AGU Fall Meeting
San Francisco, USA, 5 - 9 December 2005
Paper No: V21B-0607
Abs No: 3796

Istituto Nazionale di Geofisica e Vulcanologia
Sezione di Catania

FLANK INSTABILITY PHENOMENA OF THE SCIARA DEL FUOCO AT STROMBOLI VOLCANO, ITALY: RECENT EVIDENCE FROM A MULTISCIPLINARY STUDY

S. Falsaperla, M. Neri, E. Pecora, S. Spampinato, H. Langer
Istituto Nazionale di Geofisica e Vulcanologia (INGV) - Sezione di Catania - Italy

falsaperla@ct.ingv.it
neri@ct.ingv.it
pecora@ct.ingv.it
spampinato@ct.ingv.it
langer@ct.ingv.it

1. The Sciara del Fuoco (SDF) at Stromboli volcano, located in the western side of the homonymous island (Fig. 1) , is a deep scar prone to phenomena of flank instability, such as rockfalls and flowing debris. By 30 December, 2002, landslides associated with tsunami waves affected both the sub aerial and submarine part of SDF two days after the onset of a new episode of lava emission. Recently, continuous monitoring as well as frequent structural field survey of SDF have provided an unprecedented opportunity for analyzing similar instability phenomena.

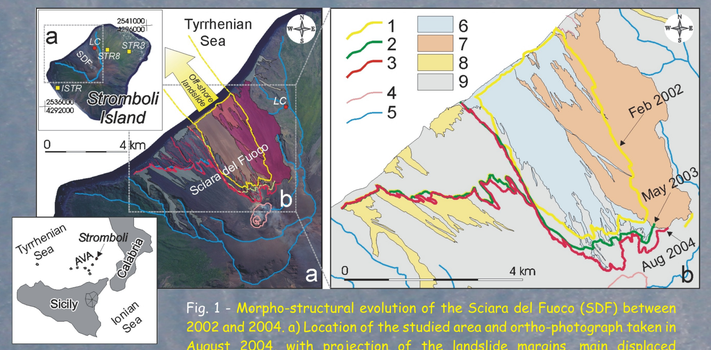

Fig. 1 - Merpho-structural evolution of the Sciara del Fuoco (SDF) between 2002 and 2004. a) Location of the studied area and ortho-photograph taken in August 2004, with projection of the landslide margins, main displaced materials, lava flows, and SDF rim. AVA = Aeolian volcanic arc; LC = Thermal and visual live-cameras; ISTR, STR3, STR8 = seismic stations. b) Morphological details of the landslide area. 1) Scarp head in February 2002; 2) Scarp head in May 2003; 3) Scarp head in August 2004; 4) Active crater summit area; 5) Main and secondary rims of SDF; 6) Main body and minor post-December 2002 landslide deposits; 7) 2002-2003 lavas and scoriae deposits; 8) Recent (pre-December 2002) landslide deposits; 9) undifferentiated volcanics.

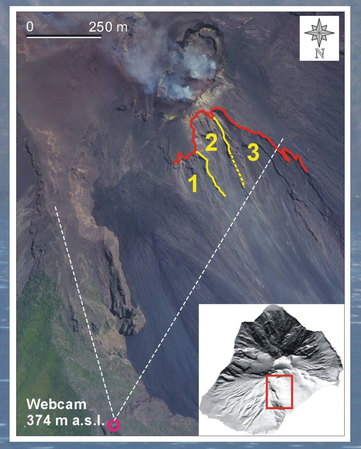

Fig. 2 - Region along the Sciara del Fuoco affected by the rockfalls of our data set documented by visual images. White dashed lines mark the visual field of our video camera at 400 m a.s.l.. The red line marks the detachment niche of the two huge landslides of 30 December, 2002. The numbers 1, 2 and 3 identify the three zones from which these rockfalls start. The figure is a close-up view of an aerial snapshot taken on 4 August, 2004 (courtesy of Maria Marsella, University of Rome 1).

2. Our study combines different data types in a complementary manner by merging geo-structural observations (Fig. 1) with visual images (taken by a video-cameras surveillance network and vertical air-photos, Figs. 1, 2) and seismic records (Fig. 3). The goal of this research is to characterize this landslide-prone area for hazard mitigation purposes. The different data types are used to assess how and where SDF morphology changed in the time span from 2002 to 2004.

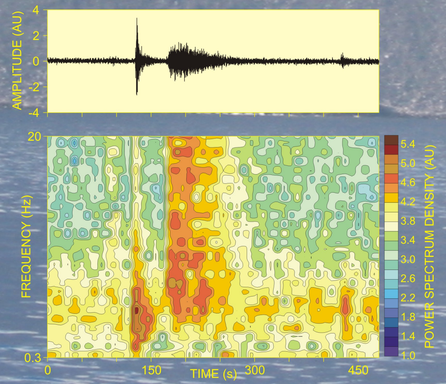

Fig. 3 - Seismogram (top) and relative spectrogram (bottom) of a time series recorded at the vertical component of STR8 on 27 August, 2004. An explosion quake shortly precedes a rockfall episode. The spectrogram is calculated applying the Fast Fourier Transform to successive time series of 2.56 s with an overlap of 50%, and depicting the results as consecutive spectra. The frequency content of the rockfall is outstandingly higher than that of the explosion quake.

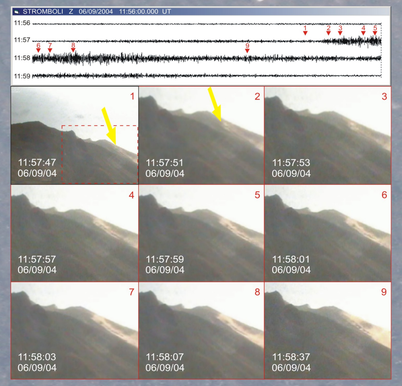

Fig.4 - Seismogram (top) and snapshots (1-9), taken from the INGV video camera, for a rockfall episode along the Sciara del Fuoco. The numbered red triangles in the seismogram match the sequence of video frames. The frames from 2 to 9 are close-up views of the red dashed rectangle in frame 1. The yellow arrows mark the visible start of the rockfall.

Table 1

Date and time (yyyymmdd hh:mm)	Duration (s)	Amplitude (counts)	Visual observations and index (I) of resolution from I (poor) to5(good)	Time onset of an explosion and crater of provenance (in brackets)
20041129 09:39:38	120.00	33352	4 Cloudy, hard to distinguish anything	
20040219 12:37:32	141.81	40218	4 Cloudy, hard to distinguish anything	
20040220 12:00:30	175.00	50000	4 Cloudy, hard to distinguish anything	
20040801 17:41:30	127	19271	5 Fine weather, no event	
20040410 09:42:34	116.78	11849	5	
20040417 17:56:35	195.34	28847	5 Strong wind and ash, hard to distinguish anything	
20040419 17:06:49	77.69	12711	5 Strong wind and ash, hard to distinguish anything	
20040419 17:35:00	57.00	25975	5 Foggy, hard to distinguish anything	
20040419 17:50:57:49	123.89	16128	5 Strong wind and ash, hard to distinguish anything	
20040419 17:58:14	16.34	13773	5 Foggy, hard to distinguish anything	
20040419 07:41:55	142.9	32998	5	07:41:21 (1)
20040415 18:07:58	177.28	66345	5	18:06:55 (2,3)
20040419 15:48:19	122.42	71074	5 Foggy, hard to distinguish anything	
20040419 08:38:07	153.78	27903	5 Strong wind and ash, hard to distinguish anything	
20040419 14:01:51	80.34	33177	5 Strong wind and ash, hard to distinguish anything	
20040420 09:46:50	197.30	25999	5 Strong wind and ash, hard to distinguish anything	
20040430 13:09:55	129.7	31723	5 Strong wind and ash, hard to distinguish anything	
20040722 17:11:39	175.29	34469	5 Fine weather, no event	
20040723 16:02:31	181.72	26635	5 Strong wind and ash, hard to distinguish anything	
20040723 16:21:33	187.2	47086	5 Strong wind and ash, hard to distinguish anything	
20040723 16:29:44	185.78	61111	5 Strong wind and ash, hard to distinguish anything	
20040723 17:22:20	214.82	28969	5 Strong wind and ash, hard to distinguish anything	
20040725 09:26:14	214.54	44299	5	
20040725 09:37:38	140.37	20661	5	
20040725 13:09:40	147.98	36783	5 Cloudy, hard to distinguish anything	
20040727 11:44:02	110.54	31178	5	11:44:20 (1)
20040727 14:47:20	68.99	33987	5 Foggy, hard to distinguish anything	
20040802 07:24:31	157.46	49584	5	
20040802 17:18:27	177.46	30201	5	17:17:49 (2,3)
20040804 17:06:39	95.7	40835	5 Fine visibility, no event	
20040807 06:37:38	118.36999	31805	5 Fine visibility, no event	
20040810 18:12:28	272.36	48227	5	18:09:44 (1)
20040811 07:38:17	120.9	35685	5	07:08:37 (1)
20040813 18:18:20	126.82	42589	5	18:18:21 (2,3)
20040813 17:44:41	133.92	20026	5	17:42:19 (1)
20040816 09:20:23	93.93	37426	5	
20040816 09:43:04	82.62	37094	5	09:40:38 (1)
20040827 16:30:50	171.46	45104	5	16:30:00 (1)
20040827 18:49:01	576.46	26266	5	
20040830 08:55:03	120	29909	5	
20040830 11:49:49	114.54	72348	5	
20040830 14:09:07	134.94	28025	5	
20040830 15:15:47	117.98	53556	5 Cloudy, hard to distinguish anything	
20040830 19:51:42	157.88	26440	5	
20040905 07:57:41	182.8	37994	5	07:56:34 (2,3)
20040905 14:41:37	171.46	45004	5	
20040906 13:37:49	123.28	37076	5	
20041010 09:04:49	137.6	49037	5 Cloudy, hard to distinguish anything	
20041013 17:00:44	97.6	42073	5 Cloudy, hard to distinguish anything	

4. Comparative video images and seismic records analysis provides an opportunity to detect the onset of these sliding episodes in time and space, and evaluate the mechanisms of motion (Fig. 4). Additionally, this analysis allows us to document numerous explosion quakes and Strombolian explosions conducive to shaking instability (see Fig. 5 and Table 1).

3. The landslide phenomena of 30 December 2002 deeply eroded the SDF, creating a depression that in some points reached depths of several tens of meters. Afterwards, a reshape process began (Fig. 1), through other minor erosive episodes and the deposition of lavas, which were erupted contemporaneously within a part of the collapsed/eroded zone, until the end of the eruption (21 July 2003). The effusion of lava contributed to fill the depression, stabilizing a wide portion (more than 50 percent) of it and approaching a new gravitational equilibrium. Instead, in the zone of the landslides not reached by the lavas, erosive phenomena have continued to the present day, as evident from the progressive regression of the erosive rim, which has approached the crater zone (Fig. 2). These phenomena yielded several rockfalls and flowing debris.

Fig. 5 - Thermal image and snapshots taken from the INGV video cameras for a rockfall episode of our data set which was preceded by a Strombolian explosion ca. one minute before its onset.

The background photo is courtesy of Mike Burton. This work was supported financially by the Project V4/02 INGV-DPC