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BOOK REVIEWS

Mechanical principles for geological structures

Price, N. J. and Cosgrove, J. W. 1990. *Analysis of Geological Structures*. Cambridge University Press, Cambridge, U.K. Price £75.00, $125 (hardback); £25.00, $49.50 (paperback).

Analysis of Geological Structures by N. J. Price and J. W. Cosgrove is a significant addition to the literature on the mechanics of mesoscopic and macroscopic deformation structures. The authors devote separate chapters to rock fracture, igneous intrusions, diapirs and impact structures, boudinage, cleavage, and structural analysis. The clear emphasis of the book, and the focus of 11 of its 18 chapters, is, however, the analysis of faulting and folding. The authors use experimental models and analytical solutions to elastic, viscous, and plastic boundary value problems to examine the formation of faults and folds in different structural settings. Notably, they discuss in a clear manner the difficulty of extrapolating the results of experimental investigations to natural deformation. They do not, however, discuss extensively the micromechanisms of deformation. As a result, this book is more reminiscent of *Elasticity, Fracture, and Flow* by J. C. Jaeger (Methuen) or *Fundamentals of Rock Mechanics* by Jaeger and N. G. W. Cook (Chapman and Hall) than other recent monographs in structural geology. *Analysis of Geological Structures* is, in my opinion, more likely to be useful in the classroom than either Jaeger or Jaeger and Cook because it analyses a wider range of deformation structures in greater depth.

The material on folding is presented very effectively, with points cogently argued and thoroughly supported by the literature. This is, in my opinion, particularly true of the chapters on the folding of multilayers and anisotropic materials, where the authors compare expertly theoretical and experimental models with selected field studies of fold development. Two points given particular emphasis in their discussions are the importance of elastic deformation in controlling the eventual shape and distribution of inelastic deformation within folded layers, and the effects of migrating stress fronts on the deformation of large layered packages. Both arguments are well supported by their citations to experimental and analytical models. At several points in the book, the authors argue for the importance of pore fluid pressure in the development of folds. Those discussions, and their assertions about elastic deformation and migrating stress fronts, are thought-provoking reading for those concerned with the development of mountain belt structures.

The chapters on fracturing and faulting present many innovative and closely-argued uses of Mohr–Coulomb theory. The discussion of the development of systematic fracture sets is particularly elegant and enlightening. The material on faulting is, however, somewhat idiosyncratic. For example, the authors imply (on p. 126) that non-fibrous slickensides result only from frictional melting along fault planes. Similarly, throughout the text but especially in Chapter 17 (pp. 448–450), the authors argue for the resurrection of the term *fracture cleavage*. Moreover, in their discussion of thrust belts, the authors do not consider the Coulomb wedge model of Davis and others, despite their reliance on the Hubbert and Rubey Mohr–Coulomb analysis to explain the motion of large thrust sheets. These are points where the authors are not in agreement with large numbers of structural geologists. More significant, in my opinion, are two recurring themes in their treatment of fracturing and faulting. First, by ignoring three-dimensional treatments of faulting, the authors contend, in effect, that even in three-dimensional strain states, only conjugate faults whose intersection parallels the intermediate principal stress direction may form. The work on three-dimensional fault sets by Reches and others suggests that the two-dimensional analysis of faulting presented in this book has some limitations. Second, in their focus on experimental models for faulting, the authors de-emphasize relationships between localized plastic deformation and faulting noted by Rice, Means and others, and alternatives to the Mohr–Coulomb failure criterion for faulting. This leads to some omissions. Notably, their analysis of the mechanics of mountain belts does not consider the yielding-wedge model of Chapple, even though the authors cite Schmid's work on localized plastic flow in major detachments. Thus, their coverage of faulting will, in my opinion, prove to be more controversial than the discussion of folding.

Because this book is designed for classroom use, it is appropriate to note a few minor problems in the presentation. Some potential for confusion arises with the notation that the authors chose for stress (S) and effective stress (σ), particularly since the authors use σ throughout the chapters on folding theory while referring only to 'stress'. There is, moreover, one instance (in fig. 11.41) where S refers to a strain ratio. Second, as is true in many first editions, there are several instances where notations in the text and in figures do not coincide. These are decidedly minor points, but they might be vexing for students. More important, many reproductions of photographs are very dark or have a distinctly muddy appearance. The reproduction problems detract from a potentially highly attractive publication, and may cause difficulty for students unfamiliar with the rock structures analysed in the book.

Overall, *Analysis of Geological Structures* is an impressive contribution. Those beginning in structural geology will benefit from its direct expository style, cogent arguments, and comprehensive use of experimental and analytical models to analyse rock structures. Those with greater experience in the field may take issue with the authors' conclusions in some places, but they will find thoughtful and carefully argued presentations throughout. With its focus on experimental and analytical models for rock structures, this monograph occupies a niche in structural geology that few others do. It fills that niche admirably well, and I anticipate that *Analysis of Geological Structures* will enjoy an enthusiastic audience for some time to come.

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Windows on deep continental crust

Salisbury, M. H. and Fountain, D. M. (editors) 1990. *Exposed Cross-sections of the Continental Crust*, NATO ASI, Series C, Mathematical and Physical Sciences, Vol. 317. Kluwer Academic, Dordrecht, The Netherlands. 662 pp. Price Dfl.315.00; £110.00 ($185.00) (hardback).

Over the last decade remote geophysical methods have revealed signatures characteristic of the deep continental crust. It seems a logical step to relate those signatures to areas where portions of the deep crust have been brought to the surface. As a whole, papers in this volume show the step to be wise and necessary, yet a step along a very slippery path. True, the rocks discussed probably resided for some time in deep parts of the continent, but *exposed* cross-sections do not necessarily relate to *unexposed* sections of continental crust. Indeed, processes that result in exhumation may themselves alter or selectively expose portions of the crust: (1) intra-crustal detachments expose the upper to mid-crust, leaving the lower crust behind; (2) some crusts are attenuated by extension prior to convergent emplacement; (3) crusts are altered in orogens that have a high geothermal gradient; and (4) underplating during uplift alters the lower crust. The volume is a realistic guide to structural and petrologic relationships in exposed continental crust, seismic and electrical signatures of deep crust that is exposed, and to the processes that create the dilemma in relating the two.

The collection of 28 papers evolved from a NATO Advanced Studies Institute symposium held in Killarney, Ontario, in 1988. The papers are arranged so that actual field studies constitute the first half of the book, while the second half contains general discussions of

crustal composition, role of fluids, deformation and emplacement mechanisms, physical properties, geophysical investigations and philosophical overviews of the importance of exposed continental sections in understanding earth history and processes. If the editors are to be criticized it is for being too modest in putting their own paper at the very end; that paper should be read first to establish a framework for the processes and specific field examples presented in the other chapters.

The field examples generally discuss structure and petrology, with gravity, magnetic and seismic reflection/refraction studies included for many. Exposures resulting from Phanerozoic orogeny include the Ivrea and Calabria zones in Italy, Fjordland, New Zealand, metamorphic core complexes of the western United States, the Sierra Nevada batholith, the North Cascades of Washington, the British Columbia Central Gneiss Complex and the Kohistan Island Arc of the Himalaya in Pakistan. This pot-pourri of tectonic settings illustrates that mechanisms of emplacement of the deeper parts of continental crust can be quite variable, including rifting, collision and erosion of batholith belts in island arcs. The Precambrian terranes (Kapuskasing zone in Ontario, central Australia, Dhwar craton of India, western Superior Province of Manitoba and the Grenville Front in Canada), with their variability in composition, age and physical properties, illustrate the complex history of formation and structural and metamorphic alteration of continental crust.

The papers on geophysics highlight differences in signature between the upper and lower parts of continental crust, and on how these differences might relate to chemical composition, rheology, structural and magmatic history, and to the role of fluids. These differences include general observations that the lower crust has higher seismic velocity, reflectivity and conductivity than the upper crust. The book is quite thorough in its discussion of processes that might have resulted in these signatures, as well as in its treatment of the selectivity and alteration of crust during exposure.

Overall the book is a valuable tool to structural geologists trying to relate field observations to processes occurring in the deep crust, as well as geophysicists looking for constraints on their interpretations. It is a bit long and perhaps weighted too heavily by North American examples; indeed the price might make it prohibitive to all but those directly involved in studies of deep-crustal processes. But I would recommend that other earth scientists at least browse through it to appreciate what has been learned over the last decade about the nature of the continental crust, as well as the practicalities of relating surface observations to what one sees on geophysical profiles.

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Precambrian crust and its treasures

Naqvi, S. M. (editor) 1990. *Precambrian Continental Crust and its Economic Resources*. Developments in Precambrian Geology 8. Elsevier, Amsterdam. 669 pp. Price Dfl.240.00; U.S.$123.00 (hardback).

This collection of papers was compiled in honour of the 70th birthday of Dr B. P. Radhakrishna, one of the pioneers of Precambrian geology in India. It is a fitting tribute; an up-to-date compilation of Precambrian crustal matters, and including several chapters about economic resources contained in the old, cold Precambrian crust.

There are 30 articles by 52 authors in total, in 669 pages of text. All is composed in camera-ready Courier type, which, unfortunately, is not the easiest of text types on the eye. Of the papers, 18 deal solely (or almost so) with India, and there are one each for Australia, Canada, China, Finland, Greenland, South Africa and Zimbabwe. The remaining five papers offer a bemusing mixture of topics, some fascinating and others just a little curious.

The first paper, by Bill Fyfe, is very appropriate for this volume—a short but visionary contemplation of the Archaean. Fyfe discusses how then, as now, the inner Earth, the Earth's surface, all creatures great and small (or rather, at that time, great aggregations of small creatures), and the Earth's atmosphere are interrelated in one system of majestic simplicity, driven by transfer of energy between its parts. As Fyfe says, "we live on a water cooled plant"—not a Volkswagen, but a Rolls-Royce, and we should treat it with due deference. I wish Bill Fyfe would write more; ideas spring from every line of his works.

The papers dealing with India are quite useful. There are several summary articles and several more specifically-targeted works, which combine to give a reasonably balanced overview of Indian Precambrian geology. As one might expect from the very unequal geographic distribution of papers, other areas receive far less balanced coverage. The sole paper on South Africa (surely one of the most important Precambrian areas on earth, from all geological perspectives) contains very little that is new. The same can unfortunately be said about the single papers on Australia, Canada, and the orthopyroxene isograd. There are a few gems, however—the papers by Fyfe, Rogers (comparing the Indian and Nubian–Arabian shields), Sugden, Deb and Windley (tectonics and mineralization in the Delhi belt), Dazhong and Songnain (North China platform), and Schidlowski (life in the Precambrian and its part in the genesis of mineral and hydrocarbon deposits) spring to mind.

Structural geologists could be fascinated for hours; however there are some very outdated and generally strange ideas presented throughout the book, on rheology, structural development, and tectonics. The book might be the basis for a higher-level undergraduate or graduate seminar series, but would need to be heavily supplemented by readings from current journals, especially to deepen the coverage of areas around the world other than India. In view of its high cost, the rather specific geographical coverage (generally good treatment for India, very spotty for the rest of the world), the review nature of a number of papers, and the limited shelf-life of some of the more specific contributions, I would be very hard-pressed to recommend that any single geologist buy this book. In these hard economic times, it becomes increasingly difficult to convince oneself that even libraries should pay the exorbitant charge that many publishers charge for these types of books—they are neither fish nor fowl; neither a specialist text nor an all-encompassing general treatise. However, if a certain library services a group that specializes in the Precambrian, then I would say (guardedly) that they should consider getting a copy.

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North American granitoid magmas

Anderson, L. J. (editor) 1990. *The Nature and Origin of Cordilleran Magmatism*. Geological Society of America Memoir 174. Geological Society of America, Boulder, CO, U.S.A. 414 pp. Price $65 (hardback).

The Nature and Origin of Cordilleran Magmatism (Geological Society of America Memoir 174) edited by J. L. Anderson, was produced from a GSA Symposium held in Hawaii. The 23 chapters in this volume are a synthesis of the works of the 57 co-authors and constitute a major contribution to the understanding of Cordilleran magmatism. The data and interpretations on the Mesozoic and Tertiary igneous suites of the Cordillera from Alaska to Baja, California, represent a new stage built on earlier, broader based work on circum-Pacific terrains reviewed by Roddick (1983, Geological Society of America Memoir 159). The book is not a collection of review papers, rather individual studies of specific areas with a strong emphasis on magma genesis and evolution.

Specific studies include the Peninsular Range Batholith, Sierra Nevada Batholith and Salinan magmatic arc, Great Basin plutonism, Klamath Mountains pluton, Idaho Batholith, Colville Igneous complex (Washington), Coast Batholith (Alaska and British Columbia) and Transverse and Mojave Desert plutons.

Much of the book is concerned with magma genesis, and specifically the role of multiple sources in controlling the chemical and isotopic composition of the plutons. This is meat and grist for petrologists, geochemists and isotope workers, but it can certainly be rather dry, esoteric fodder for the non-cabalist! It seems to me that endless major and trace element diagrams, some purporting to show tectonic setting, plus Σ Nd–Sr diagrams with Lewisian amphibolite and granulite facies fields are tedious and do not help us to really understand the sources of *American* granitoid magmas. Attempts to identify specific source materials for most granitoids is difficult at best, for the crust is not homogeneous, and actual compositions of the lower crust at any given place almost unknown. Furthermore nice simple crutch-like classifications based on source such as the 'I' and 'S' classification, unfortunately travel abroad rather poorly and certainly not *in toto* to America.

Many of the papers also explain in some detail the evolution of the magmas by crystal fractionation, assimilation crystal fractionation,