American Mineralogist, Volume 86, pages 202–203, 2001

BOOK REVIEW

CRYSTAL HABITS OF MINERALS. By Ivan Kostov and Ruslan I. Kostov. Bulgarian Academic Monographs (1), Prof. Marin Drinov Academic Publishing House and Pensoft, Sofia. 1999, 415 p. Hardback $65.00.

Modern crystallography has its roots in curiosity, with attempts to answer the question of why one crystal species can take on a variety of external forms. In 1611, J. Kepler, fascinated by the elaborately varied dendritic forms of snowflakes, considered all snow crystals to be formed of close-packed equidimensional spheres even though the variety of forms ranged into the thousands. His observations marked the start of observational crystallography. In 1669, N. Steno formulated the law of constancy of interfacial angles, based on measurements from various prismatic forms of quartz that he had collected from mineral-filled alpine fissures. In his treatise, he explained the origin of varied polyhedral forms in quartz as a product of growth-rate anisotropy in different crystallographic directions. His concept of growth-rate anisotropy is the basis for modern studies of crystal forms.

It is interesting to note that both structural crystallography and the science of crystal growth emerged from curiosity about the large variety in crystal forms. For mineralogists, this curiosity survives in attempts to derive meaning from crystal habit (*habitus* or *tracht* in the German literature on this topic). Mineralogists have long been interested in the level of information that variation in habit may convey relating to growth and/or post-growth histories and conditions of mineral formation. The nine volumes of "Atlas der Kristalformen" published by Goldschmitt between 1923 and 1931 are a classical example of the interest in this topic shown by mineralogists, even though this compendium was strictly descriptive.

The publication of "Crystal Habits of Minerals" by Ivan Kostov and Ruslan Kostov provides a new look at the importance of crystal form. This is a topic of great interest to the author of this review, because I have a theoretical and experimental research interest in the origins of varied crystal forms (Sunagawa 1989, 1995). Some background on key concepts in interpretation of mineral habits is provided next as a background to the review.

Factors in the generation of varied crystal forms are complex, including both internal (structural) and external (environmental) controls over the crystal growth process. The role of internal factors can be theoretically represented in terms of equilibrium form (Gibbs, Curie, and Wulff) and of structural form (Bravais, Friedel, Donnay and Harker, and Hartman and Perdok; see references in Sunagawa 1989). Theoretically deduced equilibrium form and structural form (both are singular) may be used as criteria to analyze observed growth forms (plural), which vary depending on growth parameters. The growth parameters affect crystal morphology in a complex and complicated manner. Deciphering growth conditions from habit is therefore a difficult undertaking. However, even if the origin of a specific crystal form can not be uniquely determined mineralogists can still use observation to correlate particular forms with geologic conditions of formation. Such observations can have practical as well as academic applications. For example, systematic correlation of habit in a particular mineral with a specific type of mineralization can be used as a prospecting tool. Such investigations have been used extensively in former Socialist countries, where this approach to applied interpretations of mineral habit is known as typomorphism. As a representative case study, observations on the variation in habit of pyrite crystals in and around an ore deposit show that there is a greater frequency of cubic habit in the mother rocks than in the ore deposit. These typomorphic investigations are not well known in the Western world, despite the vast literature accumulated under this field in the former Socialist countries. The reviewer remembers well the surprise of foreign participants at the International Mineralogical Association meeting in Novosibirsk (in 1978) when they encountered many presentations on typomorphism by mineralogists from former Socialist countries.

The new book by Kostov and Kostov is an important contribution to our community as both an introduction to a research area foreign to many and as a summary of data on applied typomorphism. The book begins with a well-documented historical background (Chapter 2) that reviews curiosity about crystal forms dating back to Greek texts. Chapters 3 to 5 provide a background on mineral morphology, extending to twinned crystals, epitaxy, malformed crystals, crystal aggregates, and quasicrystals. The explanation of mineral growth is rather elementary, but provides a good introduction for beginners. The core of the text is Chapter 6, which provides a thorough and systematic summary of typomorphic investigations of important minerals, covering more than 150 minerals representing all mineral classes. Most importantly, these observations are related to geological occurrences. Many of the observations summarized are those of geologists and mineralogists from former Soviet countries and are not well known in other countries. In systematizing typomorphic observations, the authors have used a simple approach. They have classified crystal habits into four broad categories: axial, planar, pseudoisometric, and isometric. This fourfold classification

scheme is based on axial ratios of unit cells and is used to define the standard habits of respective minerals; deviations from the standard habit are then analyzed in relation to growth conditions. Viewed from the perspective of current research into the atomistic mechanisms of crystal growth, this classification may sound rather primitive, yet the present reviewer feels it as a useful approach in dealing with phenomena occurring in complex systems like natural crystallization.

Chapter 7 concludes with a brief discussion of applied crystal morphology, illustrating applications of crystal habit in geoscience and in industry. The text includes an extensive bibliography listing about 1000 publications with full titles, and an index of mineral species. Many of the works listed in the bibliography are Slavic-language publications that will be important to Western researchers who are interested in this field; these include publications that are poorly cross-referenced in many of the electronic databases and search engines that are used routinely by Western scientists. The bibliography alone is therefore a valuable tool.

In conclusion, I welcome the publication of this book and recommend it to those who are fascinated by the variability in crystal morphology. The studies of typomorphology summarized by Kostov and Kostov represent a significant effort by many scientists in a particular methodology of decoding letters sent from the depths of the Earth. For Western scientists, attuned to reading another literature, this book is both a literal and philosophical translation.

ICHIRO SUNAGAWA
Professor Emeritus, Tohoku University and
Yamanashi Institute of Gemology and Jewelry Arts
Kashiwa-cho 3-54-2
Tachikawa
Tokyo, 190-0004
Japan

REFERENCES CITED

Sunagawa, I. (Ed.) (1989) Morphology of Crystals, Parts A and B. Terra Science Publishers, Tokyo, and Reidel, Dordrecht.
Sunagawa, I. (Ed.) (1995) Morphology of Crystals, Part C. Terra Science Publishers, Tokyo, and Reidel, Dordrecht.