Volcano monitoring in the Virunga Volcanic Province, DR Congo

N. d’Oreye (1,2), F. Albino (3), V. Cayol(4), P. Gonzalez (5), F. Kervyn (3), S. Samsonov (6), B. Smets (1,3,7), C. Wauthier (3,8*), L.M. Bagalwa (9), N. Mashagiro (9), A. Muhindo (9), M. Syauswa (9)

1. European Center for Geodynamics and Seismology, Luxembourg (Indregegs.lu)
2. National Museum of Natural History, Luxembourg
3. Royal Museum for Central Africa, Belgium
4. Laboratory Magmas et Volcan, Univ. Blaise Pascal, Clermont-Ferrand, France
5. Univ. of Western Ontario, Canada
6. Canada Center for Remote Sensing, Ottawa, Canada
7. Univ. of Brussels, Belgium
8. University of Liege, Belgium; * Now at Carnegie Institution of Washington, USA
9. Goma Volcano Observatory, Democratic Republic of Congo

Introduction:
The poster presents the efforts initiated in 2005 to contribute to the study and the monitoring of Nyiragongo and Nyamulagira volcanoes, two of the most active volcanoes in Africa located in the Virunga Volcanic Province (VVP) in Democratic Republic of Congo. Satellite radar interferometry (InSAR) proved to be the most reliable technique as, unlike the ground based monitoring systems, it does not suffer from interruptions resulting from the local insecurity, lack of infrastructure, geopolitical instability, or more natural causes like lightning or rainstorm. However, it is not continuous in time and ground based monitoring systems remain fundamental tools for the Goma Volcano Observatory. In 2006, we started deploying a network of 8 permanent real time geodetic GPS receivers that helped to monitor the 2006 and 2011/12 Nyamulagira eruptions. Maintaining ground based networks is however a challenge in the specific socio-economic and political context of North Kivu. InSAR and ground based measurements in VVP and South Kivu Volcanic Province provide tools for studying the continental break-up along that portion of the East African rift and the related hazards.

The Nyamulagira 2010 eruption:
On January 2, 2010, Nyamulagira started to erupt after less than two hours of seismic precursors. Thanks to the numerous remote sensed data and the ground based networks, this is the most quantitatively documented eruptions of Nyamulagira (Smets et al., in prep.). Deformations were captured by InSAR from 8 look angles by 3 satellites. Deformations are best fitted with two dykes with two independent overpressures and a deflating sill-like reservoir below Nyamulagira caldera (Wauthier et al., in press). Seismic and tilt data confirmed the visual observations of 4 different phases of the eruption. Innovative, multidimensional small baseline subset InSAR time series method allowed identifying unambiguous pre-eruptive deformations that started more than 2 weeks prior the lava outburst (Samsonov and d’Oreye, in press). Deformations measured by the permanent GPS network show a deformation pattern that contrasts with the deformations observed during the following 2011/12 eruption. Nyamulagira 2010 eruption ended on January 27.

The Nyamulagira 2006 eruption:
The first eruption since the systematic monitoring of the VVP by InSAR started on November 27th 2006 after 1.5 days of intense seismic activity. The deformations captured by satellite from 3 different look angles. At least two sources are needed to account for the observed deformation: one dyke extending below Nyamulagira and Nyiragongo (connected to eruptive fissure) and an infesting sill-like source or a spherical reservoir (Wauthier et al., in press). Preliminary models however only partially fit the observed deformation. Unfortunately no ground based deformation data were available. The eruption lasted probably until December 5th 2006.

The Nyiragongo 2002 eruption:
On 17 January 2002, Nyiragongo volcano erupted along a 20 km-long fracture network extending from the volcano to the city of Goma. The event was captured by InSAR data. The best model to account for the observed deformations involved a shallow dike and a deeper dike (see poster by Wauthier et al. this issue). The low overpressures inferred (~1-10 MPa) for these dikes are consistent with lithostatic crustal stresses close to the dikes and low magma pressure. As a consequence, the dike direction is probably not controlled by stresses but rather by a reduced tensile strength resulted from previous rift intrusions. The lithostatic stresses indicate that magmatic activity is intense enough to relax tensional stresses associated with the rift extension (Wauthier et al. 2012).

The Nyamulagira 2011/12 eruption:
Nyamulagira volcano started to erupt on November 6th, 2011 after two days of intense seismic activity and ended 4-5 months later. Location, duration and erupted volume contract with the previous recent eruptions. Deformations are captured by InSAR from 6 different look angles. InSAR data revealed more than 1.5 cm and more than 50cm ground deformations respectively in the Nyamulagira main crater and at the two eruptive fractures located 1 km from the NE of Nyamulagira. Preliminary modeling of the InSAR deformations suggests that eruption started with the opening of a NE dike at the eruptive fracture and an almost NS diking intrusion below the summit crater. Preliminary weekly solutions from the GPS permanent network revealed a sustained subsidence at the Nyamulagira during the whole duration eruption.

Conclusions:
That portion of the East African Rift, and the Virunga Volcanic Province in particular, is a complex and highly active system as illustrated by the numerous recent and historical events. InSAR, and more recently GPS offer new opportunities to study that peculiar portion of rift zone. Combined to future structural and geomorphological studies (see poster by Kervyn and d’Oreye; this issue), ongoing research are contributing to address more fundamental questions like: what is the plumbing system below these volcanoes and what drives the magma storage within the active rift system; where and how does the strain accumulates during extension; what are the interactions between tectonics and magmatism; what controls the rift opening... Moreover, these fundamental questions are not limited to the specific context of VVP but are also of major interest for the study of the EAR and the lifting mechanisms in general.

References:

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