SPECIAL RELEASE ON MANDELBROT'S CONTRIBUTIONS TO THE EARTH SCIENCES

NEW HAVEN, CONN. Benoit Mandelbrot, Sterling Professor of Mathematical Sciences at Yale University and the "father of fractals", shared the 2003 Japan Prize for Science and Technology.

Thanks to the major role that fractal geometry achieved in the earth sciences, Mandelbrot can arguably be called the originator of a first quantitative approach to a study of roughness. His 1967 paper on "How Long is the Coast of Britain" [48] became an instant classic. Ironically, it was not originally meant to contribute to geomorphology, but began as a ploy to gain acceptance to his work on turbulence that led to [66, 72]. Specialists in turbulence spurned the mathematics in this paper and did not see how it related to their work, and potential specialists in his mathematics spurned turbulence and did not see that it contributed to their work.

The solution of the quandary relied (as M.S. Longuet-Higgins later put it in a review), "on the plausible assumption that many mathematicians who would run a mile from a Hausdorff measure will quite willingly fall into the arms of a fractal." This quote used "mathematics" in the British nineteenth century sense. Mandelbrot's "plausible assumption" was confirmed by experience and the ploy opened a Cornucopia, a Horn of Plenty.

The most widely known analytic tool of fractal geometry consists in power-law relations and power-law probability distributions. One of the earth sciences has known of power-laws for a particularly long time, since Ohmori's law of seismology was discovered in 1894. (Thus it predates even the Pareto law for the distribution of personal income which was discovered in 1896.) But in 1950, when Mandelbrot began investigating related power laws [1], such laws had not been brought together credibly and were viewed by statisticians and earth scientists alike -- as anomalous. They were questioned and played down. Mandelbrot's work changed the situation completely in many sciences and power-laws have now moved to the forefront. He made them into evidence of a broad geometric scaling property of invariance that led him to the concept of fractal. Power-laws came to critical phenomena long after Ohmori and Gutenberg-Richter. They also came after Mandelbrot's work on 1/f noises and finance. (But in critical phenomena the power-laws were soon fully explained.)

Hydrology was first to be affected by fractal geometry. The time domain problem was tackled in a series of papers, the first dating to 1955 [38] and many of the others coauthored by J.R. Wallis and J.W. Van Ness [52, 53, 54, 57, 58, 59]. Thanks to those papers a contested experimental power-law due to H.E. Hurst ceased to be viewed as due to a meaningless transient and was reinterpreted as a statistical manifestation of a fundamental underlying self-affinity. This in turn led Mandelbrot to the notion that the span of statistical dependence can be infinite or global. From an esoteric possibility entertained but not explored in pure mathematics, this notion moved to become a central issue in the Earth and Planetary sciences.

In the space domain, many scattered power-laws were known to relate such quantities as the width and depth of rivers. They ceased to be isolated and could be interpreted as symptoms of spatial self-similarity or self-affinity.

Mandelbrot then moved on and constructed a new and widely accepted approach to geomorphology that is centered on yet another empirical power-law due to L.F. Richardson and first used it in his "Coast of Britain" paper. His fractal forgeries of mountains implemented by R.F. Voss and his fractal forgeries of clouds implemented with S. Lovejoy have become classic.

For ubiquitous phenomena of increasing variety, fractal geometry has provided excellent descriptions. The number of phenomena it explains is also growing. That is the case even for phenomena definitely in the domain of physics, such as turbulence in fluids.