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NEWS

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Coastline carve thyself

Philip Ball

Theory accounts for land's fractal fringes.

Rocky coasts are natural fractals.

The beauty of jagged, rocky coastlines will prevail, however hard the sea pounds them. The classic coastal profile is a balance between the sea's eroding power and the ability of the coastline to damp it out, say researchers in France and Italy.

Although a coast continues to crumble and break up under the relentless assault of the waves, it soon adopts a pitted, fractal form that modifies the force that erodes it. "Whatever its initial shape, a rocky shore will end up fractal," the researchers conclude.

When the science of fractals emerged in the 1960s, the ordered complexity of coastlines quickly made them the best example in the natural world. A fractal pattern repeats over and over at different scales of magnification - so that a one-kilometre stretch of coast looks as rugged as a 100-kilometre one.

But there has never been an explanation for why coastlines are fractal, says Bernard Sapoval of the Ecole Polytechnique in Palaiseau, France.

Until now, that is. "Fractal coastlines are best at damping waves," Sapoval explains. "As the coast damps down the waves, the erosion to which it is subjected is reduced."

To test the idea, Sapoval and his colleagues built a computer model of coastal erosion. Material in the model is removed from the coastline either by fast 'quarrying' by waves, or by slow 'weathering', where minerals dissolve in water.

In the model the coastline is divided into a grid. The rock type - and thus the resistance to weathering erosion - varies from one grid cell to another at random.

The erosive power of the sea depends on how heavily damped the waves are. They will be calmer in a narrow bay or inlet, for example. Sapoval and colleagues assumed that this damping increases as the coast becomes more pitted.

Running the model, the researchers found that an initially smooth coastline

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rapidly breaks up into a rough-edged profile with many offshore islands. Eventually it settles down into a realistic-looking profile with a fractal shape[1]. Their modelled coast was similar to the real US East Coast.

> **Fractal coastlines are best at damping waves**
>
> Bernard Sapoval
>
> Ecole Polytechnique, Palaiseau

The model neglects some processes that are known to be important in shaping some coasts, such as sediment transport by rivers. But the researchers think that the basic process they have identified - modification of erosion force by the coast itself - plays a central role in carving out coastlines.

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References

1. Sapoval, B., Baldassarri, A. & Gabrielle, A. Self-stabilised fractality of sea-coasts through damped erosion. Preprint, http://arxiv.org/abs/cond-mat/0311509, (2003).

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