The Canadian Mineralogist
Vol. 44, pp. 981-984 (2006)

BOOK REVIEW

Khibiny. By V.N. Yakovenchuk, G.Yu. Ivanyuk, Ya.A. Pakhomovsky and Yu.P. Men'shikov. Edited by F. Wall. Laplandia Minerals, Apatity, Russia. 2005. 472 pages, hardcover (with dust jacket). ISBN 5–900395–48–0. CDN$220 plus shipping in Canada. Available from the Ed Leith Cretaceous Menagerie, Department of Geological Sciences, University of Manitoba, Winnipeg, Manitoba R3T 2N2 (contact: Sharon Kirsch, se_kirsch@umanitoba.ca). US$179 plus $15 shipping and handling in the United States. Also available from Excalibur Mineral Corp., 1000 North Division Street, Peekskill, N.Y. 10566, U.S.A. (e-mail: info@excaliburmineral.com).

Khibiny is a magnificent book on the minerals of the Khibiny alkaline massif in Russia's Kola Peninsula. With an area of 1327 km^2, the Khibiny massif is the world's largest alkaline complex. For many, the word Khibiny (also spelled Khibina) conjures up agpaitic pegmatites and their rare and exotic minerals, often as remarkable specimens. The massif is one of the world's most prolific mineral provinces, with a species list of about 480 (the exact number is a matter of debate among Russian mineralogists). Within its boundaries are the type or cotype localities for 93 species, several described since *Khibiny* was published. *Khibiny* is the latest addition to the growing number of books published in English that focus on the mineralogy of the Khibiny massif and its neighbor, the Lovozero alkaline massif. These include *Mineralogy of Hyperagpaitic Alkaline Rocks* (*Can. Mineral.* **33**, 1340), *Lovozero: History, Pegmatites, Minerals* (*Can. Mineral.* **39**, 927), and *Kukisvumchorr Deposit: Mineralogy of Alkaline Pegmatites and Hydrothermalites* (*Can. Mineral.* **42**, 1261).

Khibiny was published in association with the Mineralogical Society of Great Britain and Ireland, the Apatit Joint-Stock Company, operator of the apatite mining complex in the Khibiny, and Finlandia Minerals Ltd., the publisher. The authors are all researchers at the Geological Institute of the Kola Science Centre of the Russian Academy of Sciences. Three of them (Ivanyuk, Yukovenchuk and Pakhomovsky) are also the authors of *Kovdor*, a book on the geology and mineralogy of the Kovdor intrusive complex in the Kola Peninsula, which was recently reviewed in these pages (*Can. Mineral.* **43**, 1799).

The book has four chapters: Introduction, Summary of the Geology, Minerals, and Concluding Statement. At the outset, it should be mentioned that with the exception of SEM images and a few historical photographs, all the illustrations in the book are in color. The Introduction is a succinct (7 p.) description of the geography of the Khibiny massif, its geological exploration and evolving geological interpretation beginning in 1834, and the development of a knowledge base on its mineralogy. The chapter is illustrated with a topographic map of the massif, reproductions of four historical maps, a photograph of Mount Mannepakhk, the site of A.E. Fersman's first expedition, and photographs of several key players in the exploration of the massif, including in addition to Fersman, W. Ramsay and V. Hackman (both of whom were honored with mineral names that are no longer valid). The Introduction concludes with a page of what would normally be a separate preface and acknowledgements. Buried in this is some important information pertinent to the mineralogical data in the third chapter, Minerals, which would have been better placed in that chapter.

The second chapter (70 p.) covers more than its title, Summary of the Geology, would imply. It begins with a very brief overview of the geology of the Khibiny massif, consisting of a half page of text and two "simplified" geological maps, one of the Kola Peninsula and one of the Khibiny massif. This is followed by the first of three sections, Description of Rocks, in which the petrology of the rocks is described in considerable detail under the headings Main Stage Intrusive Rocks, Fenites and Hornfels, Pegmatite and Hydrothermal Veins, Rocks of the Dyke Complex and Carbonatites. For readers who might like to know what rocks such as foyaite, rischorrite or melteigite actually look like, the authors provide color photographs of polished hand specimens (14 in all, shown at near actual size), and photomicrographs of thin sections in plane-polarized light. There are also several photographs of rock outcrops. The dominant rock-type in the concentrically zoned, roughly circular massif is foyaite. An inset of composition profiles shows how the content of 17 oxides and fluorine in the foyaite varies from the outer edge of the massif to its center. The apatite–nepheline rocks in the Khibiny massif and their industrial exploitation are the *raison d'être* for all the attention that the massif has received. The total reserves of apatite

in the Khibiny massif are estimated to be 3 billion tonnes! A table of the mineral composition of several textural varieties of apatite–nepheline rock reveals that it contains up to an average of 75 vol.% fluorapatite. The next section, Apatite–Nepheline Deposits (9 p.), touches on the history of the discovery and exploitation of the deposits, and describes the geology of the largest bodies that have been mined, Kukisvumchorr (Kirov mine), Yuksporr, Apatite Circus, Rasvumchorr, Koashva and Niorkpakhk, with the aid of geological sections and a block diagram. Four panoramic photographs spanning double pages give a vivid sense of the massive scale of the mining operations. The core of the second chapter is a 47-page section titled Description of Mineral Localities in which the authors describe what they consider to be "the most interesting mineral occurrences" in the Khibiny. These clearly represent a broad sampling of mineralization throughout the massif. Totaling seventy in number, the occurrences consist of "veins", "veinlets" and some large xenoliths of hornfels. Most of the veins are what others would call pegmatites, and it is odd that the authors seem to avoid the term. The shape of some of the "veins" also hardly conforms to the common image of a vein. Each of the occurrences is numbered, and its location is shown on the geological map of the Khibiny massif in the first chapter (p. 11) or on a plan of the Kirov mine (p. 57). Many of the occurrences are also located by number on panoramic photographs of geographic features like Mount Eveslogchorr, Marchenko Peak and the Hackman Stream valley. As well as showing the reader places that otherwise are just names in a book, or on a mineral label, the photographs convey the rugged beauty of the massif. The descriptions of the occurrences are from a quarter page to a full page in length and cover the type of host rock, the shape and dimensions of the vein or xenolith, its internal structure and its mineralogy. Most of the veins are zoned, and each zone is described in detail. The mineralogical information includes the morphology, color, and size of the principal minerals, and their location within the assemblage relative to other minerals. These descriptions of the mineral occurrences invite comparisons with those of other alkaline complexes and their paragenesis.

The third chapter, Minerals, at 355 pages, makes up the bulk of the book. In it, the authors describe 431 mineral species (this reviewer's count is at odds with the authors' stated 436) that have been identified from the Khibiny massif. Included in this number are some strictly rock-forming or accessory minerals. The minerals are described under the following chemical classification, in the order: native elements (5 species), sulfides and sulfosalts (25), halides (5), oxides and hydroxides (61), silicates (246), phosphates, arsenates and vanadates (29), molybdates (1), sulfates (9), carbonates (49) and oxalates (1). Within each classification, the minerals are presented alphabetically by species or by mineral group and species. The inclusion of group names defeats the convenience of an alphabetical listing for readers who are unfamiliar with which species fall within which group (fortunately a species index is provided on p. 461-464). Those familiar with mineral groups will also need to refer to the index, as the authors have introduced their own, unconventional group names. The hematite and ilmenite groups are combined as a "corundum group." The "hollandite group" is separated from the accepted cryptomelane group, the "loparite group" from the perovskite group, the "imandrite group" from the lovozerite group, the "stronalsite group" from the feldspar group, and the "remondite group" from the burbankite group. The kaolinite-serpentine group is divided into "kaolinite" and "serpentine" groups. Inexplicably, some mineral polymorphs have been grouped together: gibbsite and nordstrandite in a "gibbsite group", andalusite and sillimanite in an "andalusite group", epididymite and eudidymite in an "epididymite group", and natisite and paranatisite in a "natisite group." Other questionable groupings are the "dawsonite", "gaylussite" and "natron" groups. The smectite group is renamed the "montmorillonite group." A non-zeolite, lithosite, appears in the zeolite group. The names of minerals for which the type locality is in the Khibiny are distinguished by a blue font. The type locality for two of the species so designated is in fact not in the Khibiny: götzenite and manganokukisvumite. One of the described minerals, "hydrosodalite", is not a valid species. Two of the mineral names, "eudialyte-Fe" and "eudialyte-Mn", are not IMA- approved and are not in accordance with the IMA accepted nomenclature for eudialyte-group minerals. Several mineral names are misspelled: "calcioancylite-(Ce)" for calcio-ancylite-(Ce), "fluorrichterite" for fluororichterite, "magnesiumastrophyllite" for magnesium astrophyllite, "potassic-fluorrichterite" for potassic-fluororichterite, and "potassic magnesio-arfvedsonite" for potassic-magnesio-arfvedsonite.

The mineral descriptions are comprehensive. They include the chemical formula (some at variance with other sources), crystal system, space group, unit-cell dimensions, occurrence and morphology, physical properties, optical properties, chemical analyses, any observed alteration or replacement, and the strongest six lines in the X-ray powder-diffraction (XRD) pattern. Most of the XRD data are accompanied by a sample provenance or a reference and an ICDD (International Centre for Diffraction Data) powder-pattern number. A note of caution here is that the ICDD number is not necessarily for the given pattern, *e.g.*, the ICDD number for hilairite is for a sample from Mont Saint-Hilaire, not Mount Kukisvumchorr. References are provided for data drawn from the literature. Otherwise, as stated on p.8 in the Introduction, "all data on the composition and description of the minerals are original and previously unpublished." From two to 10 chemical compositions,

including the ideal composition, are given for each mineral. According to the authors, there is a total of 1062 analytical datasets, of which 772 are original. The datasets are identified only as "microprobe" or as "wet", but information on the method of analysis can be found on p.8 in the Introduction. A provenance is indicated for each analyzed sample. For twelve rock-forming or accessory minerals, there are insets with compositional profiles showing how the proportions of selected components in the minerals change in the rocks across the Khibiny massif from its margin to its center (the traverse is located on a simplified geological map included in the insets). It would have been better to present this information of petrological significance in a unified way in the second chapter, Description of Rocks, which already contains similar data. The occurrence and morphology of the minerals are described together. The occurrences include the numbered localities in the second chapter as well as many others. For each, there is a succinct statement of the geological setting, the appearance of the mineral (morphology, crystal forms, color, size), and the principal associated minerals. Added for type minerals is information on who first described the mineral, where it was discovered, and the origin of its name. Most of the minerals are illustrated by color photographs or SEM photomicrographs. Some of the rock-forming and accessory minerals are shown in photomicrographs of thin sections of rocks in plane-polarized light, or in back-scattered-electron images of polished sections of the rocks. Crystal drawings have been kept to a minimum, with only 13 minerals so depicted. For a bit of variety, there are several photographs of localities enshrined in mineral names. Intriguing is the inclusion of a black-and-white photograph of a building named "Tietta" in the Saami language. It turns out that this was the first scientific station of the Academy of Sciences of the USSR, which is commemorated in the mineral name *tiettaite*. This must be one of the few if not the only mineral to be named after a building. The mineral descriptions are followed by a list of 35 "inadequately characterized" or doubtful minerals. About a third of these have been reported by reliable researchers but simply lack full supporting data. Among these is an IMA-approved species, clinobarylite, which the authors claim to have discredited on structural grounds.

For most people, the minerals of the Khibiny massif are associated with the pegmatites and in hydrothermally altered assemblages. This notion is reinforced by the books cited in the first paragraph of this review. The mineral descriptions in *Khibiny* reveal that the hornfelses in the Khibiny massif have yielded their own suite of exotic minerals. Forty-seven species are associated exclusively with the hornfelses. Also noteworthy is an intrusion of carbonatite, the so-called Carbonatite Stock, which contains an interesting assemblage of minerals, including many rare-earth-element carbonates. Some of the species hosted by the pegmatites and in hydrothermally altered assemblages occur as inclusions in common minerals. One wonders how many more minerals would be discovered at localities such as Mont Saint-Hilaire by the kind of systematic examination undertaken by Russian mineralogists.

The book concludes with a one-page Concluding Statement, a table of Luminescent Minerals, an alphabetical listing of Investigators of Type Minerals from the Khibiny (including some Canadian mineralogists), References (342 entries), an Index of Minerals, an Index of Mineral Localities (unfortunately, only the numbered localities described in the second chapter are indexed), a note About the Authors, and a List of Contents. The table of luminescent minerals lists 83 species and their color response in "photoluminescence" or "cathodeluminescence" or both. "Photoluminescence" presumably refers to fluorescence under ultraviolet radiation, but this is not spelled out, nor whether the radiation was short- or long-wave; there is no mention of phosphorescence.

The text in *Khibiny* is virtually free of the English syntax and grammar errors that plague some English-language books published in Russia. A few captions, the insets of composition profiles, and the Concluding Statement apparently escaped the scrutiny of the English editor (from the Natural History Museum, London), as did such mistranslations as "head" for termination, "bi-headed" for doubly terminated, "tetragonal trioctahedral" for trapezohedral, "deltohedral" for trisoctahedral, and the enigmatic "case-like crystals" and "crystals [that] look like battens with flat heads." There are very few spelling errors, probably no more than in most books of this size. Other errors are minimal. On p.11, in reference to the geological map, "north-west" in the phrase "they mark the north-west contact of the massif with metavolcanics" should be southwest. On p. 41, the strike of a vein is stated to be "almost horizontal [*sic*]." On p. 265, the images should be reversed to conform to the caption. None of the illustrations are numbered, precluding an index. Thin sections and SEM photomicrographs in the Minerals chapter are not identified as such, nor is it mentioned whether the thin sections were photographed in plane-polarized light. These are mostly minor criticisms of an otherwise excellently edited book.

As befits its high price, *Khibiny* is a high-quality, large-format (21 × 30 cm) book with cloth-bound hard covers, printed on heavy-weight glossy paper, with a very nice layout and a crisp text. Observant readers will note that the marbleizing in the end-papers is a thin section of khibinite, a variety of foyaite. The book is lavishly illustrated. This reviewer did not count the number of illustrations, but according to the authors, they include a remarkable "592 original colour and

SEM–BSE photos." The color photographs are superb, and the color graphics are excellent. The color printing, by a Finnish company, is as good as it gets.

Khibiny ranks with the very best of the topological mineralogies that have been published in recent years. Whereas some previously published books focus on specific localities within the Khibiny massif, *Khibiny* is an authoritative source on the mineralogy of the massif *in its entirety*. Although its high price may be a deterrent, it is in the range of other currently available mineralogical monographs. The comprehensive data provided on the minerals of Khibiny, in large part previously unpublished, and the detailed descriptions of mineral occurrences, make *Khibiny* a valuable reference for anyone involved with minerals and their occurrence in alkaline complexes. Mineral enthusiasts will enjoy the book for its numerous superb photographs of minerals. This is a handsome book that should be on the shelf of libraries, mineral museum curators, serious mineral collectors, and mineralogists and other geoscientists with a special interest in alkaline complexes.

Peter Tarassoff
91 Lakeshore Road
Beaconsfield, Quebec H9W 4H8, Canada