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BOOK REVIEWS

DNAG reaches Alaska

Plafker, G. and Berg, H. E. (editors) *The Geology of Alaska, DNAG volume*. Geological Society of America, Boulder, Colorado, U.S.A. 1055 pp. ISBN 0–8137–5219–1. Price: $135.00.

The Geology of Alaska, (Volume G of the *Decade of North American Geology* series) is an excellent addition to the bookshelf of anyone interested in the tectonic evolution of the North American Cordillera. The aim of the book, to summarize the onshore and offshore geology, tectonic evolution and mineral resources of Alaska and its adjacent continental margin, is mostly achieved. Unfortunately, delays in completion of some contributions have had an adverse impact on the remaining chapters, a number of which are somewhat out-of-date.

This immense volume contains 33 chapters and 13 plates that described in detail the geology and geophysics of Alaska's principal onshore and offshore regions. In addition it covers several topical subjects of broad interest. Chapter 1 provides an introduction to the history of Alaskan geologic studies and to the volume itself, while Chapter 33 presents an overview and synthesis of the preceding chapters. The intervening chapters include Regional Geology (12 chapters); Successor Basins (1 chapter); Crystalline Rocks (11 chapters); Paleomagnetism (1 chapter); Quaternary Geology (2 chapters); and Resources (4 chapters). The volume includes 13 high-quality plates that present 1:2,500,000 scale maps and cross-sections detailing: geology, physiography, terrane designations, metamorphic rocks, latest Cretaceous and Cenozoic igneous rocks, sedimentary basins, isotopic age data, gravity, magnetic anomalies, metalliferous deposits, neotectonics and volcanic rocks.

The 12 chapters on regional geology present a comprehensive but varied treatment of Alaskan geology. 'Classical geologic mapping' and 'terrane analysis' are variably favored by the authors of each chapter, and in some cases the two different approaches are within a single chapter. As stated by the editors, this fundamental difference in approach is certainly 'challenging' for the reader. I found the chapters that dealt with geology rather than terrane analysis more useful, in that from the geologic data presented I could evaluate the proposed geologic interpretations and suggest other means to satisfy the data. In chapter steeped in terrane nomenclature it is difficult to see where geologic data end and terrane interpretations begin.

The 11 chapters describing crystalline rocks provide a good means to cut through the terrane analysis approach in many cases, and they provide good overviews of various types or ages of crystalline rocks in Alaska. In many cases these chapters emphasize unifying geologic threads rather than emphasizing terrane differences. For example, a chapter on crustal melting events (Chapter 20) addresses the tectonic processes recorded by three distinct ages of granitic rocks. Chapters 22 and 23 both cover the temporal and spatial evolution of Aleutian magmas, and together these chapters provide a 'fun' introduction to the field of magma genesis. The authors of these two chapters agree upon little, being on opposite sides of each of three major controversies; yet the adjacent, but hardly companion, chapters provide a wonderful forum for the uninitiated to gain an appreciation of the arguments and their implications for arc magma genesis.

Chapter 26 on paleomagnetic data (accepted 5/90), an important topic for all Alaskan tectonicists, provides an example in which the extended publication time may have adversely impacted the chapter's staying power. In the early to mid-1980s, when this chapter was written, evidence supported a southerly Permo–Triassic position for Wrangellia. However, by the late 1980s a growing body of paleomagnetic, paleontologic and geologic evidence—uncovered mostly by Canadian workers—supported a northern hemisphere pole position for Wrangellia and Stikina rocks during Permian, Triassic and Early Jurassic time, indicating paleolatitudes concordant with those of ancestral North America (e.g. see Irving & Monger 1987, Irving & Yole 1987, Oldow *et al.* 1989, Irving & Wynne 1990, Irving & Wynne 1991a, b and references therein). Thus the weight of present evidence indicates that these rocks were in a northern position in pre-Early Jurassic time, that they moved southward in Jura–Cretaceous time, and that they have moved northward again since the mid-Cretaceous. The relative displacement of these rocks by a kind of 'yo-yo tectonics', with margin sinistral translation followed by margin dextral translation, is fundamental to understanding the tectonic evolution of the northern Cordillera and Alaska. Omission of these data might be excused in Chapter 26 due to timing mechanics; however, discussion of these data is underrepresented in relevant chapters written in the early 1990s. Chapter 12 on the southern Alaskan margin (accepted 2/93) hints at possible southward displacement of outboard terranes in the Jurassic (their fig. 5A), but the figure, caption and text present many confusing inconsistencies. Chapter 33 (Overview and synthesis, accepted 12/93) assumes only northward transport, and therefore only margin dextral translation, of the outboard terranes.

Maps and figures are used to good advantage throughout the chapters and the combination of patterns, shading, and black and red tones results in excellent figure clarity even in the case of necessarily complex, busy diagrams. The reproduction of geologic maps (as figures) with attention to clarity, and consistency in explanations and symbols, makes referring to maps and figures a true reading aid. References are extensive in most cases, and in many cases were updated as a result of the long time that the volume was 'in press'. In a few cases the cited chapters were obviously not the relevant chapter, or the citation was left blank—forgotten during editing—but this is not unexpected for such an extensive volume that was in progress and in flux for several years. Several references to companion chapters within the volume reveal a number of changes in authors through its process, but this is to be expected in undertaking such a formidable task.

The plates are very useful, as well as aesthetic. They are all at the same projection and scale (1:250,000) so the various datasets they illustrate are easily compared. In addition, they are of similar scientific vintage, also a bonus for dataset comparison. Plate 4 (metamorphic rocks) deserves special mention, as it contains incredibly detailed information with respect to protolith, metamorphic grade, host terrane(s), and temporal constraints on metamorphism delineated as minimum and maximum ages, and direct evidence for temporal relations. So much information is presented that it is necessary to approach this plate with specific questions, but one will be rewarded with specific answers. In contrast, Plate 3 (lithotectonic terranes) is much less useful. By the author's own admissions the plate has not been updated and does not dove-tail with recent (and much more detailed) terrane maps of the Canadian Cordillera. Many (most?) of the chapters either do not mention Plate 3, or if mentioned the chapter authors discuss how their own terrane interpretations differ.

All geologists working in Alaska and the northern North American Cordillera will want to have a copy of this volume available; however, I recommend it with a few caveats. (1) There is a bias in many of the chapters toward Alaskan geology, at the exclusion of Canadian data, despite the importance of these data to the chapter topic. The volume presents a U.S., and in fact, U.S. Geological Survey, view of Alaskan geology. This is not necessarily bad, but should be recognized by the reader. The U.S.G.S. has certainly had a strong presence in Alaskan geology, and without the U.S.G.S. contribution such a volume would not likely be possible. (2) The volume has taken a long time to prepare. Initial organization began in 1982, and some manuscripts were written as early as 1984, whereas other manuscripts were completed almost ten years later! Unfortunately the reader cannot use the acceptance date as a measure of time, because the manuscripts were mostly 'accepted' in 1990, even though many were submitted and out of the authors hands many years before that. Authors who got their own manuscripts in on time were twice (at least!) beaten by the system; once in that others had more time to make their contribution up-to-date, and twice because the authors who submitted early (actually on time!) either had to rewrite their submission at a later date, or have their material appear dated by comparison. Three chapters co-authored by the volume's senior editor have acceptance dates essentially three years after the nominal dates of other chapters. It is unfortunate for the 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