Pattern formation within a sandpile formed by a mixture of grains: The selection of stratification and segregation patterns

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By pouring a mixture of two types of grains into a large vertical cell of narrow dimensions, an avalanche occurs toward the bottom of the sandpile, and the mixed grains separate into their respective grain types due to the Brazil nut effect, which is caused by the vibration of the avalanche. The effect causes spontaneous formations of stratification patterns or segregation patterns in a sandpile. The selection of the pattern in the sand pile is determined by a competition of angles of repose and the grain sizes of the two grain types. In the condition of a formation of a segregation pattern, a size of grain A is larger than that of grain B, and a repose angle of grain A is smaller than that of grain B. On the other hand, the grain size and repose angle of grain A are larger than those of grain B for the formation of the stratification pattern. We investigate pattern formation in a sandpile by pouring a ternary mixture of grains into a narrow vertical cell. Size segregation in avalanches causes the formation of patterns. Four kinds of patterns emerge: stratification, segregation, upper stratification–lower segregation, and upper segregation–lower stratification. A phase diagram is constructed in a parameter space of θ_{11}/θ_{33} and θ_{22}/θ_{33}, where θ_{11}, θ_{22}, and θ_{33} are the repose angles of small, intermediate, and large grains, respectively. To qualitatively understand pattern formation, a phenomenological model based on a roll-or-stay rule is proposed. A similar pattern formation is found in a numerical simulation of the phenomenological model. These results suggest that the ratios of the repose angles of the three grain types are important for pattern formation within a sandpile.

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