Preface

In this book the author attempts to provide up-to-date information about the geochemistry, exotic mineralogy, petrology, and experimental studies on ultrapotassic feldspathoid-bearing mafic and ultramafic rocks, which are quite distinct from the rocks of basalt family. The parental liquids for this intriguing group of rocks bear definite signature of their deep mantle source. Modern developments in earth science show that carbonates, N_2, O_2, P, H_2O, and K-rich crustal materials can be recycled into the deep earth causing mantle metasomatism. Partial melting of such a modified mantle source could be responsible for the generation of such K-rich silica-deficient magmas.

Age determination of ultrapotassic rocks show that the origin of their parental liquids are related to the last few hundred million years of mantle evolutionary history in contrast to generations of komatiitic magmas, which were partial melting products of the mantle, evolved mainly during the Proterozoic or Archaean, albeit with a few exceptions.

In the introductory chapter, the geochemical and mineralogical peculiarities of K-rich silica-poor rocks in contrast to alkaline basalts have been described. This chapter also describes the objective and scope of this book. In the next five chapters of this volume, the characteristic mineralogy (Chap. 2), classification (Chap. 3), their distribution in all the continents and oceanic islands (Chap. 4), major minor, trace and isotopic geochemistry have been discussed (Chap. 5). Physico-chemical constraints for the crystallization of leucite and melilite, their P-T stability together with the oxygen fugacity condition of their formation, are described in Chap. 6.

Experimental studies on the system nepheline-kalsilite-SiO_2 in air and under 1, 2, 3, 5, and 20 kb in presence of excess water have been summarized in Chap. 7. Genesis of pseudoleucite and the problems related to survival of leucite beyond Tertiary due to analcitization are discussed in this chapter.

Incompatible relationship between the mineral pairs, leucite and sodic plagioclase and occurrence of the former, in association with calcic plagioclase can be understood from the study of the systems leucite–albite and leucite–albite–anothite under atmospheric pressure. These results are summarized in Chap. 8.

In Chap. 9, phase relations in the system diopside–nepheline–sanidine studied in air and under 1, 2, 10, and 20 kb in presence of excess water, are summarized. The course of crystallization of leucite-bearing tephrites and basanites is also described in this chapter with reference to the system forsterite-diopside-leucite-anorthite. Association of silica-deficient feldspathoidal rocks occurring in close proximity to silica-saturated feldspar-bearing lavas can be very well understood from the study of the diopside-leucite-anorthite-SiO_2 system. Experimental results of various joins of these systems are described also in Chap. 9.

In Chap. 10, genesis of melilite- and leucite-bearing rocks are described in detail with reference to the study of the systems forsterite-diopside-leucite-akermanite and diopside-nepheline-leucite-akermanite under atmospheric pressure.

Experimental study of the system forsterite-diopside-leucite and forsterite-akermanite-leucite under 23 kb in presence of excess water at variable temperatures show that leucite and kalsilite-bearing mafuritic rocks are represented under high pressure in presence of excess water by lamproites and minettes. These results are also discussed in Chap. 10.

In certain petrographic provinces such as Coli-Albani and Somma-Vesuvius of Italy and the Bufumbira province of equatorial Africa, K-rich silica undersaturated rocks occur in close proximity to their silica-saturated analogues. This is also true in the Highwood Mountains region of the USA. Such occurrences may be understood with reference to the detailed study of the system leucite-akermanite-albite-SiO_2, studied under one atmospheric pressure by Gupta and Gupta (1985). Similar studies on the system leucite-akermanite-albite with or without anorthite have been conducted by Dwivedi et al. (2007). These results are discussed in Chap. 11.

The P-T stability of phlogopite can be understood from the study of the system forsterite-kalsilite-SiO_2 in presence of excess water at 1, 2, and 3 kb (Luth 1967). The same system has been investigated at 20 kb in presence of CO_2, H_2O and under dry condition by Wendlandt and Eggler (1980 a–c) and upto 28 kb with or without H_2O, and in presence of CO_2 by Gupta and Green (1988). These studies are discussed in Chap. 11. Foley et al. (1986) also studied the system forsterite-kalsilite-SiO_2 in presence of F up to 28 kb at variable temperatures to determine how presence of F affects stability of phlogopite. His studies are also included in this chapter.

Study of Yoder and Kushiro (1969) up to 30 kb (with or without excess water on the stability of phlogopite has been discussed in Chap. 12. Trones (2002) also investigated the stability of phlogopite up to 70 kb and variable temperatures. High pressure-temperature stability of K-ricterite by Gupta and Venkatesh (1993) and Konzett et al. (1997) has been included in Chap. 12. Experimental results of Massone (1992) on phengite as a source of potassium are also described in this chapter.

Investigation on ultrapotassic rocks under atmospheric pressure and high temperatures has been summarized first in Chap. 13. This is followed by high pressure-temperature studies on synthetic and natural rock systems by various petrologists as available till date. These studies give an insight into the nature of parental source materials of such magmas.

Structural and tectonic control in the migration of leucite-bearing mafic and ultramafic melts are discussed in Chap. 14. These studies, conducted by different structural geologists and geophysicists, are summarized in great detail in this chapter.

In Chap. 16 the genesis of K-rich feldspathoid-bearing lavas is discussed. Different hypotheses, invoked during the first half of the last century involved (1) assimilation between different magmas and rock types (Daly 1910, 1933; Shand 1933), (2) subtraction of eclogites from peridotite or picritic magmas (Holmes 1932; O'Hara and Yoder 1967), (3) gaseous transport hypothesis (Kennedy 1955), (4) zone refining process (Harris 1957), and finally, (5) partial melting model of phlogopite and/or richterite-bearing peridotites (Gupta and Yagi 1980; Gupta and Fyfe 1975). Merits and demerits of different processes have been critically analyzed in this chapter.

It has been emphasized in Chap. 15 that in the genesis of ultrapotassic magmas, partial melting of a fertile mantle source is required. Formation of such a modified mantle is related to recycling of the crustal materials into the deep earth by the process of subduction. Possible causes for the frequent occurrence of K-rich silica-poor volcanic rocks during the last few hundred million year history of the earth are also described in Chap. 15. In Chap. 16, a brief summary of the entire volume is given and petrologic conclusions are discussed.

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