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BOOK REVIEWS

Fractals for earth scientists

Turcotte, D. L. 1992. *Fractals and Chaos in Geology and Geophysics*. Cambridge University Press, Cambridge, U.K. Price £29.95, $54.95 (hardback).

Not so very long ago, to confess to an interest in fractals or (worse) chaos was to invite instant denunciation as a 'trendy'. It is a mark of the change that has taken place in the Earth Sciences over the last few years that these concepts have found their way into the classroom, and this evolution is celebrated by the appearance of a text-book designed for advanced-level undergraduates and beginning postgraduates which provides an introduction to these important concepts. This book is written by Don Turcotte, who has been one of the leading proponents of the application of these ideas to the study of the Earth.

There is a danger that, having agreed to review a book, it may sit unread on the bookshelf, staring reproachfully down as you prevaricate. No such problem is encountered with the present volume. Indeed, one warms immediately to an author who, in a radical departure from established practice, begins by handsomely acknowledging the graduate students who introduced him to fractals and contributed to his thinking on the subject.

The first two chapters are an introduction to the elements of fractal geometry using examples familiar from other similar introductions, such as the calculation of the length of a coastline.

Chapters 3, 4 and 5 extend the discussion of fractal geometry to include an analysis of the fragmentation of a body into a number of parts with a power-law distribution of sizes, and show the relevance of this simple example to the study of seismicity, specifically to the description of size distributions of earthquakes; and to the calculation of ore grades and tonnages.

Chapters 6 and 7 introduce further theoretical considerations of clustering. Chapter 7 is a discussion of self-affinity, particularly as it applies to the analysis of topography. Another aspect of geomorphology—the role of erosion and river patterns—is discussed in Chapter 8.

Chapter 9 introduces some of the basic concepts of the study of dynamical systems. The logistic map, a classical example of a non-linear system with well-defined chaotic behaviour is discussed in detail in Chapter 10.

On this basis, the following four chapters discuss specific non-linear models which describe systems of geophysical interest. The first of these is the slider-block model of seismicity, a simple low-dimensional paradigm for fault behaviour which is shown to lead to a chaotic regime, implying that earthquake prediction is not possible in a deterministic state. The simple model described in the chapter includes only two connected sliding blocks and is a useful example which allows a detailed analysis, but most current slider-block models appearing in the literature at the moment include a large number of inter-connected blocks. These models do not permit such a clear exposition of the characteristics of chaotic dynamics, but they do appear to lead to self-similar geometries. Larger models are discussed briefly in the context of self-organized criticality and cellular automata in Chapter 16, but the connection between the larger models and the two block model is not discussed. This is a pity, because such a discussion could have highlighted some of the difficulties in analysing more complex models in terms of, for example, the Lyapunov exponent. In addition, this would have been an excellent place to emphasize that what one is modelling is, after all, seismogenesis, and the question of the physical realism of the various sliding block models is not always evident, particularly where the models are small and dominated by boundary effects.

Although the word 'geophysics' occurs in the title of this book, it might more properly be described as a book about *solid earth* geophysics, since examples from oceanography and meteorology are conspicuously absent. This omission seems slightly unfair in Chapter 12, which continues the discussion of dynamical systems, by means of an exposition of the Lorenz equations. These equations describe thermal convection and were developed by Edward Lorenz, a meteorologist studying weather forecasting. Chapter 13 is devoted to the question of chaotic convection such as may occur in the mantle, and finally Chapter 14 describes the Rikitake dynamo, a chaotic model of the geomagnetic field which leads to a random pattern of reversals of the geomagnetic field.

The renormalization group method is the subject of Chapter 15. This is a technique which relies upon the concepts of scale invariance and has been used by physicists in the study of phase transitions, particularly those involving magnetism. It has been applied to simple cases of fault systems and rock fracture. Chapter 16, as has already been mentioned, is devoted to self-organized criticality, an approach to the study of seismicity which is the object of considerable interest at present.

The subject of this book is evolving rapidly: every month sees the appearance of a large number of articles which extend our insight into the role of fractal geometry and chaos in geophysics. It is therefore inevitable that any book will appear narrow. This is perhaps accentuated by the limited range of topics the book attempts to cover. Apart from basic matter which can be found in most elementary text-books on fractals and chaotic dynamics, the subject matter corresponds closely to the areas addressed by the author and his co-workers. This is in part a tribute to the immense, pioneering contribution of Professor Turcotte, but there are nevertheless a few surprising omissions. One might have expected to read rather more about percolation theory, which has a natural affinity with fractal geometry and has been employed quite extensively in seismology. Also, though most dynamical models of seismicity are based upon frictional phenomena, a number of authors have concentrated upon the fracture-mechanical aspects, and this might have been, at least, mentioned in passing.

A further criticism might be levelled at the publisher. The production is handsome, notwithstanding a number of trivial typographical errors, but a price of nearly £30 for such a slim volume must be regarded as excessive for a book aimed at students. In the current economic climate, even departmental libraries will think twice before ordering a copy.

And this is unfortunate, because this book will be particularly valued by students. The classic reference on fractals by Benoît Mandelbrot is a hugely impressive work, but it does suffer sometimes from being rather obscure. In contrast, Professor Turcotte's book is a model of clarity, with important concepts illuminated by carefully chosen examples. This comment is no less applicable to the parts which deal with chaotic dynamics. When the paperback edition is produced, which one hopes is soon, it should form a well-thumbed addition to the bookshelves of its target market.

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Iran's salt diapirs

Jackson, M. P. A., Cornelius, R. R., Craig, C. H., Gansser, A., Stöcklin, J. and Talbot, C. J. 1990. *Salt Diapirs of the Great Kavir, Central Iran*. Geological Society of America, Memoir 177. 139 pp. + 13 plates. Price $36.25 (hardback).

Memoir 177 of the Geological Society of America is entirely devoted to salt diapirism in the Great Kavir Basin of Central Iran. The Great Kavir dessert is one of few regions on earth were salt diapirs are relatively well-exposed at the surface but nowhere on earth are the two-dimensional internal structure of diapirs so well visible on aerial photographs and satellite images as here. The book consists of four parts: (1) *Geology*; (2) *Centrifuge modelling*; (3) *Analytical modelling of diapirism*; and (4) *Summary and conclusions*.