formation between the polyanions; the lowest ratio of cations per cluster known is for In_{11}^{7-} and its analogs (see the figure), although examples with still lower ratios may be found in network structures (*3*). Second, further reaction and condensation of MAl_4^- clusters are expected because of the availability of low-energy, vacant "frontier orbitals," which play an important role in many reactions in condensed systems (*9*). [In contrast, isosteric clusters of later, electron-richer main-group metals, such as the square planar analog Bi_4^{2-} with all skeletal bonding and lone-pair orbitals filled, are even stable to amines (*3*).] Phosphine ligands R_3P are commonly used to stabilize polygold clusters against further condensation (*10*), and something similar may be possible here. But even if these attempts are unsuccessful, the hypothetical aromatic M_6Al_4 species already noted may be better candidates for synthesis and may turn out to be stable in the solid state. Chemistry is exciting when novel ways are found to get around such perceived problems, which are always too heavily predicated on just what is known.

Li *et al.*'s surprising aluminide clusters not only extend aromaticity into metallic elements but also bring to our attention to other factors that govern structural patterns and the stability of solids. These are especially clear here because the aromatic clusters are gaseous, allowing the origin of their stability to be singled out in terms of their electronic structures. Similarly interesting gas-phase species can be anticipated for heavier elements such as Ga, In, and Tl, for which the strength of π-bonding has been controversial and the lone-pair states are increasingly core-like (*2*, *11*).

References and Notes

1. All the faces of a deltahedron are triangles. The simplest regular deltahedron is the tetrahedron, and the most complex is the icosahedron.
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NOTA BENE: ANIMAL BEHAVIOR

Texas Elephants Stomp to Victory

The old saying "putting an ear to the ground" may turn out to be literally true for elephants, according to a recent report by O'Connell-Rodwell and her colleagues (*1*). When elephants generate their low-frequency vocalizations (rumbles), acoustic sound waves traveling through the air are accompanied by seismic waves that travel through the ground. Given that a variety of creatures, from insects to rodents and even the enormous elephant seal, use the generation and detection of terrestrial vibrations to communicate, O'Connell-Rodwell and her team wondered if elephants, too, have this seismic signaling capability.

Eschewing the grasslands of Africa for a residential facility in Texas, the scientists analyzed acoustic and seismic signals generated by two captive Asian elephants. Whenever the elephants "rumbled" or stomped their feet during mock charges, seismic data were collected with geophones—sensitive microphones placed 10 m and 30 m from the elephants' pen that transformed terrestrial vibrations into electrical signals. Simultaneously, acoustic data were collected with audio equipment.

The seismic and acoustic waves generated by rumbles and foot stomps had similar frequencies (20 to 24 Hz) that fell within the ideal range for the long-distance transmission of low-frequency sounds. Intriguingly, the two sets of waves had different velocities (248 to 264 m/s in the ground, and 309 m/s in the air), so that they were no longer in phase as they traveled further away from their source. This hints that elephants may make their rumbles and foot stomps loud enough to produce separate acoustic and seismic waves.

Through mathematical modeling, the investigators estimated that the seismic waves created by their stomping elephants traveled at least 36 km. Conceivably, these long-distance seismic signals may enable elephants to communicate with other herds. The location of a distant herd could be pinpointed by assessing the time delay between the arrival of seismic and acoustic signals.

Elephants are known to move toward thunderstorms that are more than 25 km away, too far for them to hear the sound of thunder. It is possible that they can detect the terrestrial vibrations associated with distant storms, presumably a major advantage in their search for new water sources.

Generating seismic signals is easy, but what about detecting them? The elephant's trunk has mechanoreceptors that respond to mechanical pressure. There may also be similar receptors in the elephant's well-innervated foot pads. These mechanoreceptors may explain foot-lifting behavior during which elephants lean forward and lift up one foot, possibly to improve their sensitivity to ground vibrations.

Establishing that elephants use seismic signaling for long-distance communication is no easy task. Undaunted, O'Connell-Rodwell and her team plan to train their elephants to respond to seismic waves by pulling a lever with their trunk or pressing a button with their feet—with, of course, the provision of a reward for the correct response.

—ORLA SMITH

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