

BOOK REVIEWS

SILICATE MELT EQUILIBRIA. By WILHELM EITEL, x+159 pp., 200 figs. New Brunswick, New Jersey, Rutgers University Press, 1951. \$5.00.

This little book is a translation from the German *Die heterogenen Schmelzgleichgewichte silikatischer Mehrstoffsysteme*, first published in 1943. Of the first edition only a single copy survived the bombing of Leipzig in 1944. A second printing was made in 1945, but of this only the author's copy appears to be available in this country. Translation was carried out principally by J. G. Phillips of the Department of Mines and Resources, Ottawa, Canada, and his late colleague, T. G. Madgwick. They had the advice and assistance of a committee of the American Ceramic Society under the chairmanship of R. B. Sosman. Unfortunately, these collaborators have not always translated the German all the way to English. The corners of a triangle are, in at least one place, referred to as its end points and even the eagle eye of Sosman did not catch the sentence, "From F. A. H. Schreinemakers' detailed theoretical work on three-component systems of this kind, only so much is here extracted, for example that which concerns ternary silicate-systems in equilibrium with sulphide or oxide melts."

This reviewer does not share the translators' aversion to the use of the straightforward translation of the German, "feste Losungen," namely, "solid solutions." Those who work with them most call them just that almost invariably. Occasionally they speak of mix-crystals, to which the translators object also, but their objection is not well taken. It would apply only to the expression "mixed crystals," which has a possible significance in everyday parlance, but "mix-crystals" is a purely technical term without possible ambiguity. In adopting the term "crystalline solutions" the translators have only added to the language burden, though the expression is in itself irreproachable.

The book presents a graded series of equilibrium diagrams of systems of more than one component with a discussion of them. Such material, brought together in English, will prove very useful to a great number of technologists and petrologists.

Beginning with a statement of the phase rule, which is the principle governing all aspects of these diagrams, the author leads the reader from the more simple binary diagrams into those involving phase transformations, to others involving solid solutions, immiscibility in the liquid state and all the well-known complications of binary systems. From these one passes to the simpler diagrams of ternary systems, then to those involving the same complications and finally comes to equilibria in multi-component systems. All of this is presented in the conventional manner, as developed principally by the Dutch masters of heterogeneous equilibrium, but emphasis is laid on those types of diagrams that are most likely to be encountered in silicate systems. Most of the diagrams are theoretical but a few are of actual investigated systems.

The author states frankly in the preface that he has not attempted to give exhaustive references. There are, however, 92 in all, which is a considerable number for a small book, and one cannot fail to wonder whether a more judicious choice might not have been made. Many refer to papers treating the particular question under discussion in a theoretical manner, a type of treatment of practically all the questions to be found brought together in one place in the larger treatises. Probably a greater proportion of references to experimentally determined examples, illustrating the principles involved, would have led to greater usefulness. For example, in discussing liquid immiscibility in binary and again in ternary systems, the author mentions the actual systems in which the phenomenon has been observed but the papers detailing the investigations are not referred to and the name of Greig, who carried out all of the investigations on these systems, is not mentioned.

The above general suggestion is made in the interest of greater usefulness of a possible

second edition and there are a few matters of detail that may be mentioned with the same end in view.

As has already been said the book begins with a statement of the phase rule, which requires that for invariance the number of phases must exceed the number of components by two. For the novice it would have been well if the author had made it clear why it is that in silicate diagrams a number of phases exceeding the number of components by only one is ordinarily regarded as giving invariance. It is, of course, because the vapor phase in such systems can be neglected and pressure is not ordinarily to be considered as a variable. The importance of keeping these facts in mind is realized when one finds that the author himself has not always done so. Thus in figure 6, where the effect of the pressure variable is definitely under consideration, the author depicts, in the curve ue_2' , the change from incongruent to congruent melting induced by pressure and says that, in the special limiting case shown in the separate diagram figure 7, there is a four-phase point at which crystal phases A and A_mB_n and the liquid and vapor phases coexist. Actually the special point is like any other point in ue_2' , namely one at which said two crystal phases are in equilibrium with liquid in the absence of vapor. The vapor phase can exist along this univariant curve only at the invariant (quadruple) point (at some very low pressure less than p_1) at which the curve, as well as three other curves, originates. The only special features of the limiting case depicted in figure 7 is that the liquid phase happens to have the composition of the compound A_mB_n . Moreover the diagram (figure 7) should be changed left for right, leaving the lettering unchanged, in order that it may properly depict a special case of figure 6.

These considerations emphasize the importance of realizing that in silicate diagrams we ordinarily neglect the vapor phase and pressure as a variable, but as soon as we begin to regard pressure as a variable we must have carefully in mind the limitations as to presence or absence of the vapor phase in order that the phase rule be properly applied.

One may question the advisability of the use of "*unstable crystal phases*" to designate stable phases existing under metastable conditions as is done in the discussion of figures 12-15.

The author states in paragraph 78 that the curves separating fields in ternary diagrams should be called "boundary curves" and that the term "eutectic curves" is less to be recommended. This reviewer agrees most heartily and is therefore somewhat disappointed to find the author using the latter in paragraph 149. The term "eutectic" should be applied only to points, never to curves.

For the novice it might have been well if the author had made it clearer that the temperature t_z of figure 16 and the temperature T_m of figure 68 are identical, provided that A and B are the same substances in both figures and no matter what the third substance C may be. A similar relation holds between figures 17 and 69.

In paragraph 162 the statement is made that 1042° is a temperature-minimum for the existence of leucite, according to figure 59. Understanding reference to this figure makes it entirely clear that the temperature 1042° is merely the minimum temperature of existence of leucite *in contact with liquid in the ternary system*, nevertheless it would have been well if the author had added the qualifying phrases here given in italics. The petrologic novice might get the impression that leucite could form only above 1042° , a relation which exists, without qualification of any kind, only for a compound of the type depicted in figure 68.

The new figure 124 differs from the corresponding figure 120 of the German edition in that the latter is the diagram of Ferguson and Merwin and the new figure is intended to embody corrections by Osborn. Actually one major Osborn correction is not shown, for he found that each of the curves 13-14 and 3-1 has a maximum temperature on the diopside-wollastonite join whereas figure 124 shows the temperature falling in one direction from end to end of these curves.

In paragraph 203 the author discusses the case of unmixing of solid solutions in a ternary system and correctly states that a succession of three-phase triangles develops in ternary compositions below the critical temperature of unmixing t_k . However the diagram (figure 135) which is intended to illustrate this relation is bound to give the reader an erroneous concept of the nature of these three-phase triangles. Even at the lowest temperature E_t the liquid apex E_t of the three-phase triangle should be joined to points near A and near B and not to A and B themselves. At higher temperatures successive points on the curve E_{t_k} should be joined to points in AB that continually approach each other, until finally at the temperature t_k the two points should coincide and the three-phase triangle is reduced to a line. The joins t_kA and t_kB of figure 135 are thus altogether misleading.

In paragraph 205 it is stated that figure 141 is derived from figure 138, if the maximum K is shifted further into the interior of the concentration triangle. Actually no amount of movement of the maximum K can alter the fact that figures 138 and 141 are essentially different in that figure 138 shows immiscibility on the binary side-line.

The sections on four and more components summarize the various attempts that have been made to depict such systems graphically and to treat them analytically. They serve to emphasize how limited has been our progress in these directions.

As a whole the subject matter of the book is presented in a clear and orderly manner and, in spite of the few suggestions made as to corrections, the book must be regarded as an excellent addition to the literature of silicate equilibrium. It presents a large volume of facts and of the principles governing them in conveniently small compass. Most petrologists and silicate technologists will find it a desirable addition to their libraries if they can find the necessary \$5.00, which must be regarded as rather a high price for a small book. But such are the ways of university presses.

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CRYSTAL GROWTH by H. E. BUCKLEY. xv+571 pages, John Wiley and Sons, Inc., New York, New York; Chapman and Hall Ltd., London, England, 1951. Price, \$9.00.

This book is a much more complete, systematic, and comprehensive treatment than the volume of the same title published by the Faraday Society in 1949. The earlier volume is a general discussion, composed of 49 individual papers. More details of some processes are given in the Faraday volume, of course, but there are also some overlaps and some gaps not found in the integrated treatment by Buckley. In a work of such broad scope one would not expect to find experimental details of all of the processes outlined. In the preface Buckley says, "It is hoped, however, that even such [the specialists] may derive a little profit or inspiration from contact with the larger whole—and will look with tolerance on the elementary descriptions of their main preoccupations." The excellent bibliographies that follow each chapter give ample reference to original work so that anyone interested in duplicating, or extending, an experiment can find all of the pertinent details that have been published.

Perusal of the chapter headings gives the impression that the work is largely theoretical, but in most of the chapters enough specific examples are cited to give a practical turn to the theory. The titles of the chapters are: 1. Solution and solubility, solubility and supersolubility; 2. The artificial preparation of crystals; 3. The Curie theory of crystal growth; 4. The so-called velocities of growth; 5. The diffusion theories; 6. Recent theories of crystal growth; 7. Ideal and real crystals; 8. Miscellaneous types of crystallization; 9. Dissolution phenomena; 10. Crystal habit modification by impurities; 11. Relationship of substances during crystallization; 12. Peculiarities of crystal growth.

These twelve chapters form the bulk of the text and occupy 528 pages. There follows a

31-page appendix on Habit Modification as a Result of the Presence of Impurities. This is a subject in which Buckley is particularly interested and in which he has done a great deal of work. The appendix is really supplementary to Chapter 10 and in it 56 compounds are listed and variations in their crystal habit and appearance brought about by deliberate addition of impurity to the mother liquor are outlined. All of these examples are well-attested; many more were omitted where the emphasis was on systematic inclusion of the impurity and where otherwise little information was given regarding modification of habit.

At the end of the appendix there is a table in which 33 "useful habit-modifying dyes" are listed. Many other dyes mentioned in the appendix and throughout the text are not listed in the table and there is no summary of other organic modifiers such as dextrin, gum arabic, metanilic acid, and sulfanilic acid, or inorganic modifiers such as borax, metallic chlorides, and sodium sulfate, a considerable number of which are mentioned throughout the work.

Neither are these compounds listed in the index, nor are most of the compounds whose habit modifications are discussed. For example, the modification of the crystal habit of sodium chloride by urea is mentioned in at least two different places, yet neither compound is in the index. In fact, the subject index is quite a disappointment after one reads through the very complete treatment in the text. It occupies but 5 pages and only a fraction of the topics, compounds, theories, types of equipment, etc., discussed in the text are listed. The six-page author index is much more nearly complete.

Buckley has done an excellent job of summarizing existing experimental data and theories of this interesting and important field. After one reads through chapters and chapters on crystal growth and one on dissolution of crystals, however, he is impressed by how little is really *known* about why or how crystals form or dissolve.

It is surprising in a volume by one who has long been interested in mineralogy to find so little mention of natural crystals. There are many places where principles developed, or phenomena observed in the laboratory, could be applied to problems of crystallization in Nature, yet only rarely is such application attempted. For example, in the chapter on velocities of growth such factors as composition of the solution (including impurities), imperfections and orientation of the lattice, and mechanical inhibition, are discussed, but no mention is made of direction of motion of solution past a growing crystal. This factor can produce asymmetric growth on different faces of a given crystal form and thus affords an important clue in certain mineralogical and geological problems. This effect has been observed and recorded in growth of artificial crystals. Some of the references that are made to natural phenomena are antiquated if not actually in error. For example, on page 257 the terms "eutectic ground mass" and "eutectic texture" are used in discussing rocks. It has long since been demonstrated that few, if any, of the graphic textures observed in pegmatites and the groundmass of porphyries are due to crystallization at a eutectic. On the same page in a discussion of the effect of water on crystallization of a magma, a 1922 paper by Morey is quoted to the effect that "a 0.1% proportion of water will reduce the melting point of anorthite by 5° C." There has been in the literature for quite some time now much more detailed and pertinent work on the effect of water on the crystallization of silicates, some of which could have been quoted to advantage in this discussion. This lack of attention to natural phenomena is unfortunate for mineralogists, petrologists, and geologists because it renders the volume less attractive and useful to them than it might otherwise have been.

In the discussion of melting point determination on pages 260-262 considerable emphasis is laid on the difficulties brought about in the cooling or heating curve method by the tendency of many substances to undercool or superheat. Yet no mention is made of the quenching technique by which these difficulties were overcome for silicates and similar compounds many years ago at the Geophysical Laboratory.

Typographical errors are relatively few and unimportant. On page 83, line 2, "Fig. 32 b" should read "Fig. 32 c." In Fig. 34, page 85, an inlet and outlet for "CO₂" are shown, but the coolant mentioned in the discussion of the figure on page 84 is "nitrogen." At the top of page 107 "and" is used in a French quotation. In the second sentence of paragraph 2, page 264, failure to close the parenthesis at the proper place, after the word "type," is confusing. The columns of Table 15a on page 267 should be headed "cm per min" instead of "cm per mm." Plate 59 on page 429 is a reproduction of part of plate 39 on page 363 at twice the scale, but both are marked "X2." On page 475, paragraph 2, line 6, "interfacial" should read "interfacial." Use of the term "four faced cube" on page 123 and in Fig. 51c, page 137, can hardly be called a typographical error, but the equivalent term "tetrahexahedron" would have been much more readily understood by (at least American) mineralogists and crystallographers.

This book is, of course, the most complete and up-to-date summary of the theory and practice of crystal growth. It is a worthy companion to the 1949 volume of the Faraday Society; both should be in the library of any individual or institution interested in any phase of the growth of crystals.

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EINFÜHRUNG IN DIE MINERALOGIE (KRISTALLOGRAPHIE UND PETROLOGIE) by CARL W. CORRENS. viii + 414 pages; 405 illustrations, 13.5 cm. Wulff net; 68 tables in Parts I and II; Part III is composed entirely of tables. Price, Bound 41.60 DM. Springer Verlag, Berlin, Heidelberg, 1949.

Professor Correns has prepared this text as an introduction to mineralogy for students in mineralogy and particularly for students in the related professions. The material was selected to meet the course requirements in German Universities. Professor Correns stresses the relationship of mineralogy to other sciences. He writes, "Other important boundary fields besides those already mentioned (mathematics and physics) are chemistry and physical chemistry and even biology in sedimentary petrology. In the life of the natural sciences, mineralogy thus stands in the midst in continuous reciprocal relation with its neighbors." This book, he feels, will lead to a comprehension of mineralogy but it will not replace a systematic textbook.

An examination of the table of contents of this book causes one to turn back and look at the title. Part I is crystallography, Part II petrology, and Part III a supplement or appendix (Anhang). Mineralogy does not appear as a heading in the table of contents.

This book is a refreshing treatment of mineralogy, using that term in its widest sense. It is original in plan, in ideas, in manner of presentation and in illustrations. In general, it is above the level of undergraduate students of mineralogy in most American universities. It should be carefully read by graduate students in mineralogy, petrology, and "hard rock" geology. Mineralogists, crystallographers, and petrologists will find this book to be well worth the effort required to read a book in a foreign language. It is both comprehensive and stimulating.

PART I: KRISTALLOGRAPHIE: *Kristallmathematik* is covered in 45 pages. Of this, 25 pages are devoted to a discussion of the 32 crystal classes and 17 pages to a discussion of the general principles of crystallography, symmetry relationships, and calculations. *Kristallchemie* occupies 40 pages in the text. This section is a brief introduction to the theory of crystal chemistry. It follows the Goldschmidt approach. Various types of binding, ionic, intermolecular, metallic, etc., are illustrated. The structure of the silicates is given in more detail than that of other substances. This section is well illustrated and contains the electron density maps of halite, quartz, diamond, and hexamethylenetetramine deter-

mined by Brill, Grimm, Hermann, and Peters. *Kristallphysik* is covered in 52 pages. This section opens with a good discussion of the plastic deformation, mechanical properties, and elastic behavior of crystals. The relationships to crystal structure are emphasized. Tabular summaries of the physical data are included. Crystal optics is covered very briefly in 22 pages. The treatment is advanced and contains discussions of strain-birefringence and form double refraction. The description of x-ray optics is also very brief. *Kristallwachstum und -auflösung*: The subject of crystal growth and solution is a relative newcomer to textbooks of mineralogy. Professor Correns has presented a very interesting introduction to this field. The data of Spangenberg on the growth of potash alum crystals, solution phenomena, and etch-figures afford the experimental background. The treatment of crystal growth in terms of lattice energy considerations follows Kossel and Stranski.

The treatment throughout Part I is brief, but should the reader gain the idea that this is all that the student need to learn, Professor Correns warns as follows:

“Wir haben mit diesen Betrachtungen die kristallographische Formenlehre abgeschlossen, ein Gebiet, das dem Anfänger besondere Schwierigkeiten zu machen pflegt. Bei vielen Menschen ist das *Raumvorstellungsvermögen* nur schwach entwickelt. Wer sich aber mit der Architektur der festen Stoffe, mit der Kristallbaukunde, beschäftigen will, muss das Raumvorstellungsvermögen entwickeln. Das geschieht durch Übung, vor allem an kleinen Holzmodellen. Das sog. Klötzchenpraktikum hat darin seinen Sinn, dass man lernt, Symmetrieelemente zu finden und zusammengehörende Flächen zu erkennen. Über diese Schulung hinaus ist aber die Kenntnis der 32 Kristallklassen und der bei ihnen vorkommenden Formen die Grundlage für die Beschreibung der Minerale, für die Untersuchung des Wachstums, der physikalischen Vorgänge, wie z. B. des mechanischen und optischen Verhaltens. Die Ansicht, dass es genüge, “ein wenig über die Struktur” zu wissen, dass aber die Kristallmorphologie “unnötig” sei, verhindert ein tieferes Eindringen in die Probleme. Auch für das Verständnis der Strukturen ist die Kenntnis der Kristallklassen Voraussetzung.”

PART II: PETROLOGIE: *Einige physikalisch-chemische Grundlagen*. This section is chiefly a short description of one, two, and three component systems. The diagram for the system leucite-silica is in error and appears to be based on a mixture of old and new data on leucite. Photomicrographs and sketches are used to illustrate practical applications of the principles discussed. Under the title, “*Die magmatische Gesteinsbildung*,” Professor Correns treats the fundamental processes of the origin of igneous rocks, their classifications, and Niggli numbers. He also discusses the frequency of the chemical elements, rôle of volatile constituents, critical phenomena, pneumatolysis, hydrothermal solutions, ore deposits, and the deposition of minerals in cavities in igneous rocks. This section is well substantiated by tables. The next two sections in Part II, *Verwitterung und Mineralbildung im Boden* and *Die sedimentäre Gesteinsbildung* represent Professor Correns' field of specialization and they are exceptionally well done. The approach is from the physico-chemical view. These sections are rich in original ideas and methods of presentation. The last section is closed by a discussion of the rare and unusual elements in biogenetic and chemical sediments. *Die metamorphe gesteinsbildung* is discussed in 27 pages. It includes the topics, recrystallization, deformation of rock, the facies concept, and granitization. The final section in Part II is entitled *Geochemische Ergänzungen* and contains a discussion of the concept of geochemistry, geochemical balance, and the frequency of occurrence of the chemical elements.

PART III: ANHANG: is made up of tables. This includes a tabular review of the data of the 32 crystal classes; a table showing the relationship of the Naumann and Miller indices; the symbols of the 230 space groups, expressed in Schoenflies and Hermann-Mauguin symbols; relation of crystal symmetry and physical properties; atomic and ionic radii; tabular summary of 300 common minerals and their properties. Thirteen pages of

tables are devoted to petrologic data, including average chemical analyses of rocks and modes. The book contains a collection of suitable references and it is well indexed.

The text is designed in such a way that a college professor can select those topics which he wishes to cover in a given course. He will have to expand the discussions of most topics. The tables and illustrations will prove very valuable in this connection. The tabular summary of the properties of 300 minerals is a compact presentation of the data commonly appearing as separate entities in the usual mineralogical textbooks.

The reviewer believes that Professor Correns is to be congratulated on a very fine book.

GEORGE T. FAUST

DICCIONARIO MINERO-METALÚRGICO-GEOLÓGICO-MINERALÓGICO-PETROGRÁFICO, Y DE PETRÓLEO (INGLÉS-ESPAÑOL, FRANCÉS, ALEMÁN, RUSO), by ALEJANDRO NOVITZKY, vi+369 pp. quarto, Buenos Aires, 1951.

The author is well qualified to compile a polylingual dictionary, because he was born and reared in Russia and has studied and worked in France, Germany, Yugoslavia, Turkey, North Africa, the Balkans, and Argentina. He is a mining engineer, so it is natural that this field and metallurgy should be named first and covered more thoroughly than are the related Earth Sciences.

The work contains approximately 18,000 terms, many of which are not to be found in more general technical dictionaries. It should therefore be very useful in translating from English to Spanish, French, German, or Russian, since the arrangement is alphabetical in English. For other purposes, however, it appears that its usefulness will be largely limited to checking meanings. For example, if one wishes to know the meaning of a Russian word, there is no way to look it up directly. If he has an indication of what the word means in English he can look up the English word(s) that might have the same meaning and see whether the Russian word is listed. It is unfortunate that no glossary, or index, of Spanish, French, German, and Russian terms was prepared, which would have multiplied the usefulness of the book almost fivefold. There is no indication in the introduction, or in the arrangement of the terms on the pages, that any such supplementary glossary is contemplated. It would appear that the glossary would be more than worth the extra time and expense of preparing it.

A "technical vocabulary"¹ published in Finland in 1950 uses this system. The words are listed alphabetically in German; on each page the lines are numbered. The index has Finnish, Swedish, English, and Russian words listed alphabetically, with reference to the proper page and line for each. This means that the book can be used for looking up the meaning of words in any of the five languages and hence for translating from any one of them to any other.

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¹ "Tekniikan Sanasto (Technical Vocabulary; German-English-Finnish-Swedish-Russian), xxiv+1518 pp. (exclusive of index, which is a separate volume), Kustannusosakeyhtiö Otavan kirjapaino, Helsinki, 1950.

ANNALS OF THE UNIVERSITY OF STELLENBOSCH. Volume 26, Section A, Nos. 3-11, 1950. Edited by C. A. DuTorr. 507 pages. Price 1'1'0 (\$2.90). Cape Town, South Africa.

Volume 26 of the *Annals of the University of Stellenbosch* contains nine articles on the geology and petrology of South Africa. *Aspects of the Geology of the Northern Soutpansberg Area* by J. S. Van Zyl demonstrates that the Soutpansberg is a stepfault-block mountainland and describes rocks of the Karro and Waterberg systems, the Old granite, the James-

town intrusives (anorthosites, perknites and serpentinites) and the Moodies series (quartzites, magnetite-quartz rocks, marbles and aluminous gneisses and schists). W. C. Brink, in *The Geology, Structure and Petrology of the Nuwerus Area, Cape Province*, depicts the geological features of an area underlain by rocks of the basement complex (Namaqualand granite with roof pendants of the Kaaieu series), of the Nama system and by a few diabase dikes. Deductions on the contamination of granite magna by country rock assimilation, based on the criteria of chemical analyses alone, are reviewed and criticized.

A new deposit of pyrophyllite, described by C. T. Potgieter in *The South African Pyrophyllite Deposits*, consists of a sericite schist containing kyanite, andalusite and diaspore as well as pyrophyllite. In the fourth paper, *The Geology and Chemistry of the Laingsburg Phosphorites*, H. C. Strydom presents a geologic and petrographic description of the Upper Dwyka shales and their phosphorite concretions and suggests a theory of origin. *The Dolerite Intrusions of the Wellington-Moorreesburg Area* by Q. C. Bouman concerns itself with the petrology of these rocks and the low-grade regional metamorphism responsible for their alteration. By means of grain-count and elongation-index-frequency methods, M. R. Henzen, in his paper, *A Comparative Petrographic Study of the Sediments of the Rooiberg and Stavoren-Vlakfontein Areas*, concludes that the quartzites of two separate occurrences had dissimilar provenances.

The second paper by C. T. Potgieter is entitled, *The Structure and Petrology of the George Granite Plutons and the Invaded Pre-Cape Sedimentary Rocks*, and deals with the petrography of the granite and of the country-rock schists, phyllites and quartzites. The next paper, *Morphological Aspects of the Bokkeveld Series at Wuppertal, Cape Province*, by B. Swart is concerned with the sedimentary structures, heavy minerals and fossils of these rocks. The last paper is by P. J. Van Zijl (spelled Zyl in the Table of Contents) on the petrography and petrogenesis of *The Complex Dioritic Stocks West of the Malmesbury-Paardeberg Granite Pluton*.

Throughout the volume the authors and editors have successfully maintained a high standard—in content, organization and presentation. Many large folded insert maps illustrate the reports.

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