

How do silt and sand differ when going with the flow?

December 16 2019, by Mike Williams



Rice University postdoctoral researcher Hongbo Ma holds sand from the Mississippi River, left, and silt from China's Yellow River. Ma led a study that showed particle size controls how sediment moves in flowing rivers changes dramatically when the grains are about 150 microns in size. Credit: Rice University

The river may rage or gently roll, but in the end the sand and silt will have their way.

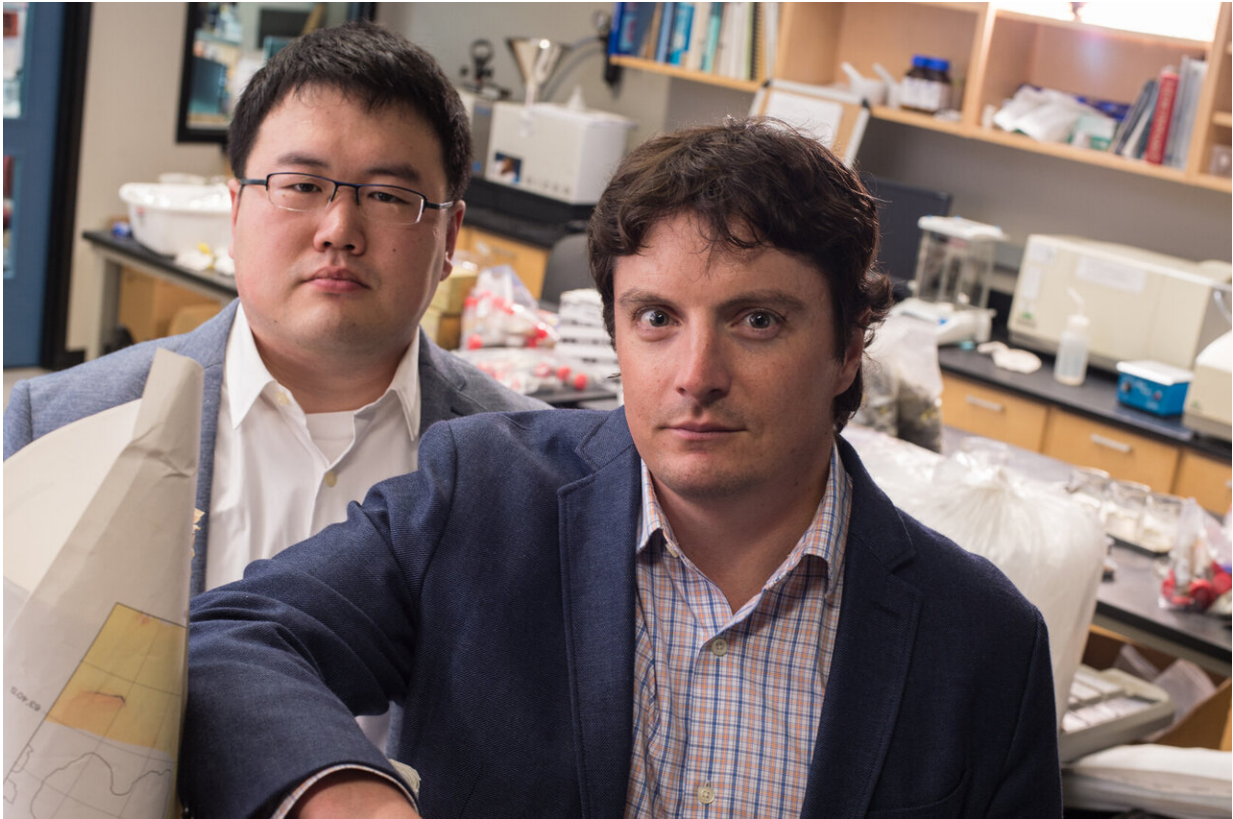
Rice University Earth scientists and their colleagues have defined a surprising breakpoint at which the grain size of riverbed [sediment](#) exercises extraordinary control over how much material will be transported downstream, nourishing deltas and coastlines.

New work led by Rice coastal geologist Jeff Nittrouer and postdoctoral researcher Hongbo Ma brings decades of experiments and field observations into focus by showing that sand and silt suddenly shift from one means of transport to another.

In short, some grains of sediment larger than about 150 microns (considered fine sand) move along the riverbed and some are suspended in the current. Finer grains are completely lifted into the flowing water and move much faster toward the mouth of a river. There, they can rapidly change the landscape and generate deltas while supplying coastlines with sediment.

The researchers were surprised to find that grain size dominates the manner of transport regardless of how fast the river is flowing, according to their report in the *Proceedings of the National Academy of Sciences*, which won this year's "Best Paper Award" from the International Association of Chinese Youth in Water Science.

"Most people look at silt and at sand and say these things are awfully close to one another," Nittrouer said. "But the reality is there are fine-scale differences between the two that offer enormous changes in the amount of material moved. We often consider the world to be a linear place, but if you change grain size by just a small fraction, you suddenly change the volume of material transported by 10- to 20-fold."



Rice University researchers Hongbo Ma, left, and Jeffrey Nittrouer, an assistant professor of Earth, environmental and planetary sciences, led a study that found a sharp break in the transport mechanism characteristics of sand and silt in riverbeds. Credit: Jeff Fitlow/Rice University

Relatively coarse material is associated with large sand dunes that make riverbeds rough and provide friction that limits the amount of energy available to move sediment, he said.

But silt and very fine sand, transported via suspension, build long, low dunes that reduce the energy consumed by friction and facilitate high sediment transport rates. "Direct suspension allows more of the flow's energy to be utilized in transporting the sedimentary material," Nittrouer

said.

Sediment flux alters coastlines, deltas and the course of rivers themselves. "Our capability to predict how fine-grained sediment moves in different environments has been very limited," Ma said. "We basically set out to simplify the entire system."

He said previous algorithms provided patchwork solutions that applied to either large sand particles or silt but didn't account for what was assumed to be a gradual transition from one means of transport to the other. "We were surprised to find there's no continuous transition between them," he said. "It turns out that at a certain point, they suddenly transition to another state."

Ma built the universal transport algorithm after considering nearly 2,000 sets of sediment transport data from several decades of published research, along with his team's own observations, particularly through a National Science Foundation-backed study of China's Yellow River (aka the Huanghe River).

"Hongbo has essentially taken a large database and used it to ground a new algorithm that allows for a spectrum of grain sizes," Nittrouer said. "It lets us make predictions about how much and where [sand](#) or silt should move under the influence of given environments and [boundary conditions](#)."



About a billion tons of sediment flow to the delta of China's Yellow River each year. The river was closely studied by Rice University scientists and their colleagues, who found a universal transport algorithm to explain that particle size yields great control over how sediment moves, regardless of the river's flow. Credit: Wikipedia Commons

"That has a lot of bearing on how we understand the movement of material on Earth, as exemplified by fine-grain rivers like the Yellow River," he said.

The Yellow River is known to send about a billion tons of sediment each year towards the sea. The Rice lab has already used its new algorithm to predict changes in the Yellow River delta, the results of which appear in a recent paper led by graduate student Andrew Moodie, also a co-author

of the new study.

Nittrouer suggested the algorithm could have wide application on Earth and beyond.

"If we want to understand how much material is moving on a planet like Mars or the structure of the system that transported that material—the channel dimensions, the bed forms in the channels—we can use inverse modeling to determine what the transport conditions were like in the past," he said. "That ties intimately into the environmental conditions that were present within that region at some given time."

He noted the surprising boundary may reflect even larger forces at work in nature. "You can push nature for so long and then, once you cross some threshold, major shifts begin to happen," he said. "People are trying to figure out where these thresholds exist in terms of climate perturbations and [climate change](#)."

"So this is a demonstrable example of a threshold in nature, a small change that can provoke big ones," he said.

More information: Hongbo Ma et al., "Universal relation with regime transition for sediment transport in fine-grained rivers," *PNAS* (2019). www.pnas.org/cgi/doi/10.1073/pnas.1911225116

Provided by Rice University

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