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PETROGRAPHIC AND GEOCHEMICAL FEATURES OF THE 2002 NYIRAGONGO LAVA FLOWS

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Abstract

Preliminary data on the petrographic and geochemical characteristics of some volcanic products of the January 2002 Nyiragongo (Democratic Republic of Congo) eruption are reported. Selected rocks were collected at three different sites: Shaheru fracture, Monigi vent and Virunga flow. They are represented by nephelinites, which closely resemble historical (1977 and 1982) products of the Nyiragongo volcano.

Keywords: East African Rift, Nyiragongo volcano, 2002 eruption, nephelinites

1. Introduction

The Nyiragongo complex, belonging to the alkaline province of the East African Rift (Western branch), consists of three volcanoes (Baruta, Nyiragongo, Shaheru) aligned in a N-S direction and by numerous parasitic cones located on the volcano flanks along radial fractures.

Nyiragongo volcano is well known for its lava lake intra-crateric activity (Tazieff 1949, 1977 and 1994). In historical time the Nyiragongo volcano erupted in the 1977 when rifting caused the opening of several fractures in the upper part of the volcano. On June 1982, volcanic activity resumed and magma erupted from two vents located along two of those fractures and forming a pseudo lava lake (Demant *et alii* 1984). During the last eruption of the Nyiragongo Volcano (January 2002; see Komorowski *et alii* this volume, for details), the 1977 fracture systems were reactivated. The eruption started immediately north of Shaheru crater; the fracture system rapidly propagated toward Goma, and partly covered the city. The eruption lasted about 24 hours with a total volume of 25×10^6 m^3 of lava ejected. The purpose of this paper is to describe the petrographic and geochemical characteristics of some volcanic products from 2002 eruption and to compare them with those collected from 1977 lava flow and 1982 lava lake activity.

2. Classification and petrography

Rock samples have been collected along the N-S fracture system connecting the Nyiragongo crater with Goma town and precisely along the Shaheru fracture, close to the Monigi vent and at Virunga – South of Monigi (see Figure 1 in Capaccioni *et alii* this volume). Exact sample locations are reported in the Table 1. Rock samples are represented by strombolian scoriae and lava flows. In the chemical classification diagram of Le Bas *et alii* (1986), these samples plot in the foidite field (Fig. 1). All the studied samples are hypocrystalline porphyritic, but differ in their texture and modal mineralogy. Rocks from Shaheru fracture display small amounts (< 10 vol. %) of microlithes of melilite and kalsilite, and minor clinopyroxene (Ti-augite) and rhoenite set in a glassy groundmass. Rocks from Monigi and Virunga exhibit a phenocryst content ranging from 30 to 50 volume %. Phenocryst mineralogy consists of nepheline, leucite and lower amounts of diopsidic clinopyroxene; olivine ($Fo_{73\text{-}84}$) is present as microphenocryst; in addition to

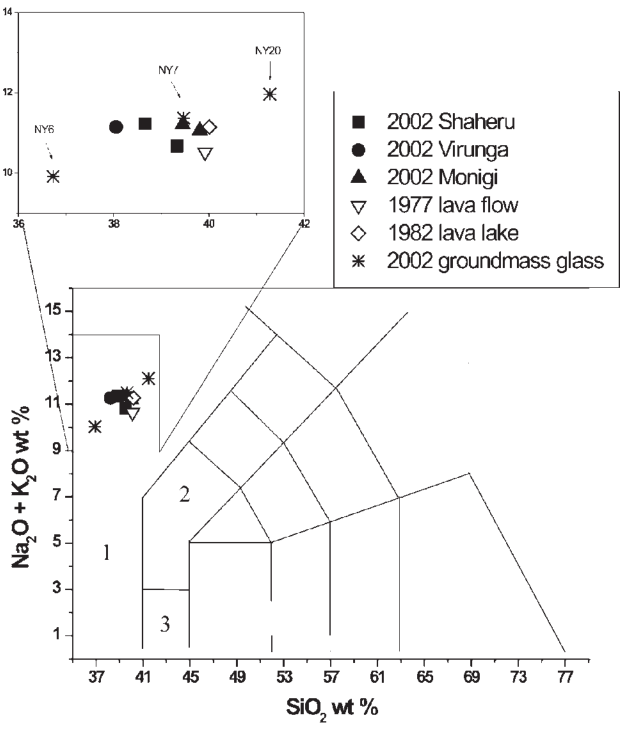

Fig. 1. Total alkali-silica classification diagram (after Le Bas *et alii* 1986). Fields: 1 = foidite; 2 = tephrite and basanite; 3 = picro-basalt. 1977 lava flow and 1982 lava lake data are from Demant *et alii* 1994.

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TABLE 1. Sample location and description.

Sample	NY6	NY7	NY9	NY19	NY20
Local name	Shaheru	Shaheru	Virunga	Monigi	Monigi
Coordinates	01°32'56.4" S 29°15'02.0" E	01°32'56.4" S 29°15'02.0" E	01°39'36.5" S 29°13'59.5"E	01°38'34.9"S 29°14'45.1" E	01°38'34.9" S 29°14'45.1" E
Description	juvenile scoria	juvenile scoria	lava	lava	juvenile scoria
Petrography	melilite, kalsilite, Ti-augite+apatite and Fe-Ti oxides	melilite, kalsilite+ apatite and Fe-Ti oxides	melilite, nepheline, leucite + diopside, olivine, apatite and Fe-Ti oxides	nepheline, leucite+ diopside, olivine, apatite and Fe-Ti oxides	nepheline, leucite+ diopside, olivine, apatite and Fe-Ti oxides

these minerals, melilite is present in the Virunga rock sample. The groundmass is glassy in the Monigi rocks; the Virunga groundmass contains the same phases as the phenocrysts and microphenocrysts and small amount of glass. Accessory apatite and Fe-Ti oxides are ubiquitous. The Shaheru and Monigi rocks can be classified as nephelinites, whereas that from Virunga is a melilite-leucite bearing nephelinite (Le Maitre 2002).

3. GEOCHEMISTRY

Major and trace element compositions of selected rock samples are listed in Table 2.[1] They are undersaturated rocks (normative ne > 24 wt %; TABLE 2), and are characterised by K_2O/Na_2O ratio < 1. The low Mg#, Ni and Cr (TABLE 2) indicate that they represent differentiated magmas. On the alkali versus silica diagram (FIG. 1) the composition of groundmass glasses, analysed in three 2002 samples by electron microprobe, are also reported (TABLE 3).[2] In contrast with the rather homogenous composition of whole rocks, the glasses display variable composition (SiO_2 = 36.7-41.5 %), although they still plot in the foidite field. Such a variation may indicate mixing-mingling processes between liquids with different composition coexisting in the volcanics system. Further studies will be directed at clarifying this point, which has strong petrological and volcanological implications. All the studied rocks show similar mantle-normalised patterns of incompatible elements (FIG. 2). Overall, the Nyiragongo rocks display a strong element fractionation, with enrichments in Ba and Nb, and a negative spike of K. The comparison with rocks from the eastern branch of the East African Rift (Gregory Rift, Kenia; FIG. 2) shows similar patterns, except for Ti, but with a stronger enrichment of all the elements in the Nyiragongo rocks.

As observable in Figure 1 and Table 3, lava composition

TABLE 2. Major (%) and trace (ppm) element composition of selected 2002 volcanics.

Sample	NY6	NY7	NY9	NY19	NY20
SiO_2	39.3	38.7	38.1	39.5	39.8
TiO_2	2.7	2.7	2.7	2.8	2.7
Al_2O_3	14.6	14.4	14.2	14.6	14.6
Fe_2O_3	13.2	13.2	13.1	13.3	13.2
MgO	4.1	4.1	4.1	4.1	4.1
CaO	12.2	12.2	12.2	12.3	12.1
Na_2O	5.6	5.8	5.8	5.8	5.7
K_2O	5.1	5.4	5.4	5.4	5.3
MnO	0.29	0.29	0.29	0.29	0.29
P_2O_5	1.5	1.5	1.4	1.5	1.5
Mg#	0.38	0.38	0.38	0.38	0.38
Sc	5.1	5.8	4.9	4.9	6.0
V	275	279	252	272	272
Cr	6.6	3.4	3.8	2.6	2.8
Ni	34	36	30	29	31
Rb	141	143	146	143	142
Sr	2832	2875	2873	2871	2830
Y	42	42	42	42	42
Zr	319	319	315	319	315
Nb	264	268	262	267	264
Ba	2126	2127	2197	2126	2128
La	191	192	184	185	185
Ce	340	336	330	335	335
Nd	122	122	117	121	120
CIPW norm calculation (wt %)					
Ne	25.9	24.5	24.2	24.8	25.1
Le	24.2	25.7	26.0	25.4	25.0
Di	16.3	4.3	0.6	8.4	13.3
Ol	10.5	15.8	17.5	13.8	11.8
La	10.0	14.6	16.3	13.0	10.9
Ac	0.61	4.6	5.6	3.6	2.4
Ilm	5.3	5.3	5.3	5.4	5.2
Mt	3.6	1.6	1.1	2.1	2.7
Ap	3.6	3.6	3.4	3.5	3.5

Mg# = [mol $Mg^{2+}/(Mg^{2+} + Fe^{2+})$]

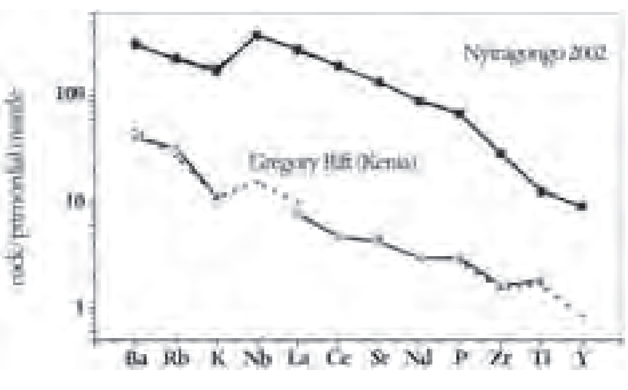

FIG. 2. Mantle normalised trace element patterns. Gregory Rift (Kenia) data from Baker *et alii* (1977). Normalisation values from Sun and McDonough (1989).

1. Major and trace element composition was obtained by X-Ray Fluorescence at the Dept. of Geology, University of Edinburgh, U.K., by mean of a Philips PW 1400 XRF. Glass disks of rock samples were used.
2. Phase composition was determined by a JEOL JXA-8600 electron microprobe operating at 15 kV and 15 nA and equipped with a Series II Tracor Northern system. Correction for matrix effects were made according to the method of Bence and Albee (1968).

from 2002 eruption closely resembles those of 1977 and 1982 eruptions at least in major element abundances.

The studied 2002 Nyiragongo volcanics display very homogeneous geochemical composition but show different textures and modal mineralogy. This may indicate magma ponding and crystallisation at different depths, a hypothesis to be tested by accurate geothermobarometric studies on rocks from different vents.

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Table 3. Major element (%) composition of 1977, 1982 lavas and 2002 glasses used for comparison with 2002 rock samples.

Sample	1977* mean lavaflow	1982* lava lake	NY20 gdm glass	NY7 gdm glass	NY6 gdm glass
SiO_2	39.9	40.0	41.3	39.5	36.7
Al_2O_3	15.0	14.5	15.0	15.0	14.3
Fe_2O_3	13.8	13.2	12.0	12.6	17.5
MgO	4.2	4.3	3.8	4.2	6.3
CaO	12.2	12.5	10.6	11.8	8.2
Na_2O	5.3	5.9	6.2	5.9	5.1
K_2O	5.3	5.3	5.8	5.4	5.1
TiO_2	2.7	3.0	2.8	2.6	4.3
MnO	0.28	0.26	0.31	0.31	0.27
P_2O_5	1.4	1.3	1.2	1.5	n.a.
Mg#	0.38	0.39	0.38	0.40	0.42

* = data from Demant et al., 1994; gdm = groundmass; n.a.= not nalysed; Mg# = [mol $Mg^{2+}/(Mg^{2+}+Fe^{2+})$]

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