The Canadian Mineralogist
Vol. 38, pp. 1487-1492 (2000)

BOOK REVIEWS

Handbook of Mineralogy. IV. *Arsenates, Phosphates, Vanadates*. By J.W. Anthony, R.A. Bideaux, K.W. Bladh and M.C. Nichols. Mineral Data Publishing, P.O. Box 37072, Tucson, Arizona 85740, U.S.A., or mineraldata.com, 2000, ix + 680 pages, $US108 plus $6 shipping and handling, hardbound (ISBN 0–9622097–0–8).

Here is the fourth volume of a monumental five-volume series of mineral data sheets. Data are presented for 680 of the about 3750 defined mineral species. Earlier volumes have been reviewed in *The Canadian Mineralogist* (**29**, 175-176; **33**, 1155; **36**, 232). This series aims to gather in convenient form the data crucial to identification of all mineral species and to provide relatively up-to-date references containing information central to the definition of each species. The authors deliver all this and much more.

Arranged alphabetically by mineral name, each species is given a one-page treatment reporting crystal data, physical and optical properties, cell and X-ray data, chemical composition, mineral group, polymorphism and series, occurrences, association, distribution, origin of the name, type material and selected references. The authors have included information such as the size of crystals, which allows an estimate of the quality of much of the data, and many calculated chemical compositions, which illustrate how closely reported compositions approach ideal fomulae. Data calculated by the authors or included by analogy to other species are clearly indicated by square brackets. Presentation of information is consistent throughout the series of books, and the reader is immediately comfortable moving from one volume to another. As in earlier volumes, the care in data collection and preparation of entries results in a product that seems virtually free of typographic or factual errors (although one typo appears on p. 194, this serves only to illustrate the exceptional care in preparing the text).

There are drawbacks to a strictly alphabetical listing based on IMA-approved mineral names. It is disconcerting to open a book describing the phosphate minerals and not find a reference to apatite. A brief section listing mineral groups would make the Handbooks more practical. There are, however, two or three listings for many minerals with essential rare-earth elements, minor variations within the broader meaning of this work. Researchers seeking to identify a mineral from results of an analysis will want to use one of the computer databases now available, such as SEARCH, advertised on page ii.

The database for Handbook IV is complete through 1999. Although new minerals continue to be described, relatively minor updates will keep this book current throughout a scientist's working life.

This book is printed on acid-free paper, with a quality binding that lies flat when the volume is open. At US$108, it is reasonably priced, and will be an essential reference for many years.

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Understanding Granites: Integrating New and Classical Techniques. Edited by A. Castro, C. Fernández and J. L. Vigneresse. Geological Society, London, Special Publication 168, 2000, 278 Pages. £70.00 or US$117 (CDN$170), hardcover. Available from AAPG Bookstore, P.O. Box 979, Tulsa, Oklahoma 74101-0979, U.S.A. (ISBN 1-86239-058-4).

Another slim (2 cm) and expensive (CDN $170) Special Publication (No. 168!) of the Geological Society (London). It is composed of 16 chapters that individually range in length from 12 to 21 pages. Each chapter concludes with its own references; most chapters have more than 30 and two have more than 100! These are particularly rich sources of information for the researcher. A comprehensive index takes up the last six pages of the book.

The subtitle of the volume ("Integrating New and Classical Techniques") mystifies this reviewer. Certainly some techniques have become classical (the structural approach of the Cloos–Balk school, gravity modeling), whereas others are clearly new (P–T–t, AMS, isotope techniques). Many techniques fall between. Nowhere in the book are integrated comparisons of the old and new offered. This does not necessarily detract the usefulness of the volume, but the reader should be warned that title and contents diverge.

The volume opens with a brief introduction by the editors who, as well, are coauthors of three chapters. Pointing out that the chief problems to attack are the sources of granitic magmas and their mode of emplacement, the editors go on to say "Partial answers... are proposed in this Special Publication.... we believe they contribute to a better understanding of the granite problem." A brief overview of the volume's contents is then given, though not following the order of the chapters.

The five opening chapters treat general principles, whereas the last eleven apply various techniques to the study of specific plutons or areas. A.B. Thompson, in the first of the general chapters, offers an overview of crustal melting using complex thermal modeling. The combinations of heat source, depths, conductivities, rates of exhumation, time lags, *etc.* are infinite. The chief problems to resolve are the relation of granite types, forms and sizes of intrusions and depth of emplacement to the temperature of intrusion, rheology of host rocks, and the timing of intrusion in the scheme of regional metamorphism.

D.B. Dingwell next treats the viscosity of granitic melts and introduces the "'isokom" (curve of constant viscosity). Following a fine summary of pertinent studies from 1934 to the present, and the problem of the non-Arrhenian effect on viscosity, Dingwell discusses the effects of alkali/Al, SiO_2, and An on viscosity. This reviewer was surprised to learn that the addition of Be increases the viscosity of a silicate melt.

L. Améglio and J.L. Vigneresse then review the geophysical imaging of granitic intrusions, dealing with everything from direct (field) observation, to a gamut of "black box" techniques. Gravity probably is the most useful tool, though seismic methods commonly reveal the floors of intrusions, the nature of which merit further study.

A.E. Patiño Douce uses major-element compositions and phase equilibria studies to cast light on the origins of six groups of siliceous igneous rocks. He concludes that only peraluminous leucogranites are crystallized from purely crustal melts; others are hybrids, and some may have been through multiple cycles of melting. Refractive residues rarely reach the Earth's surface except as small inclusions. The presence of basaltic components in nearly all silicic igneous rocks show that granitic intrusion is part and parcel of continental growth.

In the final chapter on general principles, Teresa Román-Berdiel investigates the 3-D configuration of intruded putty in a 50 x 50 cm model box with layered materials and applying scaling parameters laid out by M. King Hubbert six decades ago. She uses different layer-combinations under three regimes: static, extensional, and strike slip. Results are related to natural examples.

In the first chapter focused on specific examples, L. Hecht and J.L. Vigneresse use the Cabeza de Araya (Spain) and Fichtelgebirge (Germany and Czech Republic) granitic plutons. Data and rock density would help the reader to interpret the authors' gravity profiles. That aside, normal and reverse zoning at Fichtelgebirge are attributed respectively to rapid and slow rates of emplacement. The authors seek to derive the intrusive histories of these plutons by combining their depths and shapes with standard petrographic and geochemical studies.

J.E. Cobbing next describes the passive emplacement of the Coastal Batholith of Peru (held to be related to the opening of the South Atlantic Ocean a continent away), its stratigraphic-structural relationships, and the younging to eastern hypabyssal intrusions. All this has been presented elsewhere in journal articles and special publications familiar to most Andinophiles.

Australians R. Trzebski, P. Lennox, and D. Palmer seek to interpret coeval S- and I-type granites in the eastern Lachlan Fold Belt in what to this reviewer is the weakest chapter of the volume. To start, petrographic characteristics of the three plutons are inadequate; the reader has no feel for what rocks (one S-type, two I-types) really look like. The extraordinarily weak gravity expression of the plutons (Fig. 3c) casts serious doubt on the authors' sweeping conclusions (that one of the I-type plutons was emplaced in a dextral transpressional pull-apart structure, whereas the other I-type and the S-type pluton were emplaced in transpressional dilatational jogs along a dextral shear-zone). The reader would have been helped by seeing the locations of the 1046 gravity observations (they could have been plotted conveniently on Fig. 3a). Worse, establishing the densities of seven formations in a survey covering 875 km^2 by the measurement of only 17 rock samples (p. 130) is hopelessly inadequate. The results of massaging and modeling are not comforting either when the basal morphology of the three plutons (Fig. 6) fails to correspond to cross sections drawn through them (Fig. 4).

A.R. Cruden, H. Sjöström, and S. Aaro discuss the Gåsborn Granite, located just 2 km east to Långban of mineralogical fame. Taking into account regional geophysics (aeromagnetics and 2.5-D gravity profiles), the nature of metamorphic aureole, and internal structures, the authors conclude that emplacement of the Gåsborn pluton was complex, with doming of the roof and sagging of the floor at a depth of ~10 km. The conduit lay in the west, and the outline of the pluton was later modified by Svecokarelian deformation and Sveconorwegian shear-zones.

C. Dietl tackles the problem of emplacement – dyking *versus* diapirism – as applied to the Joshua Flat – Beer Creek pluton, California. Taking into account the fabric and petrology of the pluton and wall rocks, the anisotrophy of the magnetic susceptibility (AMS), petrofabric analysis, and other techniques, the author concludes that the Joshua Flat Monzonite was emplaced before the Beer Creek Granodiorite, all as nested diapirs. Stoping, dyking, ductile downward flow, partial melting of wall rocks, and magma-chamber expansion operated in concert at different times during a complex emplacement history.

A. Alonzo Olazabal, M. Carracedo, and A. Aranguren studied emplacement of the peraluminous Campanario – La Haba pluton, Spain, which is composed of three cordierite-bearing phases with contrasting textures but uniform compositions. The authors used AMS and structural observations to show the importance of structural control. The pluton is synkinematic, related to Hercynian dextral faulting, which resulted in tensional fractures. Space was provided by displacement of blocks along faults in the shallow crust.

C. Fernández and A. Castro studied in detail granitic outcrops in the Spanish Central System at Puente del Congosto. Taking a rheological approach, the authors envision the intrusion of magma into magma by the opening of brittle fractures. They support this view by mathematical analysis and a series of stress diagrams. The proposed model is intermediate between dyking and diapirism.

To explain the presence of K-feldspar megacrysts in the Cathedral Peak Granodiorite, California, M.D. Higgins proposes a process of coarsening of already-formed crystals where magma is held at a high temperature (but just below the K-feldspar liquidus) for an extended period. So far, so good; this much your reviewer learned as a grad student many decades ago. However, this process is accompanied by the dissolution of smaller and irregularly shaped (matrix) crystals. The modal composition remains nearly constant regardless of how porphyritic is the rock. No metasomatism ("granitization") is required.

By means of field description and modal and chemical analyses, E.W. Sawyer, C. Dombrowski, and W.J. Collins conclude that partial melting was syntectonic and coeval with granulite-facies metamorphism during a transpressive phase of deformation (D3) in a 4 km^2 area in the Wuluma Hills, central Australia. The rocks experienced 30 to 60% partial melting that, based on SHRIMP U–Pb ages, occurred over a 27 ± 23 Ma timespan. Their observation of cordierite replacing garnet (p. 226) leads this reviewer to question if anatexis wasn't decompression melting related to pressure release, perhaps the shedding of thrust sheets during the synmetamorphic orogeny.

H. Mouri and K. Korsman describe partial melting and P–T–t evolution in migmatite belt in southern Finland. Single-stage low-P Middle Proterozoic granulite-facies partial melting is held to have produced a complex series of K-feldspar-poor leucosomes with a closing stage in the stability field of andalusite.

In the closing chapter, M. Menéndez and A. Ortega, using a variety of techniques, ascribe the Guitiriz granitoid (Portugal) to the emplacement of coeval intermediate and felsic Variscan magmas *via* a common extensional feeder. The magmas are thought to be of mantle and crustal origin, respectively. Magmatic epidote reflects rapid transport of the intermediate magmas from depth, and not the shallow site of their emplacement (~2.5 kbar). The absence of reference to R. Wiebe's work on the subject of magma mixing is surprising.

The native language of many (most?) of the authors is not English, and unfortunately it shows. Rigorous editing would have improved the smoothness of the text. Then, there are a fair number of spelling errors: symplutonic, Westerley Granite, turmaline, pinnite, and isogrades, among others. The northwest-striking Franconian line (p. 100) cannot be a "major southeast dipping fault." The outline of the Cabeza de Araya granitic massif exhibits substantial differences from one author to another (*cf.* Fig. 9, p. 90, with Fig. 1, p. 96). The southern end of the stock of Sunset Hills Granite differs from one map to another (*cf.* Fig. 2, p. 126, with Fig. 3a, p. 127). Trivalent Mn in epidote (p. 260) is given as divalent in the chemical analyses (Table 3, p. 262). The legend for Figure 1 (p. 178) is confusing, and Figure 3 (p. 115) lacks a legend altogether. The grey shading on many of the geological maps is virtually indistinguishable from one unit to another (see Fig. 5B, p. 133; Fig 1, p. 163; Fig. 2, p. 164; Fig. 1, p 193, and others). This reviewer's favorite slip is found on p. 208, where we learn that (perhaps if we hurry!), we can see "quartz-diortic magma, which is still preserved in the periphery of the suite."

Understanding Granites is fundamentally a series of journal articles that tie together but loosely. Like journal articles, the 16 contributions are of varying quality. For the patient reader, however, the volume holds a wealth of useful information. The abundant references are beacons for the researcher. The high price of the volume will doubtlessly restrict its distribution.

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The Rejection of Continental Drift Theory and Methods in American Earth Science. By Naomi Oreskes. Oxford University Press, New York and Oxford, ix + 420 pp. $96 CDN hardbound (ISBN 0–19–511732–8); $30.68 CDN paperback (ISBN 0–19–511733–6).

When I was a student at the University of Sheffield in the 1950s, Alfred Wegener's theory of Continental Drift did gain occasional mention by professors, both in the Department of Geology and the Department of Geography. Though the latter, under David L. Linton, was very much concerned with physical geography, the theory was not taken seriously in either Department. Rather, it was derided, and the doctrine of the permanence of continents and ocean basins proclaimed almost as dogma. Philip Lake's two critical essays of 1922 and 1926 had proved extremely influential; his judgement that Wegener had suggested much, but proved nothing, was still being quoted. Perhaps, as Oreskes states (p. 125), British geologists in the 1920s had been "cautiously receptive" to Wegener's bold concepts. By the 1950s, however, and despite the advocacy of the Continental Drift concept by one of Britain's most respected geologists, Arthur Holmes, the concept was generally regarded as a scientific chimaera.

Reasons for this, and good reasons, it seemed, advanced for Wegener's "evidences" had indeed, at times, been ill chosen. To explain the distribution of the primitive living arthropod *Peripatus*, one did not need to evoke drift; it had formerly been more widespread and survived still in all the regions where conditions were favorable. The distribution of the Permian riverine reptile *Mesosaurus* was not evidence; its remains were simply being found in the few regions where there were Permian riverine deposits. The biological and paleontological arguments for continental drift were simply not good enough. As for the fit between the continents, why, as Bailey Willis had argued (p. 305), it was *too* good; however, could the original fracture lines be retained after 120 million years of faulting and erosion? No, the idea was considered "excessively general and excessively theory-driven" (p. 135), and therefore unacceptable. Instead, a combination of the geosynclinal theory, combined with isostasy, gave an entirely satisfactory explanation for the phenomena to be seen in the field. Of course, the field geologist was the *real* geologist!

Yet, at least, Wegener's theory was still receiving attention. Other theories had come and gone. George Darwin's fissiparturition theory of the origin of the Moon (p. 28) had not stood up to scrutiny, and Frank Bursley Taylor's belief in the Moon's capture by the Earth (p. 81) had come to be viewed with disdain. Though Eduard Suess's recognition of the processes of nappe formation remained important, his contraction theory had suffered its death-knell (p. 26, 48). William Bowie's belief that the Earth was in a state of equilibrium had been shown to be untenable (p. 169, 178, 185). As for the concepts of isthmian links to explain past and present distributions of terrestrial faunas and floras, they were already being contradicted by observations of submarine geology (p. 218). It might be said that a revision in thinking was not just due, but overdue.

Within a decade, a truly major change in thinking did indeed take place, in particular as a consequence of the discoveries made by geophysicists. In the latter regard, Oreskes summarizes the change admirably (p. 311): "... although geologists were right more often than they were wrong in their disputes with geophysicists in the nineteenth century, by the middle of the twentieth century there was no disputing which discipline held the position of greater prestige." (This situation, alas, still holds good and explains why the geophysicists' recent idea that an extraterrestrial impact at the end of the Cretaceous caused a worldwide holocaust of extinctions is still bruited abroad, despite the profuse paleontological evidence to the contrary).

Some components of Wegener's theory had not stood up to scrutiny. His belief in a continuous, thin continental crust (p. 55) and his belief that the present continents are permanent structures, albeit mobile (p. 56), were no longer tenable. However, as Oreskes demonstrates in her excellent historical account, by the 1950s there was already a formidable volume of evidence favoring the drift concept. It was coming to be recognized that ocean basins were not permanent, and that isostasy and geosynclinal theory were inadequate to explain the evolution, through time, of crustal structures.

Previous accounts of the revision of concepts that took place in the 1960s have called it a "revolution in science" and have seriously undervalued the progressive changes in thinking that had been already taking place. Oreskes's comments on one of these (p. 127) merit full quotation: "An extreme example comes from the pen of geophysicist Robert Muir Wood [The Dark Side of the Earth, 1985]...Wood painted the history of geology as a Manichaean morality tale in which the progress of the interpretive earth sciences was opposed by reactionary geologists seeking to preserve the 'purposelessness of summer field work'. With the advent of plate tectonics, Wood wrote, the old approaches were swept away by 'hard' science; traditional geology, 'framed according to the poetic and irrational measure of man', was gone forever. Wood's treatment suggests interesting questions about the dynamic nature of scientific standards, but any possible answers are themselves swept away by his overt (yet unexplained) hostility to the subjects of his story: his aversion to early-twentieth-century geology is so great that he equates opposition to Continental Drift with Nazi philosophy and Soviet communism, simultaneously! Perhaps the very fact that early-twentieth-century geologists rejected

Continental Drift is sufficient to discredit them, but this begs the question of why they rejected it. As well, it ignores that geophysicists, whom Wood admires, were equally if not more opposed to drift than were field geologists. Wood's emotional diatribe points to a general problem: the persistence of a historical cliché that American scientists in the nineteenth and early twentieth centuries were narrow utilitarians or naive empiricists focused on the collection of usable and classifiable facts."

The change of thinking during the 1960s was indeed dramatic but, as Oreskes demonstrates, the new edifice was erected upon strong foundations of earlier geological observation and thinking. Some of the materials for this new philosophical structure had been available for two decades but, because of the Second World War, had been little utilized. As early as 1928, Felix Vening Meinesz had demonstrated that major stresses were present in the suboceanic crust (p. 236, 238-239). It had also been discovered that positive gravity anomalies might have no topographic expression, whereas there were negative anomalies over oceanic deeps (p. 241), observations that aided in Harry Hess's development of the concept of tectogenesis (p. 245, 248). However, the framework for the new conceptual construct was furnished by new data; the evidences of paleomagnetism derived from the work of Blackett, Runcorn and others (p. 263-267), Tuzo Wilson's recognition of hot spots and transform faults (p. 272), the fact that oceanic observations furnished no evidence to support the idea of isthmian links, and the unexpected discovery that pre-Mesozoic sediments were not to be found on ocean floors.

All in all, as Oreskes demonstrates (p. 273, 275), the evidences for what was now being styled plate tectonics were quite different from those used by Wegener to bolster his theory of continental drift. Yet, as she stresses (p. 275), "...*plate tectonics validated Wegener's evidence*. Geologists in the 1970s used stratigraphical and paleontological evidence to reconstruct earth history in just the manner Wegener proposed, and the jigsaw puzzle fit of the continents was attributed to rifting and drifting. In the context of plate tectonics, Wegener's evidence is seen as substantially correct. More importantly, it was seen that way at the time. The evidence that Wegener used was borrowed from the lifetime work of prominent stratigraphers, paleontologists, and field geologists. In the nineteenth century, field-based pattern recognition had produced the geological time-scale, the stratigraphy of the British Isles, and the unraveling of the structure of the Swiss Alps. In the early twentieth century, it led first to the idea of Gondwana, then to Barrell's theory of fragmentation, and then to continental drift. Wegener's evidence came from the mainstream of geology, and leading geologists sought explanations for it. Few disputed that there had been some kind of intercontinental connections; the issue was always how these connections were forged. Wegener's data were not poor data. On the contrary, they were rich."

In fact, the concept of plate tectonics had been built up in a fashion quite comparable to the building-up of the geological record, with non-sequences (when the theories of Earth development were receiving little consideration) and intervals of erosion (when older theories were being jettisoned), together with periods of rapid accumulation (in this instance, of fresh data and ideas).

The new generation of geophysicists of the 1960s was sadly reluctant to acknowledge earlier work; for example, Harry Hess's pace-setting article of 1960 did not give proper credit to Arthur Holmes, who had formulated the concept of convection currents in the mantle as being the driving force for continental drift as early as 1928 (p. 116-118, 268). In contrast, this very balanced study by Oreskes gives a much fairer and fuller picture of the evolution of thinking about the motion of the Earth's component masses than any work written hitherto. It should become a required text in all courses of dynamic geology and the history of science. Its essence is admirably summed up in a sentence close to its conclusion (p. 316): "The unmaking of scientific knowledge does not happen quickly. It is not – *contra* the widely held views of Thomas Kuhn – a *gestalt* shift. At least in the case of continental drift, an edifice of scientific knowledge was not smashed and rebuilt, but rather an interwoven fabric of methods and belief was gradually unwoven and restitched. As Kuhn himself showed in his own early work, the unmaking of Ptolemaic astronomy took one hundred fifty years. By that standard, geologists moved fast!"

Yet a statement at its beginning deserves to be borne in mind by all historians of science (p. 3): "History is littered with the discarded beliefs of yesteryear, and the present is populated by epistemic resurrections. This realization leads to the central problem of the history and philosophy of science: how are we to evaluate contemporary science's claims to truth given the perishability of past scientific knowledge? The question is of considerable philosophic interest and of practical import as well. If the truths of today are falsehoods of tomorrow, what does this say about the nature of scientific truth?"

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Geometric Floor Tile Design – Do-It-Yourself Custom Patterned Flooring. By David K. Teertstra c/o Euclid Geometrics, 230 Lisgar Street, Ottawa, Ontario K2P 0C8. Really hard-bound, CDN$ 42.95 (ISBN 0-9686314-0-1).

This is the ultimate hard-cover book in the truest sense of the word: a total of 95 pages solidly bound between two A4-sized vinyl floor tiles. You even get hints how to the handle the book. For example, the author warns that in very cold climates, the book's cover will become brittle and liable to disintegrate if dropped. This remarkable book is aimed at two groups of people: firstly (and probably unintentionally) at bibliophiles or book maniacs. Where else would you still get a hand-made book bound with hand-printed linen bands for the price of $42.95? It is wonderful that in our world of mass production, someone takes the time and trouble to hand-craft a book and then makes a point of thanking you for buying the book! And what a book it is: well laid-out, neatly printed on strong paper (you can use it on the kitchen floor) or, in short, beautiful to hold. The second target group consists of home owners who always wanted to do something about their drab-looking floors and but had no idea how to go about it. Relax, relief is near in the form of this, as the author claims, definitive first book on floor tile design and a source book for geometric design.

To start off, there is general introduction about production and use of the book. In the author's c.v. which follows, we find a rather passionate description of how he ended up with floor designing after having received his Ph.D. at the University of Manitoba in Winnipeg in 1997 for a thesis entitled *Reactions of (K,Rb)-Feldspars from Rare-Element Granitic Pegmatites*. Then follows a clear introduction to crystallographic patterns, symmetry classes, mirror axes, *etc.*, as one would expect from a mineralogist. This lands us among more than 50 different tiling patterns, each with the author's preferred color scheme on the right-hand side of the book, and the corresponding uncolored version to the left. Clearly, this is an invitation to experiment.

As far as technicalities are concerned, the author says that all you need is a tile cutter and everything else will be easy. Caution is called for, however, as the patterns may contain shapes with angles less than 45°. These would be rather difficult to cut from real ceramic tiles using a plain old-fashioned manual tile cutter with a diamond- or hard-metal-studded wheel that makes scratches on the tile, which you then break into two. A diamond saw would definitely do a better job with those thicker tiles. For vinyl tiles, cutting such angles should be easier. I shall not comment on the various patterns, as these are for the reader to discover. Suffice to say that quite a few of the variations are rather intriguing.

After the section with the patterns, there are some interesting notes on subjects like playing with patterns, geometric ideas, types of patterns, the concept of design energy and style of home. There also useful hints on design selection and shopping for tiles. These chapters unfortunately are arranged somewhat haphazardly, and, except for those on the practical aspects of placing the tiles, should have been arranged before the patterns themselves. The hints for further reading and the index at the end are quite useful.

To sum up, I must say that even for a rug collector like myself, with no use for patterned floors, this book makes interesting reading. As a book made by hand by a passionate author, it is well worth having. The art of book manufacture in the true sense evidently is not dead after all.

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