THE JANUARY 2002 ERUPTION OF NYIRAGONGO VOLCANO (DRC) CAPTURED BY INSAR

C. Wauthier[1,2], V. Cayol[3], F. Kervyn[1,4], N. d'Oreye[5]

[1] Dept. of Geology, Royal Museum for Central Africa, Leuvensesteenweg 13, 3080 Tervuren, Belgium, christelle.wauthier@africamuseum.be
[2] Dept. ArGEnCo, University of Liège, Sart Tilman B52, 4000 Liège, Belgium
3 Lab. Magmas et Volcans, Université Blaise Pascal – UMR 6524, rue Kessler 5, 63038 Clermont-Ferrand, France
[4] Centre d'Informations Géographiques SODERU, Goma, North-Kivu, DRC
[5] Dept. of Geophysics/Astrophysics, National Museum of Natural History, Rue Josy Welter 19, 7256 Walferdange, Luxembourg

1. INTRODUCTION

With Nyamulagira, Nyiragongo is one of the two active volcanoes of North Kivu (Democratic Republic of Congo). It is located in the western branch of the East African rift. This area is affected by a combination of seismic and volcanic activities [1]. In this area, the rift is most likely a half-graben including a minor transfer zone induced by the rift segmentation along the rift main axis [2, 3]. Nyiragongo hasn't been much studied, in great part due to political and security tensions taking place in the country. On 17th January 2002, Nyiragongo erupted along an approximately 20 kilometers long fracture network extending from the volcano to the city of Goma and its airport [4]. Two lava flows entered the town and destroyed about 15% of the houses and infrastructures [5].

2. INSAR DATA

The event was captured by InSAR data acquired in three different modes: ERS along ascending orbits [6], and RADARSAT [7] along ascending and descending orbits. Unfortunately, only five ERS independent interferograms and with large time spans (and therefore low coherence) cover the event. The reduced number of available archives is due to sparse compatible ERS data, reducing the number of independent ERS interferograms to 5. Analysis of these five ERS interferograms is performed using a wavelet based time series technique [8]. In addition, one ascending RADARSAT interferogram (ST6 mode), having a short time span, and therefore better coherence than ERS ascending interferograms, as well as a RADARSAT descending interferogram (ST4 mode) is also available. InSAR data associated with this eruption show complex ground displacements, with several overlapping fringe patterns, probably associated to a combination of sources of magmatic and regional tectonics origins. The different acquisition modes can hopefully help to better define the 3D displacements and therefore better constrain the characteristics of the ground displacement sources.

3. MODELING METHOD

The numerical method used to model the InSAR displacements is a 3D Mixed Boundary Element method [9] that takes into account realistic topographies as well as any number and geometry of faults and pressure sources. This method is combined with a neighbourhood inversion algorithm [10] to determine the most likely sources parameters. Boundary conditions are stresses, they are null on the ground surface and correspond to constant pressures for dykes and constant shear stress drops for faults. The near neighbourhood inversion method takes the noise characteristics of the data into account [11, 12]. To evaluate the model-data fit, InSAR data are unwrapped and subsampled at circular gridded points. The interferograms from ERS and RADARSAT sensors are simultaneously used in the inversion. The combination of several possible deformation sources - a subvertical dyke, a deflating reservoir and a normal fault - is studied and discussed. The relevance of inverting for different potential sources parameters is also studied using synthetic tests.

4. CONCLUSIONS

At least, two of the potential sources described above are needed to explain the interferometric signal observed in the Nyiragongo and Goma areas. The best-fit model obtained for a single dyke and a single deflating reservoir poorly fits the data. A subvertical dyke associated to the eruptive fissures in combination with a normal fault parallel to the east African rift close to Goma seems the most likely sources. Both the fault and the eruptive fissure directions are compatible with the local extension direction of the rift. A fringe pattern in the western and south-western parts of Nyamulagira probably requires the introduction of a third source in this area. The different possibilities to explain this remaining part of the InSAR signal and other residuals data are finally discussed.

5. REFERENCES

[1] Ebinger C.J et Furman T., Geodynamical setting of the Virunga volcanic province, East Africa, In : Acta Vulcanologica, *The January 2002 eruption of Nyiragongo volcano and the socio-economical impact*, Vol. 14 (1-2) et vol. 15 (1-2), Istituti editorali e poligrafici internazionali, Pisa-Roma, 9-16, 2004.

[2] Corti G., Bonini M., Innocenti F., Manetti P., Mulugeta G., Sokoutis D., Cloetingh S., Rift-parallel magma migration and localisation of magmatic activity in transfert zones, In : Acta Vulcanologica, *The January 2002 eruption of Nyiragongo volcano and the socio-economical impact*, Vol. 14 (1-2) et vol. 15 (1-2), Istituti editorali e poligrafici internazionali, Pisa-Roma, 17-26, 2004.

[3] Wauthier C., *Modélisation des déplacements InSAR survenus au Nyiragongo en janvier 2002*, Mémoire de Master 2 recherche, Université de Clermont-Ferrand II, 52p. , 2007.

[4] Komorowski J-C, Tedesco D., Kasereka M., Allard P., Papale P., Vaselli O., Baxter P., Halbwachs M., Akumbe M., Baluku B., Briole P., Ciraba M., Dupin J-C, Etoy O., Garcin D., Hamaguchi H., Houli´e N., Kavotha K.S., Lemarchand A., Lockwood J., Lukaya N., Mavonga G., De Michele M., Mpore S., Mukambilwa K., Munyololo F., Newhall C., Ruch J., Yalire M. et Wafula M., The January 2002 flank eruption of Nyiragongo volcano (Democratic Republic of Congo) : Chronology, evidence for a tectonic rift trigger, and impact of lava flows on the city of Goma, In : Acta Vulcanologica, *The January 2002 eruption of Nyiragongo volcano and the socio-economical impact*, Vol. 14 (1-2) et vol. 15 (1-2), Istituti editorali e poligrafici internazionali, Pisa-Roma, 27-62, 2004.

[5] D. Tedesco, O. Vaselli, P. Papale, S. A. Carn, M. Voltaggio, G. M. Sawyer,et al., "January 2002 volcano-tectonic eruption of Nyiragongo volcano, Democratic Republic of Congo", *J. Geophys. Res.*, 112, B09202, doi:10.1029/2006JB004762, 2007.

[6] C. Wauthier, V. Cayol, N. D'Oreye, F. Kervyn, "Modeling of InSAR displacements related with the January 2002 eruption of Nyiragongo volcano (DRC)," *Proc. of 4th ESA Fringe2007 workshop*, ESA-ESRIN, Frascati, Italie, 26-30 November 2007.

[7] M. Poland, "InSAR Captures Rifting and Volcanism in East Africa," *Alaska Satellite Facility News & Notes*, Vol. 3:2, 2006.

[8] M. Shirzaei, T.R. Walter, "A new InSAR time series method applied to Hawaii", *German National Geologic Conference*, 2008.

[9] V. Cayol, F.H. Cornet, "3D mixed boundary elements for elastostatic deformations fields analysis", *Int. J. Rock Mech. Min. Sci. Geomech.* Abstr., 34, 275-287, 1997.

[10] Y. Fukushima, V. Cayol, P.Durand, "Finding realistic dike models from interferometric synthetic aperture radar data: The February 2000 eruption at Piton de la Fournaise," *Journal Geoph. Res.*, VOL. 110, B03206, 2005.

[11] M. Sambridge, 1999a, Geophysical inversion with a neighbourhood algorithm - I. Searching a parameter space, *Geophys. J. Int.*, 138, 479-494.

[12] M. Sambridge, 1999b, Geophysical inversion with a neighbourhood algorithm - II. Appraising the ensemble, *Geophys. J. Int.*, 138, 727-746.