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THE GEOCHEMISTRY AND PETROGENESIS OF THE LATE CRETACEOUS ABU KHURUQ ALKALINE COMPLEX, EASTERN DESERT, EGYPT

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ABSTRACT

The Late Cretaceous rocks of the Abu Khuruq ring complex (AKRC), exposed in the southern Eastern Desert, Egypt, comprise phonolite, trachyte, syenogabbro, essexite, nepheline syenite, and quartz syenite, as well as quartz- and nepheline-bearing pegmatites. The rocks of the complex are dominantly metaluminous and enriched in both large-ion lithophile (LIL) and high-field-strength (HFS) elements with a lack of a negative Nb anomaly. All rocks have high LREE content relative to HREE, show weak to steep fractionated REE patterns [$5.6 < (La/Yb)_n < 18.6$], and possess the geochemical characteristics of anorogenic suites. Syenogabbros display REE patterns [$11.8 < (La/Yb)_n < 14.2$] not significantly different from those of the essexite unit and the essexitic xenoliths found in the nepheline syenite [$(La/Yb)_n$ in the ranges 12.0–13.7 and 15.6–18.6, respectively]. They have relatively weakly fractionated HREE patterns [$3.0 < (Gd/Yb)_n < 3.7$], low Yb_n and Lu_n values (< 10), and no Eu anomaly. The syenogabbros (<3 wt.% MgO, <20 ppm Ni, and negligible Cr) presumably formed by fractional crystallization of an alkaline basaltic magma. The syenogabbroic melt yielded the essexite by removal of plagioclase and clinopyroxene. The silica-undersaturated evolved rocks have conformable trace-element and REE patterns [$10.8 < (La/Yb)_n < 14.2$], without significant variations in LILE and HFSE, and negative Ba, Sr, Ti, and Eu anomaly. The normalized trace-element and REE patterns of these two units are quite similar. We infer a comagmatic relationship for the phonolites and nepheline syenites, both formed by simple fractional crystallization of an essexitic melt. The trachytes have lower MgO and CaO contents than the phonolites. The quartz syenite unit exhibits moderately fractionated REE patterns [$9.3 < (La/Yb)_n < 14.4$], with $(Eu/Eu^*)_n$ in the range 0.5–1.1]. This marginal unit may well have been derived from the SiO_2-undersaturated syenitic magma, but it was contaminated by crustal material.

Keywords: Abu Khuruq ring complex, syenite, gabbro, phonolite, trachyte, geochemistry, petrogenesis, Eastern Desert, Egypt.

INTRODUCTION

The Abu Khuruq ring complex (AKRC), located in the southern Eastern Desert of Egypt, approximately 100 km from the Red Sea coast (Fig. 1), is one of the youngest (Late Cretaceous) and largest (50 km^2) of the ring complexes of Egypt (Fig. 2A). Unlike many other examples, the AKRC is characterized by voluminous volcanic rocks (phonolite and trachyte), SiO_2-undersaturated gabbro, and undersaturated and saturated syenites (Fig. 2B). A characteristic feature of many alkaline ring complexes worldwide is the occurrence of both undersaturated and saturated rock series (Platt 1996). The formation of phonolite and trachyte (and plutonic equivalents) in the AKRC offers petrologists an excellent opportunity to study the tectonomagmatic evolution of these alkaline igneous rocks and the various magmatic processes that occurred in the Nubian crust during Late Cretaceous time. Most previous investigations of the AKRC have been done in the context of comparative studies of numerous Egyptian ring complexes (*e.g.*, Gindy *et al.* 1978, Taher 1989, Abdalla 2006). Few studies have focused solely on the AKRC; those that have include a detailed study of radioactive mineralization (El-Afandy & Abdalla 2002) and of its Nd-isotope geochemistry (Landoll *et al.* 1994).

In this paper, we present major, trace, and rare-earth-element data for the various petrological units of the AKRC, including late pegmatites and hydrothermal alteration zones. The objective of this work is to define the geochemical characteristics of the alkaline rocks of Abu Khuruq, to shed light on the source of the relevant