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MINERAL-SCALE PROCESSES IN METAMORPHIC PETROLOGY: THE KRETZ VOLUME

PREFACE

When we first proposed to the Council of the Mineralogical Association of Canada (MAC) in 1994 to sponsor a Special Session to recognize the lifetime contributions of Ralph Kretz, the concept was accepted with unanimity and enthusiasm. It was decided that the 1997 Ottawa GAC-MAC annual meeting would be a particularly suitable venue for the occasion, both because Ralph is a longtime professor at the University of Ottawa, and 1997 was the year of his official retirement.

RALPH KRETZ is an unsung hero of metamorphic petrology in Canada, and it is very fitting that we pay tribute to his almost 40 years of original contributions to our subject. Through his teaching and published research, he has changed the way we approach the subject, and we recall here some of the areas in which he made major contributions.

MINERAL THERMODYNAMICS

Ralph has always been fascinated with the concept of equilibrium among coexisting minerals, and it is clear from his publications that he has thought very deeply about the subject. For his Ph.D. thesis under Hans Ramberg in Chicago in the 1950s, in the absence of an accessible microprobe technique, Ralph painstakingly separated metamorphic minerals from rocks, and analyzed the separates for major and trace elements to test whether there was equilibrium partitioning among the coexisting phases. His use of Nernst distribution diagrams to show that equilibrium was widely achieved, in his classic 1959 paper, was one of the touchstones of the time. It prompted the realization that equilibrium thermodynamics could be applied profitably to metamorphic rocks. He then proceeded to develop lucidly the fundamental theory of mineral thermodynamics that

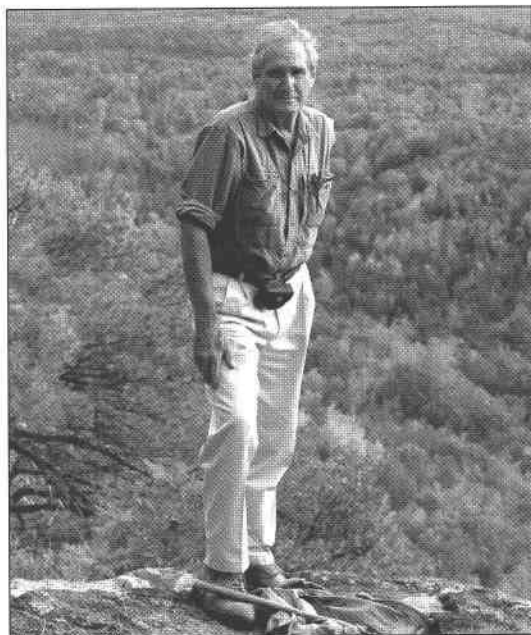


Photo: André Lalonde

RALPH KRETZ
in his Otter Lake field area, autumn, 1998.

we all take for granted these days. It is easy to forget that metamorphic petrology was taught as an essentially qualitative subject in most universities until the 1970s. Ralph was among the vanguard who put the subject on its rigorous quantitative, thermodynamic footing. This approach is so central to all modern treatment that it now reaches down to introductory courses.

Some of Ralph's contributions are so engrained in the collective subconscious that many users are unaware that these originated with him. For instance, in 1959, he pointed out that the equilibrium $3 \text{ Anorthite} = \text{Grossular} + 2 \text{ Kyanite} + \text{Quartz}$, which we now casually refer to by the acronym GASP, would be a useful barometer in Plagioclase – Garnet – Al-Silicate – Quartz assemblages. This was long before the concept of mineral thermobarometry had permeated into the consciousness of most petrologists and about 17 years before the first tentative steps to calculate the P-T location of the equilibrium were made.

MICROSTRUCTURES

Description of the microstructure of metamorphic rocks was largely a qualitative matter until Ralph turned his mind on the subject in the 1960s. After defining the four parameters necessary for the quantitative description of microstructures, that is the size, shape, spatial distribution and orientation of constituent crystals, Ralph proceeded to write seminal papers on the size, shape and spatial distribution of crystals in metamorphic rocks that remain benchmarks to this day. These papers are distinguished by their objectivity, novel methods of measurements, and statistical rigor, hallmarks of Ralph's approach to science. His thermodynamic treatment of grain shape and grain-boundary recrystallization are especially memorable and were way ahead of their time.

CHEMICAL KINETICS

Following on from his studies of microstructures, Ralph used crystal-size distributions to study the kinetics of nucleation and growth in metamorphic rocks. This was another first and another benchmark that stands to this day. He has also written on rates of reaction, volume diffusion and intergranular diffusion in metamorphic rocks, all of which were treated from a rigorous quantitative standpoint and in each case shed considerable light on these fundamental geological processes. In this area, as in his approach to microstructures, Ralph introduced the geological community to the literature in metallurgy and ceramics.

ATOMISTIC APPROACH TO MINERAL REACTIONS

Throughout his career, Ralph has thought about metamorphic processes on a range of scales, from the macroscopic scale of the phases that we observe with the eye and microscope, through the subcrystalline scale of order-disorder phenomena and crystal defects, to the atomic scale of basic reactions. A characteristic of his approach has been to try to reconcile the macroscopic properties and observations with the inferred atomic-scale processes. This is something few others have done to date, but we anticipate that here is another area where Ralph has shown us the way forward. It will be attempted more widely in the future. It is an essential approach if we are to improve our understanding of the way rocks and minerals actually work.

THE KRETZ APPROACH

Not one to be confined to an office during the summer, Ralph drew much of the inspiration for his theoretical studies from field observations, particularly from an area of high-grade rocks in the Grenville Province in western Quebec. Ralph has meticulously mapped this area, and all the major lithologies, including garnet–pyroxene amphibolite, biotite – K-feldspar gneiss, marble, gabbro and pegmatite, have served as natural laboratories for Ralph's creative studies over the last 40 years.

Ralph has always been an original thinker par excellence, as will be apparent to those who have read his papers in context. The subjects that he has thought worth examining have commonly not been those that were hot topics in the community at large, but time and again he has made their relevance and importance clear and shown that we ignore them at our peril. This is perhaps particularly true of his work on metamorphic microstructures and kinetics, and we predict that it may well be true of his work on the atomistic basis of metamorphic reactions in the future. Ralph has truly shown us the way forward throughout his career.

As a succession of graduate students at the University of Ottawa has discovered, Ralph was an ideal supervisor for those with initiative and an enquiring mind. He never babied his students, but was always available for discussion if there was a geological problem that needed his attention. His habit of thinking about a problem for several minutes in complete silence, a hallmark of his intense concentration, is well known to generations of graduate students. Ralph gave his students the freedom to get on with their research without interference, but he let it be

known, in his quiet but firm way, that he expected high-quality results when the time came to submit the thesis.

Despite the fundamental nature of his contributions over such a wide area of metamorphic petrology, and a well-deserved international reputation for his published research and his recent textbook, Ralph is not particularly well known personally in the petrological community. He has not been a leader if one measures by the conventional yardsticks to which we have become accustomed in academic circles, such as the number of graduate students supervised or the size of the research grant. He does not habitually attend scientific meetings, and he has not been the recipient of awards from the petrological community in recognition of his research contributions. We hope that he will not be offended if we characterize him as a rather shy and humble person with a deeper commitment to his science than to his success in the system.

It is our hope that the symposium and the resulting thematic issue before you, in some small measure, make up for the absence of official recognition in the past and conveyed the community's appreciation for the body of his scientific publications that changed the way we do our science. Participants took the opportunity to show appreciation to Ralph Kretz for his seminal contributions to metamorphic petrology for almost 40 years.

The Special Session, entitled *Mineral-Scale Processes in Metamorphic Petrology – A Special Session to Recognize the Lifetime Contributions of Ralph Kretz*, convened by Toby Rivers, David Lentz and David Pattison, was well subscribed, with over thirty oral and poster contributions, resulting in a much stronger session in metamorphic petrology than in most GAC–MAC annual meetings. This volume contains a selection of papers that were presented at the Special Session, as well as one or two that were submitted to *The Canadian Mineralogist* at a later date. The contributions span an eclectic mix of approaches and subject matter in metamorphic petrology, which in itself seems an appropriate way to recognize someone who has worked in so many different areas of the subject. Several of the contributions are inspired by work published by Ralph in the past. We have sorted the papers under the following headings: mineralogy and mineral physics, phase equilibria and the physical conditions of metamorphism, kinetics, trace and *REE* geochemistry, and microstructures. We trust that the volume will serve as a fitting tribute to the one of Canada's pre-eminent metamorphic petrologists.

In conclusion, we acknowledge the contributions of all the referees who provided useful, objective and, for the most part, prompt reviews of the manuscripts. The volume is much improved as a result of their collective wisdom and input. And, of course, no paper that is published in *The Canadian Mineralogist* escapes the incisive editorial eye of Bob Martin, whose insistence on clarity, consistency and scientific integrity shows through in each issue.

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