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Petrogenesis of cogenetic silica-oversaturated and -undersaturated syenites of Abu Khruq ring complex, South Eastern Desert, Egypt

Moustafa M. Mogahed

Geology Department, Benha University-Egypt, P.O. Box 13518, Benha, Egypt

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ABSTRACT

The upper Cretaceous Abu Khruq ring complex (ARC) is located in the South Eastern Desert of Egypt displays concentric zonation of syenitic rocks from quartz-rich syenite at the margin, through alkali feldspar syenite to nepheline syenite in the centre. The syenitic rocks occur with nepheline monzogabbro, volcanic rocks (phonolite and trachyte) and the quartz- and nepheline-bearing pegmatites. Rocks of contrasting composition (mafic and salic) exhibit sophisticate geometric relationships. The nepheline monzogabbroic rocks have pillowy xenoliths forms within the salic (nepheline syenite and quartz alkali feldspar syenite) rocks, suggesting synchronous emplacement of the mafic and salic magmas. Clinopyroxene analysis of mafic and salic plutonic rocks of the ARC revealed that the overall pyroxene trend suggesting that fractionation involved a late, progressive increase in Na, in a reaction of the type Ca Mg $Fe^{2+} \leftrightarrow$ Na Fe^{3+}. The chemistry of the analysed amphiboles are compositionally similar to those from typical differentiated peralkaline suites. Geochemically, the complex is enriched in the LILE, HFSE and REE. The concentrations of the compatible elements (V, Sr and Ba) generally decrease with increasing silica, consistent with fractional crystallization. A generalised increase in the Nb/Ta from the nepheline monzogabbro to nepheline syenite compositions is attributed to titanite fractionation. All the rock samples show relative increment of the LREE content than the HREE indicating weak to steep fractionated REE patterns (La/Yb) from 9.43 to 10.86, and thus retaining the geochemical characteristics of anorogenic suites. The magma sources of ARC are not derived from normal primitive mantle. The early stages of differentiation involved extensive olivine and pyroxene fractionation, the fractionation of amphibole, titanite, magnetite, apatite and feldspar may have been involved in the genesis of the salic differentiated compositions. The deviation towards silica-oversaturated members attributed to crustal assimilation and associated with fractional crystallization of the basic magma at a relatively early stage during the development of the complex. The whole complex is deduced to have originated from alkali basaltic to basanitic magma of OIB-like character. The general increasing of the amphibole and biotite among the different rocks of the complex reflects the hydrous nature of ARC magmas.

1. Introduction

Alkaline igneous rocks may be defined as those, which have higher concentrations of alkalis than can be accommodated in feldspars alone, the excess appearing as feldspathoids, sodic pyroxenes, sodic amphiboles and other alkali-rich phases. These rocks are, therefore, deficient in silica and/or alumina with respect to alkalis and will have nepheline and/or acmite in their norms.

Although, alkaline rocks occur rarely in nature but they usually have a remarkable amounts of many rare metals such as Li, Be, Nb, Ta, Zr, Th, REE and volatile components, mainly F and Cl. Hence, they are the source of various rare minerals (Sørrensen, 1992). Alkaline igneous rocks commonly provide significant information on post-orogenic or intraplate extensional magmatic processes within continental lithosphere, and trace the nature and evolution of the continental lithosphere (e.g. Wilson et al., 2004; Hou et al., 2015). According to their geologic and economic significance many studies dealt with the petrogenesis of alkaline rocks (e.g. Huang and Wyllie, 1975; Eby, 1985; Lubala et al., 1994; Sheppard, 1995; Marks et al., 2003; Yang et al., 2008). Therefore, no consensus has been reached, especially for the coexisting silica-saturated (quartz-bearing) and silica-undersaturated (nepheline-bearing) alkaline rocks that have been identified in many

E-mail address: mustafa.ahmed01@fsc.bu.edu.eg.

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intracontinental magmatic provinces (e.g. Foland et al., 1993; Wilson et al., 1995; Riishuus et al., 2008). There is a great debate whether differentiation of a parental magma could result in the coexistence of both silica-saturated and silica-undersaturated rocks. Hamilton and MacKenzie (1965) revealed that in the Petrogeny's Residua System (Ne–Ks–Qtz–H_2O) a melt can fractionate either toward the granite minimum to produce silica-oversaturated rocks, or toward the nepheline syenite minimum to produce silica-undersaturated rocks, but cannot form both silica-saturated and silica-undersaturated rocks.

The Abu Khruq alkaline ring complex (ARC) is one of about fifteen alkaline ring complexes intruding Precambrian rocks of the Arabo-Nubian shield in the south Eastern Desert of Egypt (Fig. 1) and ranging in age from Silurian to Late Cretaceous (Serencsits et al., 1979). The Abu Khruq ring complex (ARC) is an epizonal, multi–intrusion alkaline ring complex that exhibit the association of silica-saturated, under- and oversaturated rocks. The idea of the presence of silica-over and under saturated rocks are the result of the conclusion supposed by many workers (e.g. Brooks and Gill, 1982; Fitton, 1987; Landoll et al., 1989; Chen et al., 1994) that the crustal contamination is the main factor in the formation oversaturated rocks.

Most previous work of the ARC have been done in the context of regional geologic studies of numerous Egyptian ring complexes (e.g. Gindy et al., 1978; Taher, 1989; Abdalla, 2006). Few studies shed the light on the radioactive mineralization (El Afandy and Abdalla, 2002; El Afandy et al., 2013) and the role of contamination in the formation of ARC. Obeid and Lalonde (2013), introduced a comprehensive study for the geochemistry and petrogenesis of ARC. In view of the importance of the ARC on the petrogenesis of alkaline rocks, we are undertaking more detailed mineralogical and chemical studies, and present here electron microprobe investigations of the pyroxenes and amphiboles from the intrusive rocks of the ARC.

2. Geological background

2.1. Regional geology and geochronology

The Abu Khruq ring complex (ARC) is located at 130 km northeast of Aswan, roughly midway between the Nile Valley and The Red Sea coast (Fig. 1). The ARC is a prominent feature occurs in the vast plain between Wadi Natash and Wadi Shait and extending eastwards to the Gebel Migif and Gebel El Duweig. This plain is mainly consist of hornblende gneisses to the west and biotite gneisses that extending to the east. A group of volcanic plugs, such as Gebel Hamrat Salma, Gebel Umm Sarag, Gebel El Nuhud North and Gebel El Nuhud South, surrounds ARC. The ARC possesses several high peaks ranging from 619 to 874 m above the sea level, the highest peak occur at the centre of the complex at the

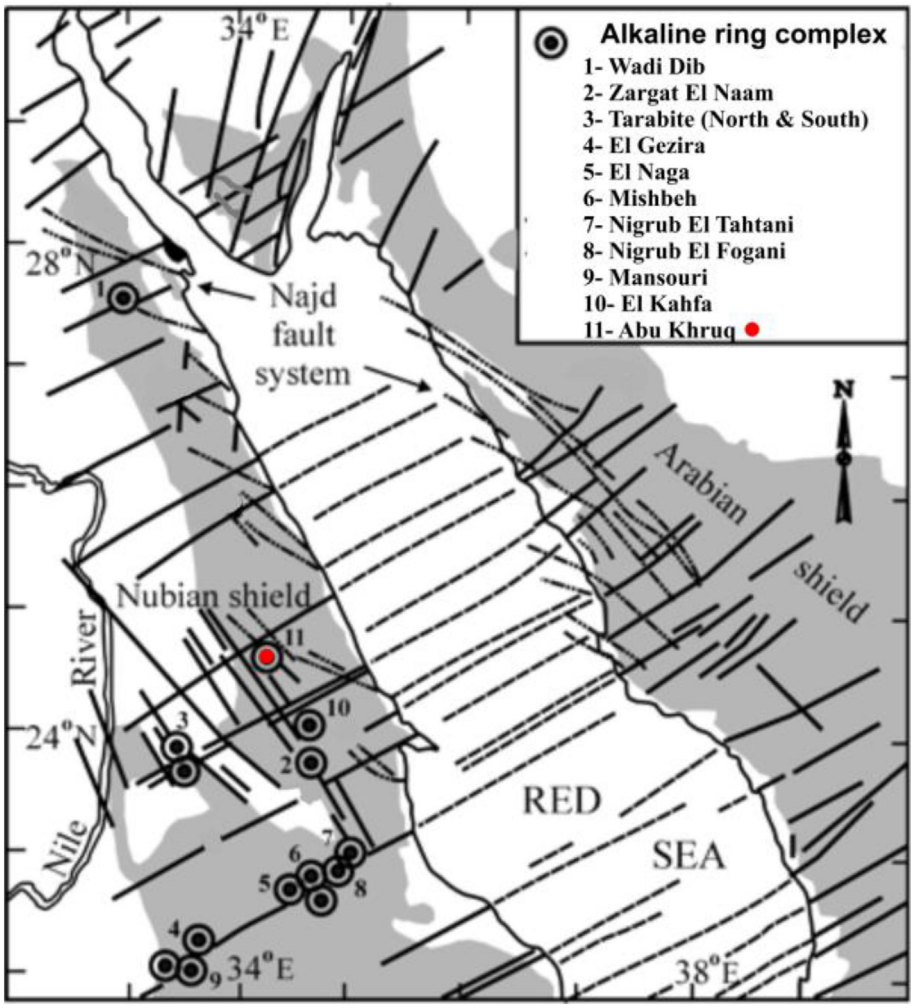

Fig. 1. Distribution of the alkaline ring complexes in the Eastern Desert of Egypt.