Journal of African Earth Sciences 121 (2016) 219–246

Contents lists available at ScienceDirect

Journal of African Earth Sciences

journal homepage: www.elsevier.com/locate/jafrearsci

The Cenozoic volcanism in the Kivu rift: Assessment of the tectonic setting, geochemistry, and geochronology of the volcanic activity in the South-Kivu and Virunga regions

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ARTICLE INFO

Article history:
Received 19 November 2015
Received in revised form
2 April 2016
Accepted 29 May 2016
Available online 30 May 2016

Keywords:
East African Rift
Kivu
Virunga
Tholeiitic
Alkaline and potassic lavas
K-Ar age dating

ABSTRACT

The Kivu rift is part of the western branch of the East African Rift system. From Lake Tanganyika to Lake Albert, the Kivu rift is set in a succession of Precambrian zones of weakness trending NW-SE, NNE-SSW and NE-SW. At the NW to NNE turn of the rift direction in the Lake Kivu area, the inherited faults are crosscut by newly born N-S fractures which developed during the late Cenozoic rifting and controlled the volcanic activity. From Lake Kivu to Lake Edward, the N-S faults show a right-lateral en echelon pattern. Development of tension gashes in the Virunga area indicates a clockwise rotation of the constraint linked to dextral oblique motion of crustal blocks. The extensional direction was W-E in the Mio-Pliocene and ENE-WSW in the Pleistocene to present time.

The volcanic rocks are assigned to three groups: (1) tholeiites and sodic alkali basalts in the South-Kivu, (2) sodic basalts and nephelinites in the northern Lake Kivu and western Virunga, and (3) potassic basanites and potassic nephelinites in the Virunga area. South-Kivu magmas were generated by melting of spinel + garnet lherzolite from two sources: an enriched lithospheric source and a less enriched mixed lithospheric and asthenospheric source. The latter source was implied in the genesis of the tholeiitic lavas at the beginning of the South-Kivu tectono-volcanic activity, in relationships with asthenosphere upwelling. The ensuing outpouring of alkaline basaltic lavas from the lithospheric source attests for the abortion of the asthenospheric contribution and a change of the rifting process. The sodic nephelinites of the northern Lake Kivu originated from low partial melting of garnet peridotite of the sub-continental mantle due to pressure release during swell initiation. The Virunga potassic magmas resulted from the melting of garnet peridotite with an increasing degree of melting from nephelinite to basanite. They originated from a lithospheric source enriched in both K and Rb, suggesting the presence of phlogopite and the local existence of a metasomatized mantle. A carbonatite contribution is evidenced in the Nyiragongo lavas.

New K-Ar ages date around 21 Ma the earliest volcanic activity made of nephelinites. A sodic alkaline volcanism took place between 13 and 9 Ma at the western side of the Virunga during the doming stage of the rift and before the formation of the rift valley. In the South-Kivu area, the first lavas were tholeiitic and dated at 11 Ma. The rift valley subsidence began around 8–7 Ma. The tholeiitic lavas were progressively replaced by alkali basaltic lavas until to 2.6 Ma. Renewal of the basaltic volcanism happened at ca. 1.7 Ma on a western step of the rift. In the Virunga area, the potassic volcanism appeared ca. 2.6 Ma along a NE-SW fault zone and then migrated both to the east and west, in jumping to oblique tension gashes.

The uncommon magmatic evolution and the high diversity of volcanic rocks of the Kivu rift are explained by varying transtensional constraints during the rift history.

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http://dx.doi.org/10.1016/j.jafrearsci.2016.05.026
1464-343X/

1. Introduction

The Kivu Rift is the middle part of the western branch of the East African Rift system (Fig. 1). This branch separated from the main rift to the north of Lake Malawi and outlined a westward curved path from Lake Rukwa to Lake Albert. The rift valley is discontinuous in displaying a succession of deep lacustrine basins and structural heights commonly overlain by volcanic rocks, *i.e.* from south to north: Rungwe volcanic area, Rukwa and Tanganiyka basins, South-Kivu volcanic area, Kivu basin, Virunga volcanic area, Edward basin,

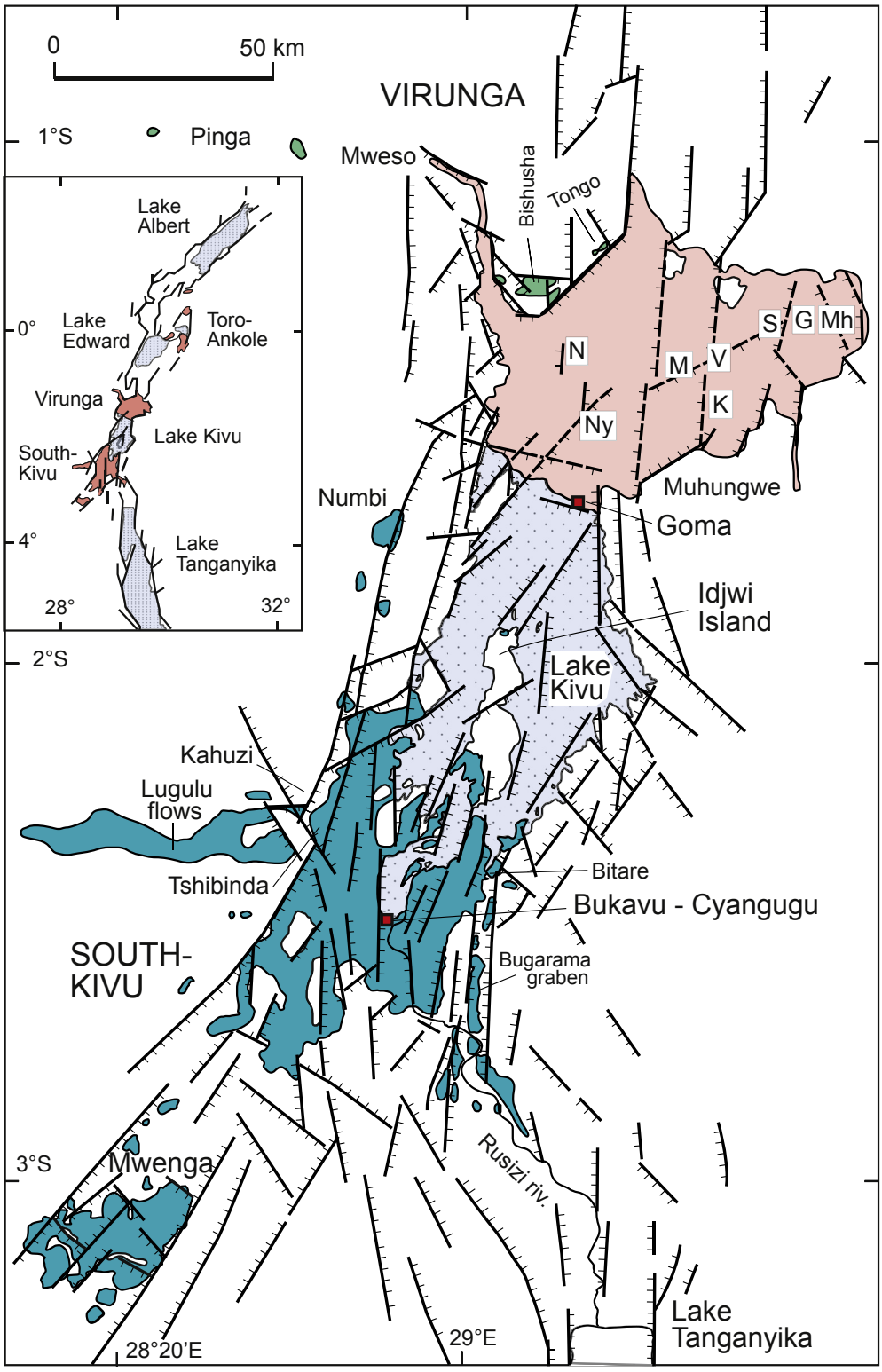

Fig. 1. Tectonic pattern of the western branch of the Eastern Africa rift system in the Lake Kivu region, after Pouclet (1976) slightly modified. Map of the South-Kivu and Virunga volcanic areas. Volcanoes of Virunga: Nyamuragira (N), Nyiragongo (Ny), Mikeno (M), Karisimbi (K), Visoke (V), Sabinyo (S), Gahinga (G), and Muhavura (Mh).