A new kind of bedform

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Numerous recent seabed observations have revealed that a striking type of large-scale pattern adorns many inner continental shelves around the world. The sediment in these environments is somehow segregated into swaths of coarse material (coarse sand and gravel), separated by domains of fine sand. Coarse swaths, usually on the order of 100 m wide, often extend kilometers in the offshore direction. Sharp boundaries separate coarse and fine domains. While the plan-view characteristics of this phenomenon vary considerably from one location to another, the pattern can be quite well ordered, reminiscent of well-organized bedforms such as wind ripples.

We present a hypothesis for the formation of these grain-size-sorted patterns, and an exploratory numerical model to test its plausibility. The hypothesis and model involve a feedback and subsequent emergent interactions that lead to an unusual kind of large-scale bedform. More familiar bedforms grow because the interaction between a topographic perturbation and a sediment-flux field cause the perturbation to grow. However, in our case, grain-size effects rather than topographic interactions drive the feedback and determine the behaviors of the resulting features.

The hypothesis begins with the observation that where a shallow seabed is covered by coarse material, that sediment is sculpted into large wave-generated ripples, with wavelengths commonly on the order of a meter. Wave motions interacting with these large roughness elements will generate large-scale, energetic turbulence. This enhanced turbulence will tend to enhance the entrainment of fine sediment, and to inhibit its redeposition locally. Then, any mean current will tend to advect the fine sediment to a location where the bed is finer, the wave-generated ripples are smaller, and the turbulence is less energetic. Starting from a nearly homogeneous seabed, these interactions will tend to preferentially remove fine sediment where the bed is coarser, and to preferentially deposit it where the bed is finer. This feedback will tend to produce a grain-size sorted pattern.
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To investigate whether this feedback and subsequent interactions between sorted features could produce large-scale sorted patterns with the characteristics observed in nature, we have developed a simple numerical model. In this model, rather than explicitly simulating the hydrodynamics and sediment transport on the scales associated with wave-generated ripples, we parameterize the effects these processes have on larger-scale sediment transport; we treat transport as a function of bed composition, as a proxy for ripple size. The model robustly generates sorted patterns. The size and appearance can match those of the natural features, although the details of the patterns depend on the wave and current characteristics. As perturbations grow to finite amplitude, interactions between them, including mergers, lead to a larger-scale, better-organized pattern. The plan-view evolution of these ‘sorted bedforms’ appears surprisingly similar to the evolution of some topographically driven bedforms.