BOOK REVIEWS

THE PRODROMUS OF NICOLAUS STENO'S DISSERTATION CONCERNING A SOLID BODY ENCLOSED BY PROCESS OF NATURE WITHIN A SOLID. English version with an introduction and explanatory notes by John Garrett Winter, foreword by William H. Hobbs, University of Michigan Humanistic Studies, Vol. XI, pt. 2, 1916; Fascimile reprinted and edited with introduction by George W. White, Volume 4 of the Contributions to the History of Geology. Hafner Publishing Co., New York and London, 1968, v and vii and 283 p., XI plates, $12.50.

Niels Steensen, the original author of this remarkable volume, was born a Danish Protestant in 1638. He studied medicine, in Copenhagen, Amsterdam, Leyden, and made his way via Paris to Florence where he became a part of the Accademia del Cimento in association with such men as Galileo's pupil Vincenzo Viviani and Francesco Redi. As a 22 year old student in Amsterdam, he made his first significant anatomical discovery, that of the *ductus Stenonianus*.

A year after his arrival at the Medicean court, his dissection of a shark's head and comparison of the teeth with *Glossopterae* turned him to geological problems. By 1669, Steno had organized the preliminary ideas which arose out of the study of the shark's head into a comprehensive and thorough analysis of the problem of solids enclosed within solids— the raw material of geological science. The *Prodromus* was originally intended as just that, a mere introduction to a major dissertation which, however, was never to be written.

About the time of the dissection of the shark's head, Steno had become a Catholic convert. By the time of the *Prodromus*, his theological interests had come to take precedence over natural science. Ordained in 1675, raised to Bishop in 1676, his piety and zeal led him to spend the remainder of his life in asceticism and theology. Steno was born too soon for the Nobel prize, but he is the first geologist for whom the machinery of canonization has been set in motion.

At the outset of the *Prodromus*, Steno expressed a clear view of the geological problem: given a solid with a certain form—to find in the substance itself, the evidences of its history. This volume did far more than reason out the organic origin of fossils. The distinction he made between the growth of crystals and the growth of animal shell are a model for any time. If ideas of forces are substituted for Steno's 'attenuated fluid' his observations of crystal form and crystal growth become clear. Steno states clearly the law of the constancy of interfacial angles, which had only been implicit in the work of Hooke. He went on to lay the basis for a crystallographic terminology, expressed the laws of superposition, lateral extension and initial horizontality, and tried to account for mountain building, as well as laying the sedimentary basis for Neptunism. These ideas he applied to the geology of Tuscany with results which provided the Italian foundation for the concept of the geological time scale in the next century.

The great merit of the *Prodromus*, like Lyell's *Principles* of the 19th Century, was not so much in publishing ideas which later geology was to adopt, since for the most part these were ideas which must have been known for centuries (the organic origin of fossils), or were even misleading (ascription of Tertiary bones at Arezzo to Hannibal's elephants). Steno had organized his ideas into a closely reasoned system based on the careful observations of a trained anatomist. The *Prodromus*, like Lyell's *Principles* three centuries later, was a manual of geologic procedures, and a guide to those who would develop the new science. In the original Latin and in English and French translation, it served to disseminate the actualistic method in geology as opposed to the speculative constructions of systems of geologic history which distinguished the following century.

In 1916, J. G. Winter, a classicist, and W. H. Hobbs, a geologist, both of Michigan,

published the first English translation since 1671. This reprint is preceded by a very brief introduction by G. W. White. It is a good look at the state of the art of history of geology of another generation. Their standards of scholarship were impeccable but the reader is painfully aware of the passage of time. The heresies for which Bruno was martyred in 1600 had little to do with his geological ideas and the mingling of scripture and geology of Steno's final pages was not an extorted apologia but a carefully arrived-at theological-philosophical position, difficult as this might be for an American academic to comprehend. Hobbs, writing five years after the first X-ray diffraction experiment, could refer to "the orientation of molecules" and Winter refers the reader to Murchison's paper of 1849 "For a modern exposition of Tuscan earth features". *Basta!* It was a triumph of American scholarship and no self-respecting geologist or crystallographer should fail to read this antique gem.

In the Introduction, Winter apologized for the omission of the original Latin as there were two editions available. What was available in 1916 is fortunately available again in 1969. The complete geological papers of Steno in Latin including the *Prodromus* with facing English translation by A. J. Pollock, with superb modern annotation and accompanying illustrations by Gustav Scherz has just been published in Denmark (Odense University Press), $12.00. A scholar's delight, these volumes should be read together, savored, and passed on to one's intellectual heirs.

CECIL J. SCHNEER
University of New Hampshire

APPLIED MINERALOGY FOR ENGINEERS, TECHNOLOGISTS, AND STU-
DENTS. BY HELMUT KIRSCH, translated by K. A. Jones. Chapman and Hall Ltd.,
London, 1968. 233 pages. $6.00 paper, $9.50 cloth.

Summarized in this rather small volume is a large amount of information. About half the book is devoted to application of mineralogy and petrology to technology. The following are selected from 20 sub-headings: ceramics, glasses and enamels, metallurgical industry (slags, molding sands, etc.), weathering of natural and artifical stone structures, grinding and polishing agents, and single crystals. In each of these sections the uses and sources of minerals or synthetic materials are outlined.

The applied mineralogy chapter is preceded by very brief surveys of general mineralogy, geochemistry, petrology, and mineral deposits. These chapters serve only to put the many mineralogic terms in a sequence of definitions. Readers (engineers and technologists) will have to go to other sources (many are suggested) for further details. A chapter listing the most useful ore-minerals and other non-ore-minerals and rocks is also included.

Most of the book is written in an outline style with very little space devoted to explanation. Most of the 103 figures are clear and support the text, although some will be difficult to understand without some mineralogic background. Those for whom the book was written will find it a useful source of mineral application information, available in no other single volume.

WILLIAM S. WISE
University of California
Santa Barbara, California

THERMODYNAMIC PROPERTIES OF MINERALS AND RELATED SUBSTANCES
AT 298.15°K (25.0°C) AND ONE ATMOSPHERE (1.103 BARS) AND AT HIGHER
TEMPERATURES. BY RICHARD A. ROBIE AND DAVID R. WALDBAUM. U. S. Geo-
logical Survey Bulletin **1259**, 1968, 256 pages.

This contribution supersedes earlier compilations of thermodynamic data for minerals [c. f., R. A. Robie, *in Geol Soc. Amer. Mem*, **97** (1966)]. In the introductory chapter the

authors discuss their sources of data, uncertainties, and the methods used in their calculations; they also present tables of atomic weights and relevant physical constants. The ten-page introduction is followed by 14 pages of abridged tables containing gram formula weights, entropies, molar volumes, and enthalpies, free energies, and equilibrium constants of formation from the elements at 25°C for elements, gases, and solid compounds in geologic systems; only gram formula weights, and free energies and equilibrium constants of formation from the elements at 25°C are given for aqueous ions. The remainder of the book is devoted to tabulation of high-temperature data; i.e., entropies, enthalpy functions (H_T-H_{298}), free energy functions ($-(G_T-H_{298})/T$), and enthalpies, free energies, and equilibrium constants of formation of minerals from the elements at higher temperatures, together with their melting points, boiling points, heats of fusion, and heats of vaporization. References are given for all data, but uncertainties in the numerical values are shown only for 25°C. Indexes of mineral names and formulas are provided at the end of the book and dates of compilation are shown in each high-temperature table.

This book is comprehensive, critical, and outstanding! It represents a valuable contribution and an indispensable reference for the geologist. Nevertheless, the book has its share or errors and inconsistencies. For example, the data given for magnesite are inconsistent with experimental phase equilibria for the system $CaO-MgO-CO_2$ at elevated temperatures. Similarly, those given for diaspore, boehmite, gibbsite, corundum, and kaolinite are internally inconsistent and in conflict with high temperature solubility data. Other problems of this kind exist in the system Fe-O as well as among various other silicates. In the present state of knowledge most such contradictions cannot be resolved without more and better experimental data. However, the problem is not critical if the reader is aware of the pitfalls inherent in the application of thermodynamic calculations to real systems.

Not all of the data reported in this compilation are experimental. Assumptions have been made in deriving various thermodynamic values, but they are stated in the list of references and notes. In some instances estimates of thermodynamic properties are given (e.g., the entropies of phlogopite, monticellite, huntite, and tremolite.) The accuracy of the numerical information in the compilation is thus far from uniform. Although heat capacity power series afford only close approximations of high temperature data, it would have been useful if the authors had included power function coefficients (such as those given by K. K. Kelley, *U. S. Bur. Mines Bull.* **584** (1960)] for the species in their compilation. They deliberately omitted heat capacity data as such on the grounds that the values given in the literature are usually approximate and derived from other measurements. Other omissions include the enthalpies of formation from the elements and entropies of aqueous ions [c.f., D. D. Wagman *et al.*, *Nat. Bur. Stand., Tech. Note* **270-3** (1968)]. The book would have broader application if the authors had also included high-temperature partial molal volumes of ions [c.f., A. J. Ellis, *J. Chem. Soc. (London)*, **1966**, 1579; **1967**, 660, **1968**, 516], and high temperature entropies and average heat capacities of ions [(Criss and Cobble, *J. Amer. Chem. Soc.*, **86**, 5385–5393 (1964)]. Inclusion of such data would decrease significantly the number of references required by the geologist for geochemical calculations.

The omissions and contradictions discussed above detract insignificantly from the value of this book; it should be a best seller in the geological community. Robie and Waldbaum ought to be congratulated; we owe them a debt of gratitude for providing us with this timely, up-to-date, and much-needed compilation of data. I only hope they keep revisions coming out!

HAROLD C. HELGESON
Northwestern University

A CATALOG OF ANALYZED CALCIFEROUS AND SUBCALCIFEROUS AMPHI-
BOLES TOGETHER WITH THEIR NOMENCLATURE AND ASSOCIATED
MINERALS. By BERNARD E. LEAKE. Geological Society of America, Special Paper **98**,
1968, 210 pages, $7.50.

Professor Leake deserves the thanks of all petrologists for performing a massive task
that makes a great wealth of data available for further synthesis. This task has been done
over a period of years, but is updated to include analyses to 1965. Coming, as this volume
does, at the dawn of the age of the electron probe, some petrologists might think of this as
the final summary of the results of wet analysis technique. Comparison of the results of the
two methods demonstrates, however, that for minerals as complex as the amphiboles,
particularly calcic amphiboles, superior wet analyses will continue to make major con-
tributions to the advancement of knowledge for decades to come. In this connection the
gradual disappearance of persons skilled in wet analysis and research in such techniques,
except perhaps in Japan, constitutes something of a crisis to which urgent attention needs
to be given.

The most important part of this volume is 60 pages of tables with 1217 amphibole
analyses, calculated cell constants, and measured physical and optical properties. There are
84 pages of detailed notes giving the locality, host rock, and associated minerals of each
analysed amphibole, and 11 pages of index. The first 44 pages of the volume consist mainly
of discussion under the following headings: Introduction, A Rational Nomenclature for the
Calciferous and Subcalciferous Amphiboles, Some Composition Ranges of Calciferous and
Subcalciferous Amphiboles, Chemical Relationships Between Amphiboles and Minerals
Associated with Them, The Quality of Amphibole Analyses.

There are several aspects of the volume that are controversial. The cell contents are
calculated on the basis of 24 (O, OH, F, Cl) placing reliance on the analysis of H_2O. Recent
workers seem about evenly divided between this traditional method and calculating on the
basis of 23 (O) on the assumption that there are really 2 (OH, F, Cl) regardless of the H_2O
analysis. Binns (1965), for example, for his specimens, demonstrates better agreement be-
tween measured and calculated density on a 23 (O) basis, but Leake has calculated Binns'
analyses to 24 (O, OH, F, Cl) for this volume. Recently the reviewer evaluated available
gedrite analyses and found chemical relationships to be far more rational when cell contents
were calculated on the 23 (O) basis. This method also seems to be favored by crystallog-
raphers doing refined structural studies. Approximately 25 percent of the analyses in this
volume have (OH, F, Cl) between 1.80 and 2.20, and hence, for comparative purposes, cell
contents nearly the same as if calculated on the basis of 23 (O). To recalculate the remain-
ing analyses on this basis will be a major task. Clearly serious questions still remain con-
cerning the roles of H_2O and O in amphibole structures. On page 36, Leake indicates that he
has undertaken further study of this matter. Intense application of solid state spectro-
scopic techniques to this question as well as the question of the oxidation state of Fe and Ti
could bring about a major advance in understanding of amphiboles.

The scheme of nomenclature proposed by Leake is disappointing. Such a scheme must
be based on the cation content of different sites in the structural formula as far as it may be
deduced from a chemical analysis using standard rules. The tetrahedral sites are filled first,
usually followed by $M(4)$, $M(1-2-3)$, and finally the A site. These rules, of course, do not
take into account the possibility of octahedral vacancies tending toward an amphibole
structurally analagous to the dioctahedral micas (J. B. Thompson, pers. comm.), but such
vacancies, if they exist, have yet to be documented. Although some amphibole chemical
compositions can be described in terms of several different sets of ideal end members, such
ideal end members can be used nevertheless as a basis of a classification scheme as Leake

does. However, in describing these end members and the amphiboles to be classified, Leake employs parameters which partially obscure the true character of their structural formulae.

All would agree with the first parameter, Si per formula unit, which is inversely related to tetrahedral Al except in the low Al analyses where Fe^{3+} or Ti^{4+} must be inserted in tetrahedral sites. The second parameter, $Ca+Na+K$ per formula unit, leads to ambiguity, because it does not uniquely describe either the A site or the $M(4)$ site occupancy. Thus an amphibole with an intermediate value for $Ca+Na+K$ could have a nearly empty A site with most $Ca+Na+K$ in $M(4)$, or it could have a nearly full A site with a substantial amount of Mn, Fe, and Mg in $M(4)$ as a substitution toward cummingtonite. Indeed, actinolites coexisting with cummingtonite can have $Ca+Na+K=1.6$ which is below the lower limit of 2.0 provided by the classification. Elsewhere, in his evaluation of the quality of analyses, Leake seems not to appreciate the importance of the substitution of Fe and Mg in $M(4)$ in hornblende. He sets 0.25 as a maximum for this substitution in a superior analysis, but notes a large number of analyses that exceed this. Furthermore, the term "subcalcic" could apply to two groups of amphiboles, those with high Fe and Mg in $M(4)$ or those with high Na in $M(4)$.

The third parameter employed is $mg=Mg/(Fe^{3+}+Fe^{2+}+Mn+Mg)$. The inclusion of Fe^{3+} in the denominator is to be regretted because of the different role cf Fe^{3+} from Fe^{2+}, Mn, and Mg in amphibole structures, and its considerable importance in certain ones. It also tends to confuse the relationships on several figures showing Fe/Mg fractionation between calcic amphiboles and other minerals. In connection with the treatment of Fe^{3+}, the use of the terms pargasite and hastingsite for magnesian and ferrous ends of a series is unfortunate. The two series adopted by Ernst (1968), pargasite-ferropargasite dominated by octahedral Al and magnesiohastingsite-hastingsite dominated by octahedral Fe^{3+}, are preferable, particularly in light of the high pressure significance of octahedral Al as opposed to Fe^{3+}.

In addition to the three main parameters, Leake has established a series of special rules to apply in certain cases and a series of prefixes to apply to the compositionally more extreme types. This has the effect of reducing the number of basic amphibole names, but substitutes for them a series of rules that are perhaps worse.

The section on chemical relationships with associated minerals contains some interesting generalizations, partly spoiled by the choice of the value for mg. Unfortunately the associated minerals are not included in the index, which is comprehensive so far as the amphiboles are concerned.

It is good that the Geological Society of America has encouraged publication of this work and it is hoped that further efforts of this type will be forthcoming. Only by understanding rock-forming minerals as they are and not as they are expected to be theoretically will correct inferences on their genesis be forthcoming.

PETER ROBINSON
University of Massachusetts
Amherst, Massachusetts

PROCEEDINGS OF THE NINTH CONFERENCE ON THE SILICATE INDUSTRY (SILICONF 1967). FERENC TAMÁS (ED.) Akademiai Kiadó (Hungarian Academy of Sciences), Budapest, 1968, 756 pages, $24.00.

The steadily growing number of participants coming from all over the globe indicate impressively that these conferences in Budapest have become an international meeting of theoreticians and practical experts in the silicate fields.

In his opening address L. Szokup, President of the Scientific Society for the Silicate Industry (Budapest), suggested two main subjects for special consideration: (1) Effects of

trace components in the mineral raw materials of technical silicates, and (2) Basic importance of particle size distribution in every branch of the silicate industry, e.g. in manufacturing high quality glasses, electronic ceramics, special hydraulic cements, monolithic refractories, and common brick and tile. In all these fields, applied mineralogy and petrography are most evident again, as they have been in the previous Seventh and Eighth Conferences [*Amer. Mineral.* **52**, 1257 (1967).]

Of the 83 contributions, 22 are in the fields of basic silicate research, and among these many are of particular interest to the mineralogist: contributions by Z. Adonyi *et al.* (*Thermogravimetric Investigation of Hydration Processes of Tricalcium Aluminate*); A. I. Boškova (Leningrad) (*Order-Disorder Structures of Tricalcium Silicate Crystalline Solutions*); Yu. M. Butt *et al.* (Moscow) (*Properties of Tricalcium Silicate and its Crystalline Solutions*); M. R. Marinov *et al.* (Sofia Bulgaria) (*Metastable Immiscibility in the Li_2SiO_3-$LiAlSi_2O_6$-SiO_2 System*); R. W. Nurse (Watford, U.K.) (*Surface Energy, Adhesion, and Cohesion in Solids*); R. Pampuch (Krakow, Poland) (*Mechanism of Topotaxial Thermal Decomposition Reactions of Layer-Lattice Silicates and Hydroxides*); M. M. Ristić *et al.* (Belgrade, Yugoslavia) (*Kinetics of Silica Gel Conversion into Cristobalite*); J. Talabér (Budapest) (*Solid Phase Diffusion of CaO in Mineral Substances*); J. E. Taylor (Boreham Wood, U.K.) (*Heat of Formation of Xonotlite, Tobermorite, Hillebrandite, and Afwillite*); N. A. Toropov (Leningrad, U.S.S.R.) (*Fundamentals of the Investigation of Silicate Systems, Particularly the Crystallochemistry of Rare Earth Silicates*). Also the more specifically technological contributions offer many fascinating examples of mineralogical and petrographic methods in silicate technology; e.g. papers by Yu. M. Butt *et al.* (Moscow) on *Molten High-Magnesia Portland Cements*; T. A. Ragozina and N. A. Akhmedov (Tashkent, Uzb.S.S.R.) on the *Influence of $CaSO_4$ on Mineralization during Firing of Cement Mixtures*; M. Révay (Budapest) on *Production of Hungarian Alumina Cement*; H. E. Schwiete (Aachen, Germany) on *Influence of Moler Earth on Properties of Blast Furnace Slag Cements*; L. A. Zakharov (Erevan, Armen.S.S.R.) on *Alumino-Belite Cements*; A. I. Korelova (Leningrad) on *Effect of P_2O_5 on Nucleation and Crystallization of Lithium Silicate Glasses*; O. V. Mazurin *et al.* (Leningrad) on *Effects of Alumina on Structure and Physical Properties of Low-alkali Lithium Borosilicate Glasses*; and J. Williamson and P. S. Rogers (London) on *Nucleation and Crystallization of Glasses Containing Iron Oxides*.

Organization and format of the book are of the best possible quality; the translations into English are excellent. In every respect, the Proceedings of the present SILICONF-Budapest 1967 fulfill the high expectation indicated by previous volumes of the series.

W. Eitel
University of Toledo

HIGH PRESSURE METHODS IN SOLID STATE RESEARCH. By C. C. Bradley. Plenum Press, New York, 1969, 176 pages, \$12.00.

The author of this brief, 176 page book states, "The purpose of this book is to give the interested reader an insight into the design and limitations of high pressure, apparatus over the whole range of static pressure to 500 kb." Selected examples of different kinds of high pressure apparatus are described together with details of sample assembly, experimental difficulties, uncertainties and limitations. Reference lists up through the year 1967 are given at the end of each chapter to serve as a source for more detailed information.

An introductory chapter gives a brief summary of methods of pressure measurement and calibration. Types of materials and some basic design principles that are used to construct various types of high pressure apparatus are discussed next. Descriptive chapters are devoted to 1, hydrostatic pressure apparatus, 2, opposed anvil apparatus, 3, multianvil apparatus (tetrahedral and cubic presses), 4, piston and cylinder apparatus (including

belt presses), and 5, specialized high pressure devices for low temperature, magnetic resonance, electron spin resonance, and neutron diffraction studies. Apparatus described in this book is mainly that which has been used in the National Physical Laboratory, Teddington, England. Appendices give the compositions, properties and suppliers of the materials used for the construction of high pressure apparatus in England. While this gives the book a provincial character, this is not a serious drawback since equivalent materials are available in most countries. The author does not discuss any of the specialized nickel, titanium, molybdenum and cobalt bases alloys which are finding increasing use for high temperature and corrosive environment service in various types of equipment.

Most of the equipment discussed are of small sample capacity, such as may be fabricated in most university machine shops, and are mainly employed for solid state research at pressures above 10 kbar. Only cursory mention is made regarding large capacity cubic presses. No space is given to the various types of materials-testing equipment such as triaxial shear presses. The common cold-seal type of rod bomb used for mineral synthesis and phase equilibria studies is not discussed. Hydrothermal pressure vessels commonly used for solubility and other geochemical studies are not described. The book would be of more interest to mineralogists and geochemists if descriptions of such equipment had been included.

This book is a valuable although limited source book for general information on high pressure apparatus and techniques. A large amount of information has been assembled. The presentation is brief, clear and augmented by many diagrams and sketches. It should be of particular interest to both students and newcomers to this field of research.

<div align="right">

CHARLES W. BLOUT
University of Georgia

</div>

THEORY OF ELASTIC WAVES IN CRYSTALS. By FEDOR I. FEDOROV. (Translated by J. E. S. Bradley). Plenum Press, N. Y., 1968, 375 pp., $25.00.

The book is a well planned comprehensive treatment of elastic waves in crystals that includes the development of the direct tensor calculus used by the author and the detailed derivation of the fundamental equations. For the most part, the development and approaches are unique because of Fedorov's employment of "coordinate-free" tensor calculus. His application of general elasticity to anisotropic crystalline systems is the most thorough and extensive this reviewer has seen. The last chapter on the calculation of Debye temperatures for cubic and hexagonal crystals is a welcome addition.

The book is divided into nine chapters of 34 to 50 pages each; the chapter titles indicate the organization and content:

1. General equations of the theory of elasticity.
2. Elements of linear algebra and direct tensor calculus.
3. General laws of propagation of elastic waves in crystals.
4. Energy flux and wave surfaces.
5. General theory of elastic waves in crystals based on comparison with an isotropic medium.
6. Elastic waves in transversely isotropic media.
7. Elastic waves in crystals of the higher systems.
8. Reflection and refraction of elastic waves.
9. Elastic waves and the thermal capacity of a crystal.

The book could serve as a useful text in courses in mathematical physics or solid state physics and as an important treatment of elasticity theory for research workers in this field. The translation reads smoothly and the text seems free of typographical errors.

<div align="right">

GEORGE W. DEVORE
Florida State University

</div>