THE CRISIS OF SANTA ANA VOLCANO IN 2005
El desarrollo de la crisis del Volcán de Santa Ana en 2005
(El Salvador)


- Bowman L., White P. Locals’ perceptions of the influx of aid into los Planes de la Laguna, El Salvador after the October 2005 Santa Ana volcanic event. Environmental Hazards, in review
Average of 4,500 seismic events registered annually (1997-2007); 100 felt with different intensities (2001: 12,828 registered, 739 felt)

90% of the country is of volcanic origin

More than 700 eruptive centers <2Ma

21 volcanic edifices < 10,000 yrs.

9 with historic activity

6 included in the Permanent Monitoring Plan
Santa Ana-Izalco Volcanic Complex
Geological setting

- Active stratovolcano: 2381 masl, 1.5 Km crater diameter, acid water lagoon (pH=0.9-1.6, T=23-27°C)

- Basaltic – andesitic composition (lava flows and pyroclastic deposits)

- Last eruption: 2005; 4 more eruptions in historic times (1879-80, 1882, 1884, 1904) (Pullinger, 1998; Scolomacchia, 2010)

- Base line:
  - Low volcanic seismicity (RSAM = 20 units)
  - Permanent emission of gases ($SO_2$ = 400-600 ton/day)
  - Temperature of gases in fumarolic field: between 100-300°C
5,000 people living within the radius of 5 km. from the vent
Santa Ana Volcanic Complex is a forest-agricultural area, biodiversity and turistic resource
TECHNICAL / SCIENTIFIC INSTITUTION

- Geological Service
- Oceanographic Service
- Hydrological Service
- Meteorological Service
- Risk Management Sv. Comunication Dept.

Volcanology (3)
- Seismology
- Geology-Landslides

EXTERNAL CONSULTIVE GROUP
- UNIVERSIDAD DE EL SALVADOR
- USGS (USA)
- CENAPRED-UNAM (MEXICO)
- INSIVUMEH (GUATEMALA)
- OVSICORI (COSTA RICA)
- INETER (NICARAGUA)
- NOVAC PROGRAM
- RESEARCH GROUPS (UNIVERSITIES FROM US, MEXICO & SPAIN)

MEDIUM TERM RESEARCH PROJECTS
WORK ON-LINE AND PROMPTLY IN CASE OF A CRISIS

VOLCANIC MONITORING
VOLCANIC HAZARD ASSESSMENT

FORECAST REPORTS
PUBLIC OUTREACH

- ON-LINE INFO
- MEDIA ATTENTION
- MAPS & BROCHURES
- OUTREACH CAMPAINGS

INCREASE FREQUENCY IN CASE OF A CRISIS
Seismicity of Santa Ana Volcano, 2002-2005

Number of events

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<th>Year-month</th>
<th>5000</th>
<th>4000</th>
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<th>2000</th>
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Seismic Monitoring

Gas emission monitoring

Visual monitoring

Hydrochemical Monitoring
Information on-line of monitoring & hazard maps:

http://www.snet.gob.sv/vulcanologia
Precursory activity

- Increased gas emissions (1500-4000 ton/day SO₂)
- Seismic Rumors in Juayua (10 km west from vent (February & May 2005) ?
- Increased volcano-seismic activity
- Decreasing SO₄/Cl ratio within the crater lake water – Changes in color
- Small phreatic eruption (16/06/05)
- Acceleration of the increased seismic activity (August-September 2005)
- Incandescence in the fumarolic field (end of August 2005)
- Changes in the frequencies of seismic signal (28-30/09/05)
Precursory activity
Changes observed & felt by communities

December 2004 – August 2005

• Effects of Acid rain
• Increasing of SO₂ content in gases (health problems)
• Increase in gas pressure (jet sounds)
• Rockfalls inside crater, increase in rock alteration
• Phreatic eruption 16/06/05 (ash collected 2 km. from vent)

Ash fall in Finca los Andes (2 km. NE from the vent). Eruption of 16/06/05 (Photo by CATTIE)
Mapa de Escenarios de Amenaza Volcánica en el Volcán de Santa Ana
Fase Actual de Actividad 2004-2005

Leyenda
- Caída de balístico
- Escenario 1, caída de ceniza con espesores de más de 1 m a varios cm.
- Zona de diserpsión de ceniza para escenario 1, acumulación de algunos ml.
- Lahar de 100 ml m3
- Escenario 2, caída de ceniza con espesores de varios cm.
- Estaciones sísmicas

Outreach campaign  
(January - February, 2005)  
Talks (July, August, September, 2005)

Action & Communication protocols  
(1st version – February 2005)  
LEVELS of INTERNAL WARNING

PRE-AVISOS – PRE-WARNING (17/06/2005)  
- Increase periodicity of reports (1 per week).  
- Attention to media once per week (July-August)

AVISOS – WARNING (1/9/2005)  
- Reports (1 per day)  
- Attention to media twice per week (September)

ALERTA – ALERT (discussed on 30/9/2005)  
EMERGENCIA - EMERGENCY
Forecast & reports from technical institution were distributed in a horizontal way to all levels of the SINAPROC (web and fax)

CIVIL PROTECTION NATIONAL COMMITTEE
(CRISIS COMMITTEE)

CIVIL PROTECTION DEPARTAMENTAL COMMITTEE
(Regional Goverments)

CIVIL PROTECTION LOCAL COMMITTEE
(Municipalities & Communities)

Forecast & reports from technical institution were distributed in a horizontal way to all levels of the SINAPROC (web and fax)

<table>
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<tr>
<th>Nivel de Actividad</th>
<th>Probabilidad de Erupción</th>
<th>Peligrosidad</th>
<th>Distancia a partir del cráter</th>
<th>Recomendaciones Generales</th>
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<td>Muy Alta</td>
<td>Dias</td>
<td>Muy alta</td>
<td>5 Km.</td>
<td>Generalmente: actividades. Solo podrán autorizarse acciones de: - Investigaciones en volcánología de instituciones nacionales e internacionales. - Emergencia acompañada de personal de instituciones asociadas. Funcionarios de instituciones de atención a la emergencia realizarán labores de vigilancia y auxiliador. - Autoridades policiales en labores de seguridad.</td>
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<tr>
<td>Alta</td>
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<tr>
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<td>Generalmente: actividades. No se autorizan acciones.</td>
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<td>Baja</td>
<td>Meses o años</td>
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<td>Baja</td>
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<td>Generalmente: actividades. No se autorizan acciones.</td>
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Ash fall mainly on the west flank (1/10/2005): 1,5 Mm³ (aprox. 0.0015 Km³)
South & East flanks of Santa Ana Volcano

7 January 2006 (Michigan Tech University)
Ballistic Projectiles

(maximum distance 2.5 km. from the vent)
Effects of blast and surge deposits on the east flank
Primary lahar occurred at southeast flank (1/10/2005)
Effect of Hurricane Stan
(01/10/05 to 06/10/05 – >700mm)

Mapa Preliminar de Depósitos Volcánicos, Flujos de Escombros y Caida de Ceniza por la erupción del 1 de Octubre del 2005 del Volcán de Santa Ana.
### Immediate and Longer Term Impacts

#### Primary Impacts to Population During the Santa Ana Crisis
- Health impacts due to gases and ash
- Damage to agriculture, mainly high-altitude coffee plantations. Loss of forest
- Self evacuation of 2 communities (San Blas & Palo Campana): 4,850 people
- 2 casualties
- Damage to infrastructure (roads and water tanks)
- Property Loss: 500 homes

#### Secondary Impacts (Entry of Hurricane Stan)
- 6 Casualties in Coatepeque Area
- 10 Municipalities affected
- Evacuation & shelter stays: 18,759 (72,000 entire country)
- Property Loss: 483 (destroyed) – 812 (damaged)
- Damage to infrastructure (road, services, etc.)

#### Long Term Impacts
- Prolonged shelter stays: 5,676 people after 2 month.
- Losses: 114 M$ (entire country)
- Lahars occurred during 2005, 2006 & 2007 rainy seasons
- 300 families affected during the construction of mitigation infrastructure in 2006
New versions of Scenario Hazard Maps
(October 2005, SNET-UNAM)

• Used in 2º outreach campaign
(December 2005-January 2006)
# STRENGTHS AND WEAKNESSES

**Disasters are an opportunity...**

- Improvement of equipment for volcanic monitoring (web cam, infrared camera, DOAS, GPS)
- Better understanding of Santa Ana Volcano eruptive behavior
- Some hazard maps with different scenarios were created

**But it is still necessary...**

- To increase the capacities of interpretation of all information provided by monitoring
- To standardize data representation, storage & lessons learned
- To build a data base of the geology & deposits of Santa Ana Volcano (& all active volcanoes).
- To improve the existing hazard maps & to explore new hazard scenarios

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- Increase of trust in scientific local authorities (government)
- Communication between technical & civil protection authorities about volcanic phenomena (during crisis)
- Communication with media professionals
- Recent memory: “volcanic activity is real”

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- To increase the trust in scientific and civil protection authorities (communities)
- To maintain communication between technical & civil protection in times without crisis. Update protocols.
- Specialized media professionals
- To develop and maintain educational programs in volcanic areas.
ROLES OF THE VOLCANOLOGISTS DURING THE CRISIS

MONITORING AND DATA PROCESSING – ELABORATION OF REPORTS

CRISIS COMMITTEE

MEDIA ATTENTION

GENERAL PUBLIC INFORMATION
Thanks for your attention
Gracias por su atención