Preliminary results from seismic monitoring at Nyiragongo Volcano through telemetered seismic network, Goma Volcano Observatory (Gvo, Democratic Republic Of Congo).

Pagliuca (1) N.M., Badiali (1) L., Cattaneo (1) M., Ciraba (2) H., Delladio (1) A.,Demartin (1) M., Durieux (2) J., Lukaya (2) F., Lisi (1) A., Marzocchi (1) W., Marchetti (1) A., Monachesi (1), Mavonga (2) G., Garcia (1) A., Sgroi (1) T., Tedesco (3) D.

(1)Istituto Nazionale di Geofisica e Vulcanologia
(2)Goma Volcano Observatory
(3)Università di Napoli 2

The Nyiragongo volcano, which rises to 3,465 m, is located on the western side of the African Rift Valley, in the Democratic Republic of the Congo.
Nyiragongo and Nyamuragira are the only active volcanoes in the region and the most active in the African continent. Nyiragongo is a strato-volcano (Simkin et al., 1981) located about 20 km north of Lake Kivu, and 15 km north of the city of Goma. It is one of Africa's best known volcanoes because of recent catastrophic eruptions. Renewed activity at Mt. Nyiragongo began on January 17, 2002. The eruption generated a 6-m-high basaltic lava flow which has advanced through the border town of Goma in the Congo. About half of the city has been destroyed and tens of thousands of refugees have fled to adjacent Rawanda. In 1977, a similar outpouring of basaltic lava killed almost 2000 people in less than half an hour. The volcano has been erupting intermittently for most of 2004.
Several small villages are located on the flank of the volcano and are frequently damaged by volcanic eruptions. In order to monitor the intense seismic activity at Nyiragongo volcano a new seismic network of seven digital stations were installed in 2003-2004.
The deployment of the seismic network proved to be very important for scientific studies and to mitigate the volcanic hazard.
The network, composed by enlarged-band or broadband 3 component sensors, has been designed on the basis of recent experiences by INGV (Istituto Nazionale di Geofisica e Vulcanologia) in digital seismic monitoring during the volcanic crisis occurred in the last years in Italy.
In fact, the acquisition software was used for the first time at Stromboli during the 2002-2003 emergency crisis and it is part of INGV centralized acquisition software suite in Rome.
The geometry of the network was constrained by the available sites. In fact in the northern part of the volcano, between Nyiragongo and Nyamuragira we could not deploy any stations. The digital telemetered seismic network, is currently operating and seismic signals are continuously recorded at the Goma Volcano Observatory (GVO).
We selected about 6 months of seismic data from the available dataset. In particular we focused on the seismicity prior to the 2004 eruptive episode recorded by the seismic network of GVO.
Based on waveforms and spectral analysis, different kind of seismic signals have been recognized:
- Volcanic-tectonic earthquakes (VT) with P and S phases discernable, havind a predominant high-frequency content (greater than 5 Hz). Their S-P times are about 10 s and are located in the Virunga volcanic area.
- Long-period events (LP): low-frequency transient signals having weak P emergent onset and characterised by the absence of S phases. Their predominant frequency content ranges between 1 and 3 Hz.
- Very long period events (VLP): they show similar features of LP events but with lower frequency content (< 0.1 Hz).

- Volcanic tremor: it appears as a continuous seismic signal and may be considered due to the sustained occurrence of long period events. It appears on a seismogram as an irregular sinusoid of long duration in comparison to a tectonic earthquake of the same amplitude.

The VT seismicity has been analyzed in term of earthquake location. P and S wave arrival times have been picked and collected and events located with HYPOELLIPSE code (Lahr, 1989).Moreover we constructed a 1D velocity model for the crust beneath the volcano using the VELEST code (Kissling et al., 1995). To better understand how the volcano works, and to define its plumbing system, the crust structure and the relationship between regional tectonic and volcanism, we plan to analyze focal mechanisms, spatial distribution of earthquakes and magnitude of events. These results will be then compared with those available from the historical seismicity that hit this region.

In the computation of earthquake hypocentres we assume a simple two-layer model which was adopted in previous works (Mavonga et al., 2006 and references therein) which incorporate gravity data results obtained from a survey in the Western part of the Virunga volcanic complex (Zana et al., 1992). The simplified model includes a low-velocity surface layer of 4.0 km/s for P wave in the uppermost 3 km. From 3 to 20 km, we adopt a velocity of 6.0 km/s. From 20 km to the Moho (~30 km), we specify a P wave velocity of 6.7 km/s. The S-wave velocities are calculated using the Vp /Vs ratio of 1.73.

We show the distribution of the VT seismicity in space and time, to better define the plumbing system. Moreover, through the analysis of low-frequency seismicity we verify the correlation between seismicity and volcanic activity at Nyiragongo.

References

Kissling, E., W. L. Ellsworth, D. Eberhart-Phillips and U. Kradolfer (1994). Initial reference models in local earthquake tomography, J. Geophys. Res., 99, 19635-19646.

Lahr, J. C. (1989). HYPOELLIPSE/Version 2.0: a computer program for determining localearthquake hypocentral parameters, magnitude, and first motion pattern, U. S. Geol. Surv. Open File Rep., 95, 89-116.

Mavonga T., S. K. Kavotha a, N. Lukaya, O. Etoy, J.Durieux (2006). Seismic activity prior to the May 8, 2004 eruption of volcano Nyamuragira, Western Rift Valley of Africa. Journal of Volcanology and Geothermal Research, 158, 355–360.

Simkin T., Siebert L., McClelland L., Bridge D., Newhall C., Latter J.H. (1981). Volcanoes of the World, Hutchinson Ross, Pa. Usa, pp. 233.

Zana, N., Tanaka, K., Kasahara, M., 1992. Main geophysical features related to the Virunga zone, Western Rift, and their volcanological implications. Tectonophysics 209, 255–257.