Geophysical Research Abstracts, Vol. 7, 07060, 2005
SRef-ID: 1607-7962/gra/EGU05-A-07060

Ground deformation monitoring at Stromboli volcano (Italy) during and after the 2002-2003 eruption and landslides.

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Introduction

Stromboli is an active volcano, about 2500 m high above the sea floor. Roughly only the last kilometer of this volcano emerges from the sea, forming an island whose diameter ranges from 2.4 to 5 km. It belongs to the Aeolian Islands and represents the most active volcano of this archipelago. Its conic shape is evidently characterized by a big depression that marks the northwestern flank of the edifice: the Sciara del Fuoco; Three active craters are aligned along a SW-NE trend, at about 750 m a.s.l., in the central part of a flat area that characterize the upper southeastern part of the Sciara del Fuoco. On December 28th, 2002, lava flows outpoured from the northern wall of the NE crater and descended into the Sciara del Fuoco, a deep depression marking the NW flank of the volcano edifice. On December 30th, 2002, two landslides occurred on the northern part of the Sciara del Fuoco; they moved a mass in the order of tens of millions of cubic meters both above and below sea level. The landslide produced a tsunami causing significant damage to the eastern coast of the island, reaching the other Aeolian Islands and the Sicilian and southern Italian coasts. This event led to the upgrading of the ground deformation monitoring system, already existing on the island; the new requirement was the real-time detection of the deformations related to potential slope failures of the SdF.

EDM network

Since January 16th, 2003, a first monitoring network, based on EDM measurements,

was set up. The first sub-network was installed on the summit area of the volcano. At the same time, 4 reflectors were installed on the upper part of the volcano outside and around the upper part of the Sciara del Fuoco area, on sites considered stable. A third monitoring sub-network, consisting of six benchmarks, was installed in the area of the niche of the December 30th landslide. All These benchmarks were measured from a pillar at the summit and two of them were equipped with two reflectors, in order to be measured also from another pillar, located on the lower flank of the volcano, at Punta Labronzo. This last pillar was set up with the aim of enabling monitoring on the lower part of the landslide area. The suitability of the station al Punta Labronzo, allowed the installation of other six reflectors from the niche area down to the sea. Finally, two other benchmarks were installed in the central part of the Sciara del Fuoco and a third pillar at Punta del Corvo was set up. At the beginning of February 2003, the monitoring control points within the Sciara were 22 and 3 pillars were installed. Throughout the EDM monitoring activities, angular measurements were carried out from the pillars by using a theodolite, in order to evaluate the three-dimensional movements of the benchmarks. The 3D vectors, through integration of EDM and theodolite measurements, provided helpful information on the dynamics (direction and displacement velocity) of the landslide.

THEODOROS system

Later on, a robotized Total Station was installed to automate the topographic measurement. The acronym of this new system was THEODOROS (THEOdolite and Distancemeter Robot Observatory of Stromboli). The set up of this new system was a real challenge, given the logistic and operative conditions existing on Stromboli during the volcanic crisis. Although the two-way link system was quite complex (optical + WiFi), it was efficient enough to guarantee the real-time control of the Total Stations from the Observatory. The actual system aims to follow the post-eruptive movements of the recent lava flow field. At present, THEODOROS counts 5 reflectors for the reference system, 10 reflectors for monitoring movements in the Sciara del Fuoco and 2 more reflectors to check the stability of the measurement both on short and very long distance measurements. The system performs 48 cycles of measurements per day. After the end of the eruption, the system was overhauled in order to optimize the instruments and set up a monitoring system aimed at measuring deformations forecasting other flank collapses. The topographic monitoring of the Stromboli volcano enables collecting important data on the dynamic of the eruption. Furthermore, the monitoring system, now provides very useful data relevant to the post-eruptive dynamic of the Sciara del Fuoco.