

THE GEOCHEMISTRY OF THE LOVOZERO ALKALINE MASSIF. BY V. I. GERASIMOVSKY *et al.* TRANSLATED BY D. A. BROWN. *Toronto University Press, 1968. Two parts, 7 x 9½ inches. Part 1: Geology and Petrology, 224 pages; Part 2: Geochemistry, 369 pages. \$11.00.*

This monograph by Professor Dr. V. I. Gerasimovsky *et al.* of the Vernadsky Institute of Geochemistry and Analytical Chemistry, Academy of Sciences U.S.S.R., Moscow, has recently been translated by Professor D. A. Brown of the Australian National University, Canberra.

The Lovozero massif is one of two enormous alkaline bodies in the Kola Peninsula of the U.S.S.R. recently studied in considerable detail. The other, the Khibiny massif, has also received much attention from Soviet geologists because of its great economic importance as a source of phosphate (apatite), nepheline syenite, and other industrial minerals. While not specifically mentioned in the volumes, the intensive work on the Lovozero massif has probably been done mainly to determine its potential as an industrial source of many elements included among which are niobium, tantalum, zirconium, rare earths, uranium, and thorium. The two alkaline massifs are the largest known intrusives of this type in the world.

The Lovozero massif is apparently a broad based laccolith that broke through and into the Early Archaean granite gneisses and Palaeozoic effusive-sedimentary rocks of the Baltic Shield during post Late Devonian time (Hercynian phase of diastrophism). In plan the massif is quadrangular in shape and covers an area of some 650 square kilometres.

Four intrusive phases and a pegmatite stage are recognized in the massif. The oldest, intrusive phase I (5 per cent by volume of the massif), includes essentially nepheline syenites and nepheline-sodalite syenites. Intrusive phase II (77 per cent by volume) is a differentiated rhythmically layered complex of urtites, foyaites, juvites, and lujavrites. Intrusive phase III (18 per cent by volume) is a weakly-layered sequence of eudialyte lujavrites, foyaites, and juvites cutting veined and layered bodies of feldspar and lovozerite-murmanite porphyroid lujavrites. There are also small bodies of eudialytes and poikilitic sodalite syenites. Intrusive phase IV (<0.01 per cent by volume) is a dyke series of alkaline lamprophyres including camptonites, monchiquites, nepheline basalts, and tinguaites. The pegmatites are mainly alkaline types containing essentially nepheline, aegirine, microcline, albite, eudialyte, and

sodalite. In chemical and mineralogical composition the pegmatites are close to the rocks in which they occur, and with which they are genetically associated. Both agpaite varieties (characterized by soda-rich minerals and the presence of abundant Nb, Zr, rare earths, Be, F, etc.) and miaskitic varieties (characterized by low amounts of Zr, Hf, Nb, Ta, rare earths, and minerals rich in calcium) are present. The pegmatites are thought to have been formed from residual melts.

Chemical analyses of all of the rocks of the intrusive phases and pegmatites are given, and the detailed petrology of the various rock types and their evolution is discussed. The layering phenomenon is said to result from rhythmic crystallization attendant upon zonal diffusion processes.

The mineralogy of the massif is varied and complex. Some 159 minerals and their varieties have been identified. Of these 86 have been observed in the rocks and 131 in the pegmatites. Many of the minerals are new, having been described for the first time in the Lovozero massif or its pegmatites. The principal minerals are nepheline, sodalite, aegirine, arfvedsonite, albite, eudialyte, loparite, apatite, and various rare minerals containing Ti, Nb, Ta, rare earths, Be, P, Li, Zr, Th, U, Cl, and F.

Some 3,000 or more analyses form the basis for a discussion of the geochemistry of the intrusive phases and pegmatites. The chemistry of some 55 elements is discussed in detail, and there is a discussion of the origin of the agpaite nepheline syenites of the massif. This is followed by general conclusions and four appendices. No attempt will be made here to discuss this vast amount of geochemical data mainly because any generalities would perhaps be misleading.

The geochemical data are, however, particularly useful to those interested in the study of alkaline intrusives. They show that the massif as a whole is greatly enriched in Na, K, Al, Li, Be, B, Sr, Ga, Rb, rare earths, Zn, Zr, Ti, Nb, Hf, Ta, Th, U, F, Cl, and S. The agpaite nepheline syenites are enriched in Li, Be, F, Na, Al, Mn, Sr, B, S, Cl, K, Ga, Rb, rare earths, Zn, Zr, Hf, Ti, Ta, Tl, Pb, Th, and U.

While an admirable attempt is made to outline the regularities of the partition of the various rare elements during the differentiation of the parent alkaline magma we are left with no particular fundamental ideas as to why alkaline rocks are the receptacle of so characteristic a suite of elements, particularly those of rare abundance in the earth such as Li, Be, rare earths, Nb, Ta, Th, Zr, and Hf. This suite of elements is so characteristic of

alkaline rocks throughout the world that it behooves petrologists and geochemists to explain why. So far we have no particular answer to the problem, and we, therefore, cannot criticize Professor Gerasimovsky and his co-workers in this respect. They have given an admirable array of data with which later workers, by comparison with other massifs, may be able to provide some fundamental answers as to the origin of alkaline magmas enriched in elements like Ti, Nb, Ta, Be, Zr, and Hf.

Professor Brown has done a remarkable job in the translation of so complex a work. Throughout the two volumes the translation is clear, and the tables and graphs are well presented. The volumes are recommended to all those interested in alkaline rocks and their close associates, the carbonatites. For graduate students in geochemistry the data and ideas advanced on the partitioning of the elements during the magmatic events that produced the Lovozero massif will go a long way in explaining some of the facets of the geochemistry of some of the rarer elements in the earth's crust.

R. W. Boyle

**THE MIGRATORY BARREN-GROUND CARIBOU OF CANADA.** BY JOHN P. KELSALL. *Ottawa: Canadian Wildlife Service, 1968. 6 x 9 inches, 339 pages, 26 plates, 17 figures, 29 sketches, 24 maps. \$3.50.*

With the single exception of the North American Waterfowl Studies, no other wildlife project anywhere has matched in scope the study of the barren-ground caribou conducted in Canada through the twenty years since 1948. This has been a co-operative study involving the Provinces of Manitoba and Saskatchewan, along with the Canadian Wildlife Service, the Northwest Territories Administration and many local co-operators. About 20 biologists have spent thousands of hours on field studies always difficult and frequently hazardous. Courage, resourcefulness, imagination and ingenuity were constantly demanded of these men. The author of this monograph, John Kelsall, was personally in charge of the study for nine years, and was a fitting choice to prepare the published account of this important and ambitious research. His account does the research team justice, their accomplishments are impressive.

The book has been designed to be of use to a very wide audience. Its wealth of original data, much of it contained in the statistical tables included in ten appendices, makes the study invaluable to the research wildlife biologist and the student of animal popula-

tions. Its careful analysis of the data, presented in well-organized and thoroughly readable style, will be welcomed by student, field biologist and resource manager, as well as by those with more general interest in the Arctic and its creatures.

The region covered in this study is the continental mainland from the Mackenzie River to Hudson Bay, south into the forested areas of the central provinces used by the caribou as winter range. This is an area of some 700,000 square miles. In the early years of exploration it carried a population of caribou estimated by Kelsall at 2.4 million. Throughout the north it was the major animal influent and no other creature played so important a role in the survival of primitive man in this area, in facilitating the exploration of the Northwest Territories and in providing food for the trappers, prospectors, and others who pioneered the New North. Thus it was that the collapse of the caribou population through the 1950's was an event of major importance to Canada and national concern led to the study.

The text is in eight chapters, the first of which deals with the caribou as an organism. Here is the "natural history" of the creature in the conventional sense. The second chapter deals briefly with the tundra and taiga as habitat for caribou. Food habits, nutrient qualities of the vegetation, the seasonal use of the plants by caribou, and the vegetative yield of different types of plant communities that compose the summer and winter range are the subject matter of Chapter 3. Chapter 4 devotes 36 pages to migratory and other movements made by caribou herds. Detailed accounts are given of actual migratory movements of known herds, as well as massive shifts in population that were not migration. Other subjects treated are stimuli to movement, orientation, long crossings over ice, summer dispersal and winter concentration. The size of primitive and recent populations, sex and age ratios and the rate of increment to the herds are treated in Chapter 5 under the general heading of Population Dynamics. This section could have profited from a more analytical and synthetic approach with life tables leading to a population model. Such techniques could have thrown into sharp relief the relative importance of the several positive and negative forces that govern abundance and trends in size of the caribou population.

The breeding biology and growth are the subjects of Chapter 6. Here the details of the rut, the location and characteristics of calving grounds, calving behaviour, nursing, development and growth of the calf are