progress of Alaskan geology that work on this volume spanned eight years (1982–1990); however, it is even more unfortunate that contributions from the editors and their co-authors held up publication unnecessarily for three more years.

Nonetheless, because the volume has taken a long time to prepare the production quality is good. The plates and figures are of particularly high quality, giving the volume high value. *The Geology of Alaska* is an impressive volume and it is certainly worthy of its place in a series celebrating the centennial of the Geological Society of America. This volume is a excellent place to start with one's introduction to, or re-acquaintance with, Alaska geology. As the editors state, I expect it will be a long time before we will see a similar effort summarizing Alaskan geology within a single volume.

REFERENCES

Irving, E. & Monger, J. W. H. 1987. Preliminary paleomagnetic results from the Permian Asitka Group, British Columbia. *Canadian Journal of Earth Sciences* **24**, 1490–1497.

Irving, E. & Wynne, P. J. 1991a. Paleomagnetic evidence for motions of parts of the Canadian Cordillera. *Tectonophysics* **187**, 259–275.

Irving, E. & Wynne, P. J. 1991b. Paleomagnetism: review and tectonic implications. In: *Geology of the Cordilleran Orogen in Canada* (edited by Gabrielse, H. & Yorath, C. J.), pp. 61–86. Geological Survey of Canada.

Irving, E. and Yole, R. W. 1987. Tectonic rotations and translations in western Canada; new evidence from Jurassic rocks of Vancouver Island. *Geophysical Journal of the Royal Astronomical Society* **91**, 1025–1048.

Irving, F. R. S. & Wynne, P. J. 1990. Palaeomagnetic evidence bearing on the evolution of the Canadian Cordillera. *Philosophical Translations of the Royal Society of London* **331**, 487–509.

Oldow, J. S., Bally, A. W., Ave Lallemant, H. G. & Leeman, W. P. 1989. Phanerozoic evolution of the North American Cordillera; United States and Canada. In: *The Geology of North America—An Overview* (edited by Bally, A. W. & Palmer, A. R.). Geological Society of America, A, Boulder, CO.

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Fractals Diversified

Kruhl, J. H. (editor) 1994. *Fractals and Dynamic Systems in Geoscience*. Springer-Verlag, Berlin. Price: Hardcover: DM 148.

The widespread use of fractal techniques in earth science research is largely due to the fact that it allows us to describe the geometry and complexity of natural patterns. While insight into complex processes has come directly from theoretical physics, in particular thermodynamics, the principal role of fractal analysis in the geosciences has been to allow quantitative comparison of patterns and to aid the development and testing of models which simulate geologic processes. This book, edited by J. H. Kruhl, arose out of a meeting on the topic of Fractals and Dynamic Systems in Geoscience, held in Frankfurt am Main in April 1993. The motivation for this meeting, outlined in the Preface, was to try to move beyond purely geometrical characterisation in order to gain greater understanding of the underlying physical processes operating. While many of the papers in this volume do address this issue, there are a number that do not and in this respect I found some of the chapters frustrating.

The book contains 31 research papers divided into four sections. The first two sections, which constitute about half of the book, cover topics related to structural geology and tectonics, and I will focus on these in this review. The third section contains papers on mineral deposits, zoning and morphology of mineral fabrics, and the fractal properties of chemical element distributions and isotopic records. The final section contains two papers on fractal analysis methods: the first describing a counter-scaling method for analysing self-affine objects, and the second showing an application of the Grassberger–Procaccia algorithm to $\delta^{18}O$ variations.

The first section, entitled Deformation and Tectonic Structures, consists of 11 papers on topics as wide ranging as theoretical modelling of fracture propagation and seismicity, connectivity of fracture networks, experimental rock deformation and field studies. In the first paper, Turcotte reviews statistical models for seismicity and discusses whether self-organised criticality (SOC) is a good description of earthquake distributions. He questions whether SOC is applicable to temporal and spatial variations in seismicity and, in particular, precursory phenomena. The following article, by Nagahama & Yoshii, discusses the role of surface roughness in the energy required for fragmentation in addition to the energy required to reduce grain size during cataclasis. Based on experimental data and theoretical arguments, a relationship between roughness and size frequency distribution of grains is derived, which the authors suggest can be scaled-up and applied to spatial variations in fault patterns and seismic b-values.

A paper by Zhang & Sanderson shows a connectivity analysis of fracture patterns generated stochastically using assumptions about spacing, length and orientation. Their principal conclusion is that, for randomly orientated or orthogonal fracture sets, the fractal dimension of connected clusters increases with fracture density. These authors also present some numerical simulations of deformation in fractured rock masses using the UDEC code. However, they do not explicitly consider the sequence of fracture growth, the distribution of fracture apertures, the effect of stress on apertures and how these factors may influence effective permeability.

The following two papers are by V. V. Silberschmidt and V. G. Silberschmidt, who use fractal analysis to quantify damage evolution in brittle materials and the propagation of joints. These authors find that heterogeneity of material properties locally controls fracture development, and that this in turn determines the fractal dimension of fractured zones and joint surfaces. V. V. Silberschmidt focuses in particular on the issue of whether fracture toughness and fractal properties of joint propagation fronts are related, and concludes that toughness reflects the overall response of a material to deformation whereas fracture growth is only sensitive to local strength variations. These papers are followed by two papers from Kristakova and Kupkova who reach a very different conclusion on the same issue. These authors first of all present a roughness analysis of experimentally-produced fracture surfaces and compare it to other measurements of physical properties to see whether there is any relationship. Although limited by the range of measurements, they conclude that a correlation does exist. The authors then show the results of computer simulations of fracture growth in which the probability of rupture depends on temperature and they relate the fractal dimension of the model fracture patterns to experimental estimates of fracture toughness at different temperatures.

Subsequent papers by Kruhl and also Pickering *et al.* present field observations on the scaling properties of veins and fault populations. Kruhl presents data on size–frequency distribution and spacing of veins, and compares the patterns to a cantor dust model. His interpretation of the data is that increased dilation is achieved by addition of thinner veins, which broadens the range of vein thicknesses observed. The paper by Pickering *et al.* deals with fault population analysis and in particular the power-law size–frequency distribution of fault displacements. The authors present field measurements of a fault population mapped at the outcrop-scale and relate it to larger-scale faults mapped from offshore seismic data in the Moray Firth region of Scotland. They find that one power-law distribution can be used to describe both datasets. As the faults occur in the same Triassic-age strata and have similar orientations, and the authors conclude that the data do indeed represent a single fault population. Therefore, it may be possible to infer the numbers of faults in the scale range between the field and seismic observations (i.e. faults with displacements between 1 m or so and 10–20 m), even though there is no data on faults at this scale. Pickering *et al.* also discuss how sampling strategies can affect estimates of the power-law exponent.

The following paper by Nagahama discusses the high-temperature visco-elastic flow of rocks. The author provides an explanation for observed power law transient relaxation behaviour by considering the superposition of standard exponential decay of mineral elements which have different relaxation times, where the distribution of relaxation times is fractal. The last paper in the first section is by Ord and shows the results of numerical simulations for shear band development using the FLAC code. The author argues that a fractal analysis of the velocity field during shear band growth, using phase space trajectories, can be used to infer the number of variables governing the underlying dynamical process.

The second section of the book is entitled Physical Features and Behaviour of the Earth and contains six papers. The first of these papers, by Meissner, reviews the non-linear processes involved in earthquake nucleation and rupture propagation and discusses the issue of whether earthquake prediction is a realistic goal if sufficient instrumentation of active areas were possible. The following article by Rossi presents a fractal analysis of the spatial clustering of earthquakes in the Friuli region of NE Italy. An observed annual variation in the degree of clustering (with the fractal dimension varying from about 0.7 to 1.5) appears to correlate with crustal strain variations determined from tiltmeter data, and is interpreted to be due to thermoelastic effects and variations in ground-water level. While this result is intriguing, the correlation is established by qualitative comparison of power spectra of fractal dimension and tiltmeter data, and possible contemporaneous variations in seismic b-values are not explored.

The next paper, by Markus *et al.*, presents a cellular automaton model for earthquakes based on simplified assumptions about stick-slip. The aim of the paper is to reduce the automaton to its simplest form in order to define a generalised number-theoretical framework for the model behaviour. Diao & Chao then review the current state of research into earthquake distributions in China and the impact that fractal analysis has had in the earthquake prediction program. Seismic b-values and spatial temporal variations in seismicity have received the most attention, with many of the standard techniques of fractal analysis applied to Chinese earthquake catalogues. Data are presented on seismicity variations before and after seven major earthquakes which occurred between 1935 and 1990, although there is little information on the data analysis procedure. The relationship between the scaling properties of the earthquakes, the roughness of fault zones, and the fractal dimension of topography in active regions is also discussed, and the paper includes many references to other published datasets in China.

There are two brief articles at the end of Section 2: the first by Kumpel explores self-similar properties of earth tides harmonics, and the second, by Ivanov, presents a fractal analysis of global topography based on a 1° gridded elevation dataset.

To summarise, this volume includes papers on a very wide range of topics in the earth sciences and thus demonstrates the considerable diversity of natural processes which may be studied using fractal techniques. However, most of the papers are designed for a specialist audience and I suspect that few readers will find this a generally accessible text. Overall the articles are succinct and 'to the point' but, in my opinion, this is not necessarily an advantage. I found several cases where assumptions or background knowledge were not outlined in sufficient detail such that a reader, unfamiliar with the work of particular authors, could not appreciate the broader context of the research presented. I see this book as a useful addition to research libraries because it does contain material not published in regular journals, but I expect most readers will focus in on just one or two articles relevant to their particular field.

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