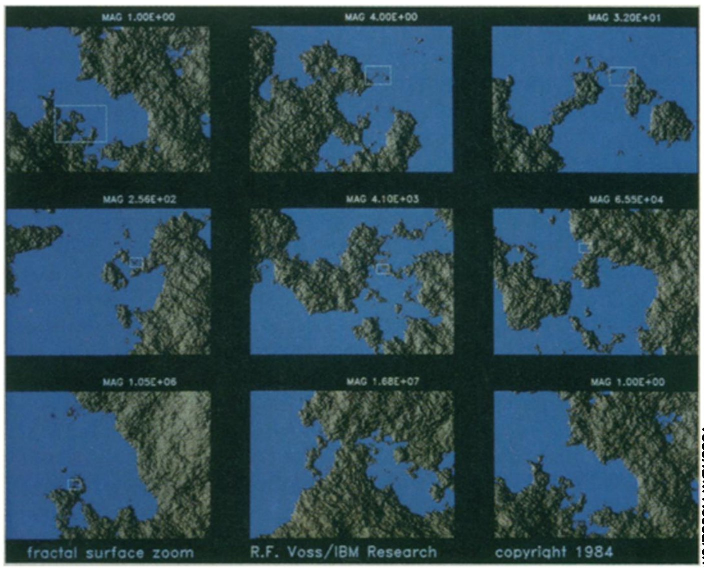
FRACTALS: MAGICAL FUN OR REVOLUTIONARY SCIENCE?

Richard F. Voss is a mathematician with the IBM Thomas J. Watson Research Center in Yorktown Heights, N.Y. An energetic young man with a very good stage presence, he is always a delight to hear, especially when he comes equipped with amazing audiovisual effects – as he usually does. It's a little bit like a scientific Doug Henning show, except that the subject, which is fractals, has serious applications to scientific reasoning. Indeed the major point of Voss's presentation at the recent meeting in San Francisco of the American Physical Society and the American Association of Physics Teachers was that fractals are a new language for the description of nature, supplanting the simple geometric figures that have been used up to now.

Another IBM mathematician, Benoit Mandelbrot, is credited with the invention of fractals, a development that came from contemplation of complicated shapes like snowflakes. Distinguishing fractals from the geometric figures Euclid taught us about are two basic qualities: self-symmetry and fractional dimension.

Self-symmetry means that an enlargement of a small part of the figure looks like the whole. Voss showed numerous examples, particularly a sequence where the camera zooms in from above onto a computer-drawn, hypothetical coastline: Each successive enlargement of a smaller area of harbors and islands resembles the previous, more distant view of a larger area. In other words, where fractals are concerned, notions of scale go overboard. You never can be sure how close to the ground you are. Mandelbrot discovered that to classify and systematize such figures he had to endow them with fractional dimensions, not 1, 2 or 3, but numbers between 1 and 2 or 2 and 3, and the precise fraction tells things about the shape and complexity of a particular figure.

Fractals turned out to be a mathematical curiosity that science was just waiting for. We now have fractal theories or suggested fractal explanations for all sorts of things from the tone sequences in Gregorian chant to the power spectrum of the sun, to the random walk of the proverbial drunk under the lamppost to the folding of proteins. We don't yet have a fractal theory of elementary particles, but if superstring theory should fail, that could well be the next thing.



Voss/IBM Research

Computer-designed coast illustrates application of fractals to mapping.

This proliferation leads Voss to claim that fractals, with their complicated regularity, are closer to the shapes nature makes than are the simple regular geometric figures we have been used to: circles, triangles, rectangles, etc. The geometric figures, he says, are characteristic of human artifacts. Fractals are characteristic of nature.

These geometric figures are also characteristic of something else: the categories and thought processes bequeathed to us from ancient Greece. Voss didn't say it, but this reporter was led to wonder whether we are not finally taking a very large step beyond the Hellenic heritage that has dominated our thought processes for millennia. The ancient Hellenes were people who believed very strongly in the power of the human mind to determine what things ought to be. Plato had the nerve to define God; a mind with that kind of chutzpah has no problem telling us what stars and planets ought to be.

Some of this inheritance seems to have been more of a hindrance than a help in the development of science. Sunspots were at first hard to accept because of the Hellenic belief that the sun had to be a perfect body. The notion that the planets could only move in circles hindered acceptance of the Copernican-Keplerian model of the solar system. Even today, a century after Riemann, Lobachevski and Bolyai, the notion that Euclidean is the only real geometry hinders many people's thought. The rectilinear method of thinking that the Greeks bequeathed us began to frazzle in the days of Newton, and it has run aground on quantum mechanics. Whoever really understands classical mechanics knows how to transcend Zeno's paradox; whoever thinks of quantum mechanics in the spirit of Neils Bohr or Max Born is not troubled by the paradox that so worried Einstein, Podolsky and Rosen.

If the history of science represents in some ways an emancipation from the Hellenic intellectual heritage, it was a gradual and very reluctant one. We needed those simple figures, these straight-on ways of thinking to analyze, to arrange and to cope with what we were observing. We couldn't have done without them.

Yet there have always been large tracts of science where these simple analytic methods hardly applied. The natural phenomena were just too complex. Over them people waved their hands in frustration and made qualitative theories, or grossly approximate theories or no theories at all. It is in these realms that fractals are finding application after application. Either the development of fractals is just a fascinating mathematical game, or it is one of the most significant steps that scientific analysis has taken.

– D. E. Thomsen