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BOOK REVIEWS

ADVANCES IN X-RAY ANALYSIS: VOL. 25 Proceedings of the Thirtieth Annual Conference on Applications of X-Ray Analysis, Denver, Colorado, 1981. Edited by J. C. Russ, C. S. Barrett, P. K. Predecki and D. E. Legden. Plenum Press, New York, v + 398 pages. $49.50.

This book consists of more than fifty short papers on geological and nongeological techniques and applications of X-ray fluorescence (XRF) and X-ray diffraction (XRD). The papers are sorted into the following categories: XRF detectors and XRF instrumentation; practical and mathematical XRF methods; XRF applications to metals, catalysts and oils; XRF applications to mineral and geological problems; XRF environmental applications; XRD methods and instrumentation; XRD search/match procedures and automation; and XRD applications. The XRF and XRD topics of the greatest interest to the mineralogist/petrologist are mentioned below.

In the very first paper A. J. Dabrowski reports on developments of solid-state, room-temperature, energy-dispersive analysis (EDA). Crystals of the HgI_2 have been produced with fair resolution, having full-width, half-maxima (FWHM) ranging from 250 eV for MgKα to 300 eV for MnKα (compared to *ca.* 150 eV for Li-doped Si detectors), providing adequate resolution for many analytical tasks. Unfortunately the HgI_2 crystals are not as yet entirely stable. These EDA detectors would allow development of field or semi-portable EDA/XRFs or EDA/SEMs without the necessity of maintaining the cryogenic conditions currently required for Si detectors. Other XRF papers of possible geological interest include the use of polarized X-ray sources in improving analytical detection limits, the combination of EDA with WDA, computer programs for data reduction, new fusion techniques for XRF sample preparation, analysis of metals in oil, and other applications to various geological problems. Among the latter is a careful evaluation of the overlaps in characteristic X-ray lines of rare earth elements in monazite by T. K. Smith.

Papers on XRD include several on computer algorithms and computerized search techniques for both single- and multi-phase identification. Typical of this genre is a paper by W. N. Schreiner and R. Jenkins which as an example claims to be able to distinguish the powder XRD pattern based on *d*-values alone for a variety of spinels, including magnetite (a = 8.397), magnesioferrite (a = 8.375–8.397) and a variety of other synthetic and natural ferrites by computerized searches of ASTM files. The authors apparently do not recognize that there is a continuum of possible ferrite solid-solutions in multi-dimensional composition space yielding a plethora of spinels with identical *d*-values, only a few of which may be found in any finite compilation. The solution to this problem requires simultaneous chemical and XRD constraints, provided in another paper in this proceedings by M. F. Garbauskas and R. R. Goehner who have computerized search proceedings using input information from both XRF and XRD. Even here the identification of multicomponent isostructural phases cannot be entirely successful with the use of finite search files unless the possible extent of isostructural solid solutions is also built into the program. Other XRD topics covered include an automated powder XRD control system, a rapid scanning XRD detector with Guinier geometry, and various applications to specific geological problems.

This book, as with previous volumes in this series, is best suited for purchase by libraries in institutions with active XRF and XRD research.

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CHARACTERIZATION OF METAMORPHISM THROUGH MINERAL EQUILIBRIA, Reviews in Mineralogy, Vol. 10. Edited by John M. Ferry. Mineralogical Society of America, 2000 Florida Avenue, N.W., Washington, D.C., 1982. ii + 397 pages. $13.00.

The past few years have seen remarkable advances in our understanding of progressive metamorphism. These advances reflect the rigorous application of thermodynamic and kinetic theories to metamorphic problems. As a result, metamorphic petrology is rapidly evolving into a discipline where subtleties of chemical equilibrium, geothermometry–geobarometry, fluid–rock interactions and the dynamics of metamorphic processes can be examined in detail. The latest volume of *Reviews in Mineralogy* satisfies the need for a concise text which summarizes many of these new ideas and approaches.

The text is divided into nine chapters. The first two, by James B. Thompson, Jr., set the tone for what follows. Thompson succinctly introduces such concepts as exchange components, additive components, composition space, phase diagrams, phase components, reaction space and reaction polytypes, summarizing systematic strategies for studying metamorphic systems and reactions. The third and fourth chapters, by various combinations of Frank S. Spear, John M. Ferry and Douglas Rumble III, build on Thompson's approach. The authors discuss a number of recent advances in graphical and algebraic techniques, apply them to the study of petrologic phase relations, and do so in a remarkably clear fashion. This includes a straightforward presentation of the Gibbs' method, popularized by Rumble in a series of scattered papers in the 1970's. The Gibbs' method presents a convenient way of estimating P, T and metamorphic fluid composition, given only mineral compositions in a suitably low-variance assemblage. The discussion of the Gibbs' method in Chapter 4 may prove to be the most widely used part of the book, because this is the first place that the entire approach has been presented in its elegance and simplicity. The discussion is enhanced by a wide variety of specific problems worked in detail.

The remainder of the text deals with more "classical" problems in metamorphism. Chapter 5 by Eric J. Essene gives an introduction to the petrogenetic grid and supports the grid with a critical survey of geothermometers and geobarometers currently used by metamorphic petrologists. Chapter 6 (Ferry and Donald M. Burt) concerns methods to determine the composition of the metamorphic fluid phase. Chapter 7 by Jack M. Rice and Ferry summarizes recent work concerning the behavior of the fluid phase during metamorphism. Rice and Ferry document techniques for testing whether rocks controlled their own fluid compositions through mineral-fluid buffer reactions or were infiltrated by an externally-derived fluid during a metamorphic event. Recently-popularized use of the reaction progress vari-

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able is emphasized, permitting calculations of the quantity of fluids that infiltrated a rock during metamorphism. Rumble follows with a chapter on stable isotope fractionation in metamorphic systems, emphasizing isotopic tests for chemical equilibrium and, expanding on Rice and Ferry's preceding chapter, stressing isotopic evidence for fluid-rock interactions. The final chapter by Robert J. Tracy concerns zoning in metamorphic minerals, especially garnets, and relates chemical zoning to mineral growth combined with later cation diffusion. This chapter also considers inclusions in metamorphic minerals.

A series of appendices provides further information. These include computer programs, algebraic techniques and thermodynamic equations. All should be extremely helpful to those who intend to use the techniques presented in the book to solve real geologic problems.

The book presents an excellent overview of the topics it discusses. The writing is clear, ample illustrations and examples are provided, and many of the topics considered are at the front of current petrologic research.

The text is not without its shortcomings. The most obvious is that it addresses only the mineralogic aspects of metamorphism. No coverage is given to the ultimate causes of metamorphism, to relationships between metamorphism, deformation and tectonics, to formal metamorphic facies series classifications nor to heat-flow problems in regional metamorphism. Problems pertaining to blueschist metamorphism are omitted. There is very little consideration given to the kinetic aspects of metamorphism. Therefore, the book cannot stand alone as text for a graduate-level class.

A few other problems are worth mentioning. The coverage given to experimental studies of dehydration reactions in pelitic schists is weak: Better reviews can be found in Greenwood (1976) and Schreyer (1976). The text contains a fairly large number of typographical errors, most of which are obvious and merely annoying but a few of which are potentially serious. The most serious typos occur on page 174, where Holdaway's (1971) aluminum silicate invariant point is placed at 600°C, 3.8 kbar rather than 500°C, and on page 164 where garnet-biotite geothermometry is listed as inaccurate for garnets with appreciable Ca or Mg (should read Mn). Essene cautions unnecessarily against applying the garnet-biotite geothermometer to all rocks with appreciable Mn, even though several recent studies have shown that Mn does not affect geothermometry at concentrations less than 30 mole percent spessartine in garnet. Nevertheless, I consider these problems trivial compared to the importance of the book.

In summary, I believe that this book presents an important contribution to the metamorphic literature. Each chapter covers useful material, much of it more clearly and succinctly than any other source. The coverage of topics is superb and should provide new material for practicing petrologists as well as students. The text is a phenomenal source of references, averaging over 90 per chapter. I recommend the book as an addition to the library of any practicing petrologist and consider it a "must" for all graduate petrology students, although I urge students to supplement the text with readings in tectonics, heat flow and reaction kinetics in metamorphism. The price of the book is refreshingly low, making it affordable on any budget.

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Holdaway, M. J. (1971) Stability of andalusite and the aluminum silicate phase diagram: American Journal of Science, 271, 97–131.

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GRANITIC PEGMATITES IN SCIENCE AND INDUSTRY. Edited by Petr Černý. Mineralogical Association of Canada short course handbook, volume 8, May, 1982. Mineralogical Association of Canada, Toronto, Ontario, Canada, 1982. xiii + 555 pages. $15.00 (Canadian).

This volume is a collection of 19 reports and 2 appendix reports which were presented at a 2-day short course preceding the 1982 annual meeting of the Geological Association of Canada and the Mineralogical Association of Canada in Winnipeg, Manitoba. The completion of the volume is due in large part to the extensive efforts of the editor, Petr Černý. As noted in the preface, granitic pegmatites have, for a long time, been an underprivileged subject in North American geology textbooks. Although a number of excellent individual reports dealing with pegmatite studies in North America have been published since the "boom days" in the 1950's, not a text or a compendium summary has dealt with granitic pegmatites in a comprehensive manner nor summarized the various studies of the last 30 years or so.

The volume includes: (1) introductory material; (2) a large section on the mineralogy of granitic pegmatites, including quartz and feldspars, micas, Li minerals, Be minerals, Rb–Cs minerals, selected peraluminous minerals, Nb–Ta–Ti–Sn minerals, P(V) and B(III) minerals, and structural descriptions of selected lanthanide, Y,Th,U,Zr, and Hf minerals; (3) petrology and geochemistry, including internal evolution, subsolidus equilibria, Rb–Sr isotope studies, stable isotopes, and petrogenesis; and (4) a final section on exploration and mineral processing. Reports in the last section describe exploration for rare-element granitic pegmatites, Ta-ore processing at the TANCO mine, operations at the Foote Mineral Company's Kings Mountain, N. C. (U.S.A.), lithium mine, and operations at the Greenbushes pegmatite, southwest Western Australia. Two brief appendices that served as field trip guides for the Short Course participants treat the TANCO mine at Bernic Lake and the Osis Lake pegmatitic granite in southeastern Manitoba.

In the above array of topics, several deserve special comment. P. Černý's introductory review is readily understandable to a nonspecialist but it also offers updated information valuable for seasoned pegmatite investigators, such as a review of pegmatite distribution and ages, and new concepts in pegmatite classification. P. B. Moore's unique genetic-cum-crystallochemical classification of pegmatite phosphates summarizes data and interpretations scattered in many of his earlier publications in a single treatise. Similarly, the chapter on internal pegmatitic evolution gave R. H. Jahns a chance to review his ideas on the subject in a comprehensive manner. D. M. Burt and D. London expanded

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their approach to chemical modeling of mineral assemblages and their alterations to mineral groups never treated before; they also acknowledged the fact that in some cases phase equilibria are not known enough for even rudimentary models (*e.g.*, the Nb,Ta,Sn,Ti-bearing oxide minerals). The stimulating reviews of Rb–Sr systematics (G. S. Clark) and stable isotopes (F. J. Longstaffe) in granitic pegmatites are the first ones of their kind. The chapter on petrogenesis (P. Černý) presents a critical evaluation and upgrading of A. I. Ginsburg's recent geological classification of granitic pegmatites, to date not available in western literature, and a review of different pegmatite-generating mechanisms. Exploration for rare-element granitic pegmatites is yet another subject that has not been compiled and reviewed in North America for decades. D. L. Trueman and P. Černý present a summary of exploration methods from incipient regional evaluation through identification of parent granites to field and laboratory methods of recognition of regional zoning, and evaluation of mineralization potential of individual pegmatite veins. Of particular interest is the review of methods for detection of hidden deposits. Finally, the three chapters dealing with mineral processing provide a diversified insight into the treatment of "exotic" ores and ore minerals, invaluable to anyone contemplating mechanized ore beneficiation in pegmatite deposits and full of ideas applicable to greisen and related ore types as well.

Even though the volume has been available for only about 1 year, the rapid generation of international interest in the book is indicated by the intention of the Academy of Sciences of the U.S.S.R. to publish a translation in Russian.

The volume has been well edited and has few typographical errors. Considering the price, this book is proof that a high-quality and complete text need not be expensive. The line-drawings and tables complement the text well. This book is to be highly recommended for graduate students, and industry, government, and research geologists as well as mineralogists. The bulk of the information should not become "dated" with the passage of time. I hope that this short-course volume will receive the attention and study that it merits. For anyone interested in granitic pegmatites, this book is a must.

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IGNEOUS ROCKS. By Daniel S. Barker. Prentice-Hall, Englewood Cliffs, 1983. xii + 417 pages. $34.95.

This book is intended primarily to be a text for an undergraduate or beginning graduate-level introductory course in igneous petrology. The prerequisites suggested in the preface include only one year of college chemistry and a single course in mineralogy (not optical). In view of the intended level, this book covers a lot of material and, I think, conveys a remarkably accurate feeling for many of the problems of modern petrology. Advanced students and professionals might find particular chapters useful for a review. The extensive bibliography is particularly noteworthy.

The first two chapters give an introduction to magma and its relationship to geologic processes, as well as a review of mineralogical concepts and data pertinent to igneous petrology. Seven subsequent chapters cover: phase relations; analyses, calculations, and diagrams; classification of igneous rocks; crystallization and textures; mechanisms for magma generation and differentiation; mechanical properties of magma and the morphology and fabric of intrusive and extrusive rock bodies; and the effect of volatile components in magmas. A series of four chapters separately cover specific ideas and problems related to the study of ultramafic rocks, mafic rocks, intermediate and silicic rocks, and silica-undersaturated rocks. Various chemical processes affecting igneous rocks in the solid state are discussed in a chapter on metasomatism. The book concludes with two chapters relating magmatism to tectonism and to energy and mineral resources.

I found the writing to be very clear and quite readable. The style is, however, solidly technical. For most of the ideas presented, there are references to journal articles. Conflicting data and ideas are presented where relevant. An effort seems to have been made to emphasize the complex and continuing evolution of petrological knowledge and to avoid simple answers (this will dismay some students).

The most interesting feature of the book is the very large number of references to journal articles for an introductory text. The bibliography is 31 pages long (nearly 8 percent of the book) and contains more than 600 references. About 20 percent of the references are from 1980 and 1981, but they extend back to 1909. Another interesting and "modern" feature is the use of SI units throughout (principally the pascal rather than the bar as the unit of pressure).

Singling out particular chapters or topics for praise is difficult because the quality is evenly high. In an introductory text some simplifications must be used, and a choice of emphasis made. In some sections, a different set of assumptions might be chosen, or an argument might be made in a different way, but I found only a very few statements that I felt were wrong, and none would significantly affect the learning of any major concept. The most serious deficiency in the book is the lack of information on the interpretation of trace-element and isotope geochemistry. In teaching from this book, I would feel compelled to present supplementary material on these important topics.

The book has been well produced, is essentially free of typographical errors, and the index appears quite adequate. The typography, layout, and figures contribute to a positive impression. The price, however, seems to be particularly high, especially if a companion text on metamorphic petrology is necessary for the course.

In conclusion, this book is well worth considering as a text for an introductory course in igneous petrology. As course emphasis, teaching style, and student expectations differ, this book will not meet all needs, but I personally think that it could be a very exciting text from which to teach. As a personal reference for advanced students or professionals (who already own another text), the book is probably, because of price, a poor bargain in competition with other needs. However, a library copy would be very useful for review of areas in which the reader is not currently active.

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PRECIOUS METALS IN THE NORTHERN CORDILLERA. A. A. Levinson, Editor. The Association of Exploration Geochemists and the Cordilleran Section of the Geological Association of Canada, P. O. Box 398, Station A, Vancouver,

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British Columbia V6C 2N2, Canada, 1982. viii + 214 pages. Price: Canadian $22.00.

This is a proceedings volume containing 13 of the 33 papers presented at a symposium of the same name held in Vancouver April 13-15, 1981. Three of the papers are general and help set the stage for more specific topics. R. W. Boyle gives a general review of precious metal deposits in the Canadian Cordillera. He treats gold and silver deposits in 15 classes, including a "miscellaneous" class. Two of these classes are unknown in the region and two are minor. The remaining types, however, may all be important and warrant exploration consideration. Some geologists would consider the Redstone River copper deposits, classified by Boyle as Kupferschiefer type, to be best classified as predominantly "red bed" type. Fourteen types of platinum metal deposits are briefly noted, although only a few of these would appear to be potentially significant in the Cordillera. L. J. Cabri provides more information on potential platinum-group element deposit types in the Canadian Cordillera. The potential for Merensky-Reef-type PGE horizons or PGE-bearing chromitites in layered gabbroic complexes appears uncertain. There may be potential for PGE in Alaskan type zoned ultramafic complexes or Alpine-type (ophiolitic) bodies, and especially in podiform chromite bodies in the latter, although they have received little study or exploration for PGE. Placers are also potentially important.

The third general paper is by C. J. Hodgson, R. S. G. Chapman and P. J. MacGeehan. On the basis of deposits in both the Superior Province of the Canadian Shield and in the Cordillera, they propose criteria for gold exploration on regional, mining property and orebody scales. They conclude that the most important regional criteria are mafic volcanic sequences, with associated ultramafic rocks within or near the area, and contacts between sedimentary and volcanic sequences. Presence of felsic intrusive and/or extrusive rocks and of rock alteration are important at the property scale, and structure is the most important feature at the orebody scale. There are some major differences between Shield and Cordilleran gold deposits, such as the absence of major associated carbonate alteration zones in the latter.

Two papers deal with analytical methods, one with neutron activation analysis for gold and the other with analysis for Au, Ag and As in waters. Another treats the "nugget effect" sampling problem in analyses for gold and other trace elements. A paper presented on this topic by C. O. Ingamells has subsequently been published elsewhere (Geochimica et Cosmochimica Acta, Vol. 45, 1981, p. 1209-1216). Two papers give case histories of geochemical programs, one bedrock and one surficial, around specific gold deposits, the Consolidated Cinola deposit on the Queen Charlotte Islands and silica-carbonate veins in serpentinite, Washington State. According to N. Champigny and A. J. Sinclair the Consolidated Cinola deposit yielded good bullseye or flanking anomalies for Au, Ag, Hg, Sb and W in rock, and for Au in soil, and more dispersed Hg anomalies in soil and peat. The recently published Special Volume 24, Geology of Canadian Gold Deposits by the Canadian Institute of Mining and Metallurgy contains a more geologically oriented paper on the Cinola deposit by Champigny and Sinclair, and another on fluid inclusion and sulphur isotope studies of the deposit by Shen, Champigny and Sinclair. A general paper by J. C. Antweiler and W. L. Campbell deals with geochemical exploration for gold deposits and the use of the composition (Au, Ag, Cu and trace elements) of alluvial native gold as a tracer for other deposit types, such as porphyry copper, skarn, polymetallic vein and tungsten deposits. They found analytically determined gold contents of panned concentrates to be a more reliable indicator of mineralized areas in some parts of Wyoming and Montana than were analyses of stream sediments, soils, waters and vegetation. All these geochemically oriented papers could be valuable in designing geochemical exploration programs for gold and some other types of deposits.

Gold in two porphyry copper deposits in Central British Columbia is treated in a paper by A. S. Cuddy and S. E. Kesler, and A. J. Sinclair *et al.* give a general review of the gold and silver grades of porphyry deposits in the Canadian Cordillera. A paper by J. A. Morin discusses the element associations in a number of Au(Ag) deposits in the Yukon.

A paper by H. V. Warren on the Stirrup Creek area, southeastern British Columbia, is short but interesting. He suggests that gold from a low-grade disseminated source has been mobilized by a cyanogenic plant, *Phacelia sericea,* which is locally enriched in gold, and that this may result in the growth of gold grains in soils and in placer deposits.

Editing of the book by A. A. Levinson, University of Calgary, is generally commendable, but more critical editing of a few of the papers would have been helpful. The paper by C. J. Hodgson, R. S. G. Chapman and P. J. MacGeehan, for example, contains a number of typographic errors, and names and other terms that are incorrectly spelled. The rendering of NSERC in the acknowledgements as "National Science. . . ." instead of Natural Sciences and Engineering Research Council illustrates the lack of attention to detail. One wonders if this mistake will be taken into account when the authors apply for their next grant. The layout for the volume and figure reproduction are excellent, however, and the volume is very pleasing in appearance. The addition of subject and locality indexing is a useful feature.

Papers presented at the symposium, but not included are listed at the end of the volume. The greatest deficiency is probably lack of the paper by C. G. Clifton or a comparable one giving a good genetic model for epithermal gold-silver vein deposits. However, many other good papers were presented at the symposium and with greater efforts it should have been possible to capture more than 40% of them.

While this is a relatively slim volume (214 pages) it nevertheless does present a general geological framework and, as noted above, a good range of geochemically oriented papers, including a few case history geochemical studies, all directed to gold and silver deposits in the Northern Cordillera. The volume will be of greatest value to company geologists planning exploration for these deposits in the Cordillera, but others will find particular papers or topics of interest. At a price of $22.00 Canadian, the volume is a bargain if you hope to find gold, even if your prime exploration credo is that gold is where you find it.

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A SYSTEMATIC CLASSIFICATION OF NONSILICATE MINERALS. By James A. Ferraiolo. Bulletin of the American Museum of Natural History, Volume 172, Article 1, New York, 1982. xi + 237 pages. $11.05.

This is a new systematic classification of the nonsilicate minerals, based on Volumes 1 and 2 of the seventh edition of *The System of Mineralogy of James Dwight Dana (DSM).* Information on individual species is presented in tabular form, in order of

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classes 1–50 of DSM, in eight columns, as follows: (1) revised Dana number, a three- or four-position number, with each position separated by periods; (2) NC, change in composition since publication in DSM; (3) NM, new mineral or validated species since publication of DSM; (4) mineral name; (5) chemical formula (usually after Fleischer, *Glossary of Mineral Species, 1980*); (6) SSD (species status doubtful); (7) crystal system; (8) space group. This is followed by a 127-page "Bibliography and Index", in which the species are listed alphabetically with references to either the original description or an abstract thereof. Table 1 notes that 1043 species were recognized in DSM, 2199 species in this compilation; of these 2199 species 1232 are new species described since the publication of DSM, and 158 are redefined species. The compilation appears to be essentially complete through 1981.

This book provides an indispensible reference for all systematic mineralogists, and will be especially useful to curators whose collections are arranged according to the DSM systematics. The author is to be congratulated on the successful conclusion of a tedious and time-consuming task; I hope he can provide a similar compilation for the silicate minerals in the near future.

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URANIUM IN VOLCANIC AND VOLCANICLASTIC ROCKS. Edited by Philip C. Goodell and Aaron C. Waters. Published by Energy Minerals Division of The American Association of Petroleum Geologists. 331 pages. $28.00.

The editors, Philip C. Goodell and Aaron C. Waters, are to be commended for organizing a much needed compendium of uranium in volcanic and volcaniclastic rocks. With one exception the articles are restricted to North America. Many of the authors did an excellent job of summarizing large previously published works, along with incorporating new material. Two criticisms are worth noting: (1) The abstracts are so brief as to be essentially worthless, and (2) Part 3 on the Chihuahua City area contains several articles that have almost no mention of uranium, or in one case, of volcanic or volcaniclastic rocks. Perhaps having such detailed geology of the Chihuahua City area is merited by the large uranium resources of the Peña Blanca Range. In any case, this is an excellent volume and worth reading for any geologist interested in uranium in volcanic and volcaniclastic rocks.

1. Chapter 1 by Robert Zielinski attempts to evaluate, through experimental studies, geologic conditions, such as temperature, grain size, pH, carbonate content, glass composition and pressure, in terms of favorability for leaching of uranium from its source rock. Utilizing these results he extrapolates to suggest geologic environments, such as the intracaldera setting most favorable for mobilization of uranium from volcanic rocks. The section on geologic implications provides an excellent summary for the reader seeking information on favorable leaching environments for uranium.

2. Chapter 2 by William Rose and Theodore Bornhorst discusses problems encountered in using ^{230}Th–^{238}U radioactive disequilibrium-series dating on quaternary volcanic rocks of Guatemala and Sumatra. ^{238}U, ^{234}U, ^{230}Th and ^{232}Th data on whole rock, glass, hornblende, plagioclase, clinopyroxene, and magnetite show significant uranium mobility negating dating methods based on these isotopes. The article presents an interesting problem for the uranium geochemist in a short and concise manner, but the section on "theoretical background" is too sketchy for the average uranium geologist to breeze through and understand the problem discussed.

3. John Gableman attempts to show the mineralogic distribution of uranium and thorium in volcanic rocks. Both elements were apparently below the detection limit of the SEM, in most of the phases studied, so much of the article is of little help to the uranium geologist. Nevertheless, he did find significant concentrations of base metals and other trace elements. When thorium or uranium were found in glass or asphaltite they were found in discrete grains in concentrations large enough to be readily recognized. Gableman believes this, along with the base metal grain concentrations, argues against a uniform distribution of the volatile metals in glass and asphaltite, suggesting migration toward grain-forming concentration centers.

4. Laurence Curtis provides the reader with a superb, well-written summary of uranium in volcanic environments in Canada, Australia and Italy. He believes that both supergene and hypogene processes played a role in the formation of these deposits, but that synvolcanic processes may well be more important than many geologists believe. The summary at the end delineating characteristics common to these uranium occurrences should be an excellent guide for the exploration geologist.

5. A brief geologic description of the Lakeview uranium district, Oregon is presented by Stephen Castor and Michael Berry. Data are presented for both the major elements and a broad suite of trace elements. Unfortunately, there are no major element data shown for those samples with trace element data, and vice versa, which prevents the reader from drawing his own geochemical associations between trace and major elements. The authors believe the mineralization to have been hydrothermal in origin due to the mode of ore occurrence, alteration, and trace element content; yet, they neglect to describe the specifics of how these criteria support such a genesis.

6–8. A very nice summary of the geology and petrochemistry of volcanic rocks in the McDermitt caldera complex is provided by James Rytuba and Walter Conrad. They relate the commendite and trachytic soda rhyolite lavas and tuffs to one another by age, chemistry and location within the magma chamber. A positive correlation is shown between Cs-enriched lavas, those with the greatest upward enrichment within the magma chamber, and uranium deposits. Complimenting this chapter are two papers by Andy Wallace and Michael Roper on the uranium deposits along the northeastern margin of the McDermitt Caldera. These papers provide an excellent description of the mineralization, alteration, and host rocks. Despite the well-known association of uranium with rhyolitic rocks, in contrast to more mafic lavas, and the abundance of such rocks in the McDermitt complex, this uranium mineralization occurs in andesites (icelandites) and in lake sediments.

9–10. David Lindsey presents a superbly organized summary of volcanism and uranium mineralization at Spor Mountain, Utah. He decribes the three stages of subalkaline silicic volcanism which began 49 m.y. ago and ended 6 m.y. ago, accompanied by extensive U, Be, and F mineralization during the last stage (21–6 m.y.). Evidence is presented for uranium concentration by magmatic processes, hydrothermal fluids and ground water. Donald Burt and Michael Sheridan draw on Lindsey's detailed geology of the Spor Mountain area to generate a model for the formation of uranium deposits related to topaz–rhyolite volcanism. They compare other areas of topaz rhyolite, mostly barren of economic mineralization, with the economic deposits

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of Spor Mountain. From this comparison they delineate those geologic conditions necessary for the generation of significant uranium mineralization associated with topaz-bearing rhyolites.

11. Tom Steven, Charles Cunningham, and Michael Machette give an overview of the uranium potential and geology of the various geographic terrains, and the known and hypothetical occurrences of uranium, in the various depositional environments of the Marysvale volcanic field. This paper is desperately in need of figures and detailed maps depicting the points made in the eight pages of discussion; the reader will find himself inundated with unit names, geographic locations, ages and uranium concentrations that are difficult to follow without some graphical aids.

12. Jan Wilt and Robert Scarborough present a very well-organized summary of volcaniclastic sediments hosting uranium occurrences in the Basin and Range province of Arizona. In addition, the paper provides a brief summary of tectonics relevant to the mid-Tertiary to recent volcanism associated with the uranium occurrences. Each subsection is summarized with a paragraph on uranium exploration guides, suggesting that favorable areas for uranium contain fine-grained sediments with carbonaceous and silicious matter, exposures of alkalic Precambrian granite, and large volumes of ignimbrites.

13. Theodore Bornhorst and Wolfgang Elston give an excellent summary of the uranium geochemistry of volcanic rocks in the Mogollon–Datil volcanic field, with some good extrapolations to the remainder of the state of New Mexico. In contrast to the description of uranium in the Marysvale volcanic field, these authors avoid getting bogged down in local volcanic stratigraphy and stick to the topic of the book. It's too bad that such a nice overall summary of uranium in volcanic rocks isn't available for other states.

14-15. Uranium in the volcanic and volcaniclastic sediments of the Trans-Pecos, Texas area are discussed by Joseph Cepada, Christopher Henry and Timothy Duex. They describe the stratigraphy and uranium distribution within the Chinati Mountains Caldera, relating the various flows by fractional crystallization, and showing uranium mobility within the caldera. They believe uranium enrichment within fluorite deposits suggests that fluoride complexes are important for uranium mobility. Christopher Henry and Timothy Duex continue in the next chapter with a description of the diagenesis of tuffaceous sediments of the Trans-Pecos. They show little uranium mobility as a result of diagenesis, particularly after the formation of Fe–Mn–Ti oxyhydroxides, and almost exclusive association of uranium with the Fe–Mn–Ti oxyhydroxides at the expense of such minerals as clinoptilolite and opal.

16–23. The remainder of the chapters in the book discuss the geology and uranium occurrences in the Chihuahua City, Mexico area. Neil Bockoven describes the stratigraphy of the Sierra Del Gallego area, and correlates these units with those hosting the rich uranium deposits of Sierra Peña Blanca 30 km to the south. Peter Megaw presents a nice summary of the geology of the Sierra Pastorias Caldera, fitting it into the regional Sierra Madre Occidental framework, but he provides no uranium or other trace metal geochemistry. Thus, the paper is of little value to the uranium geologist, particularly if one accepts Megaw's conclusion that the presence of a uranium deposit is unlikely. Richard Mauger takes 35 pages to describe some geology and mostly petrology of the central part of the Celera-Del Nido Block in exquisite detail. The word uranium only occurs in one small paragraph, buried under the heading "structure," leaving the reader wondering what all this has to do with uranium in volcanic and volcaniclastic rocks. A paper by Richard Capps on the geology of the Rancho El Papalote area suffers from basically the same problem as the last paper, although there are at least uranium determinations shown for a few of the volcanic rocks. The stratigraphy of the limestone bedrock beneath the uranium deposits of Sierra Peña Blanca is discussed by Bruce Stege, Nicholas Pingitore, Philip Goodell, and David LeMone. Although little mention of uranium is made in this paper, the authors believe these limestone units, rich in mud, formed a hydrologic barrier that prevented downward or lateral migration of the uranium-bearing solutions from the Peña Blanca uranium district. For the uranium geologist the highlight of the Chihuahua studies is the geology of the Peña Blanca uranium deposits by Philip Goodell. This paper presents good stratigraphic descriptions of the host units, yet over half of the paper discusses the uranium deposits, mineralogy and trace-element geochemistry. Goodell believes these deposits to be derived from the alteration and leaching of volcanic glass by geothermal convective ground water systems, rather than by magmatic-hydrothermal fluids. S. M. Mitchell, P. C. Goodell, D. V. LeMone, and N. E. Pingitore provide an interesting discussion of uranium mineralization in limestones of Sierra Gomez. The uranium as well as many other metals are enriched to concentrations of over 1%. Nevertheless, other than that the authors believe the source for the uranium to be the volcanic rocks of the Mesa formation, the reader is left to wonder what this article has to do with uranium in volcanic and volcaniclastic rocks any more than does any Colorado Plateau sandstone deposit. A regional geophysical study of the Chihuahua City area by C. L. V. Aiken, D. L. Garvey, G. R. Keller, P. C. Goodell and Mauricio de la Fuente Duch attempts to delineate, through magnetic and gravity surveys, the subsurface geology in hope of locating the primary uranium source for the Peña Blanca District.

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