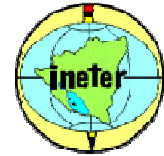




NICARAGUAN INSTITUTE OF TERRITORIAL STUDIES (INETER)



GENERAL DIRECCION OF GEOPHYSICS

DIRECCIÓN OF APPLIED GEOLOGY

# Methods for instrumental monitoring of landslides in Nicaragua

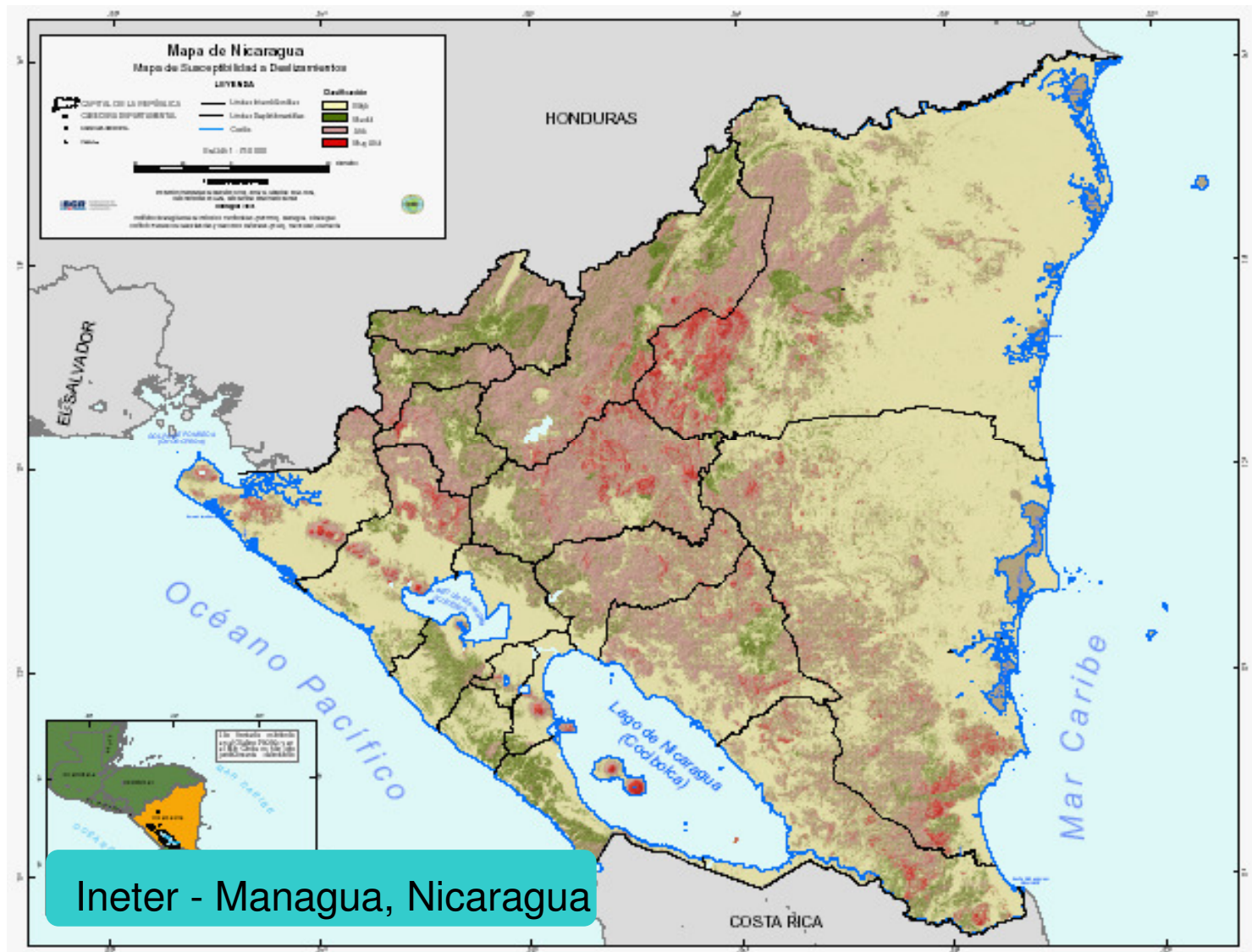
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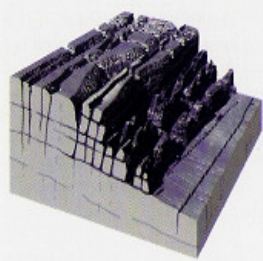
Doctor **Tupak Obando**  
Geologist Engineer

MANAGUA – November 2008

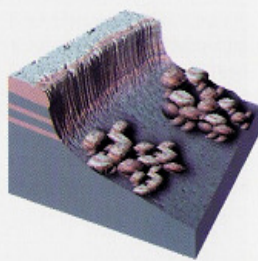
*Email: [tobando\\_geologic@yahoo.com](mailto:tobando_geologic@yahoo.com)*

# Susceptibility of Landslides in Nicaragua

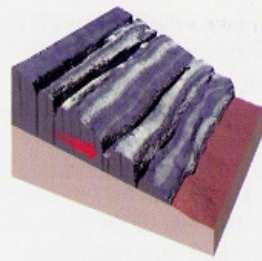




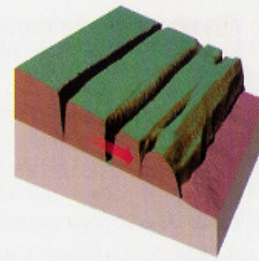
Desprendimiento tipo Vuelco



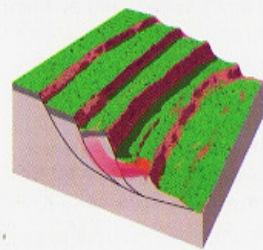
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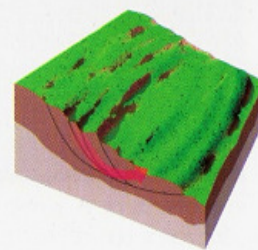
Deslizamiento Traslacional en roca



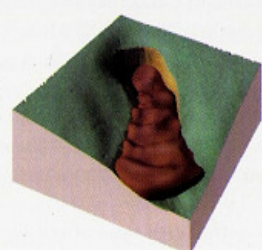
Deslizamiento Traslacional en suelo



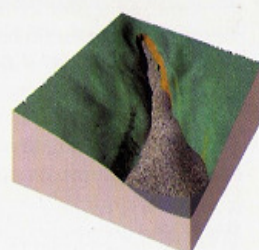
Deslizamiento rotacional 1



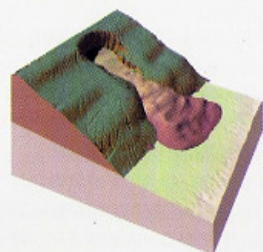
Deslizamiento rotacional 2



Colada tipo Flujo de Lodo



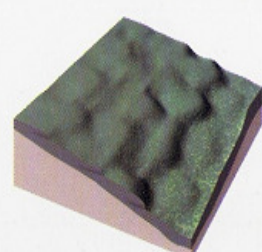
Colada tipo Derrubio



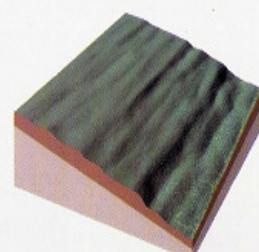
Flujo de Suelo



Flujo de Derrubios



Colada tipo Solifluxión



Colada tipo Reptación

Type Movements	Percent distribution (%)	Slope Angle (°)	Type material
Rock Fall	4	30	andesita, basalt, ignimbrite, dacites, riolites, conglomerates, schist, granite
Slides	24	20 - 45	Schists, Phyllites, basalt, ignimbrites, andesitas, dacites, conglomerates, granites, colluvial deposits and residual soil
Debris (earth and mud flow)	66	15 - 35	They involved soil, colluvium and weathered rock (schists, phyllite, ignimbrites, conglomerates), pyroclastic material and ashes, block of lavas, and pyroclastic deposits

Sources: Devoli,2008 (Doctoral Thesis)

**Total: 17,000 landslides**

**ROTURE MECHANISM**

Source: Pobres x desastres (2,007)



# Purpose of landslides monitoring

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To understand the past and current behavior of instability of lands, which allows to **evaluate the hazard that these represent**, and particularly, the possibility to preserve constructions.





To know parameters that **determine the movement of land**, for generating engineering works, and to control their final stabilizer effect.

To determine the evolution of soil movements to **emit forecasts based on their future behavior**. It can be defined by variations of amplitude of the movements which affect the mass of land or the buildings (cracks), so that they work as material test in juridical actions



This step will lead, whether the declaration or not, of a  
**State of Alert**

Example: Cerro El Volcán (Dipilto) and communities La Tablazón, El Volcán, Las Nubes y Dipilto Viejo

STATE OF ALERT	
<input type="checkbox"/> For rains of 60mm with 3 hours of duration	
<input type="checkbox"/> Rains of 100mm, with 6 hours of duration	
<input type="checkbox"/> Rains of 150 - 300mm, with 12 hours of duration	 <i>Evacuation</i>
<input type="checkbox"/> Rains > 300mm with 24 hours of duration	

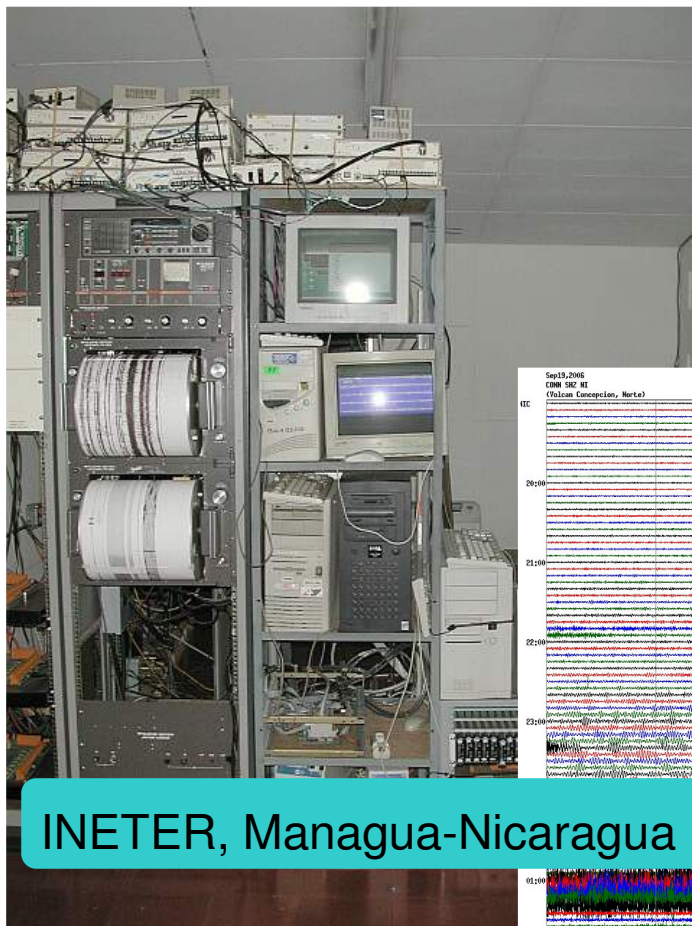
**Source:** Cruz (2005)

## a)METHODS:

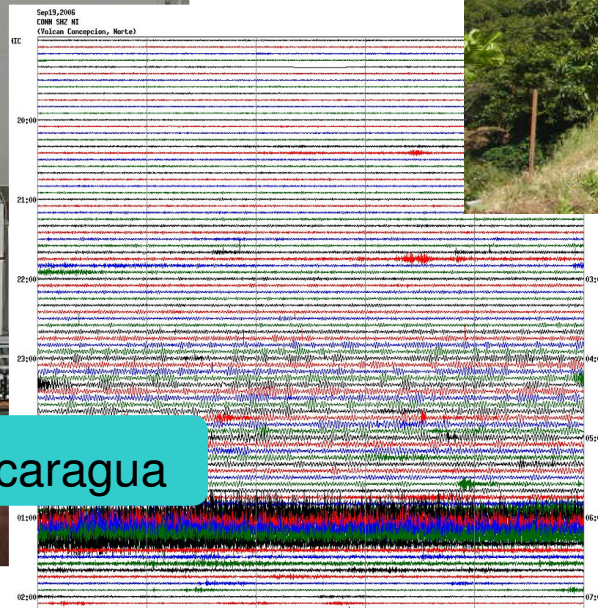
- ❑ **Daily mensuring:** It implies the **definition of responsible-observers of rain precipitation** or specific landslides



- ❑ Registrations of datas: This task is characterized by an organized registration. The information is distributed to the drawees of decision (communal representatives and local authorities) by radio communication net



INETER, Managua-Nicaragua



Dipilto, Nueva Segovia



## □ Analysis and forecast of the information:

It is an essential task the definition of protocols that **guarantee security and validity of the information** without **generating false alarms** and rumors.



Dipilto, Nueva Segovia

El Cuá, Jinotega





The analysis of the information allows to settle down preventive orientations for preserving human lives of people living in that place. To reach this, it is required a training process and to have open minds about the meaning of the alerts.

Mateare, Managua



**San José de Cusmapa  
(Madriz, Nicaragua)  
October 2008**



## B) PRINCIPAL INSTRUMENTS OF MENSURATION-SURVEILLANCE

**Radio-communication:** A support equipment to transmit and transfer information between different places



Dipilto, Nueva Segovia, 2008



**Pluviometer:** It measures the quantity of rain (in mm) in a specific place through a direct visual reading. The simple pluviometer (of a direct visual reading) has a recipient and a funnel. Data are taken every 12 hours of pluviometer readings.

Dipilto, Nueva Segovia,  
2008

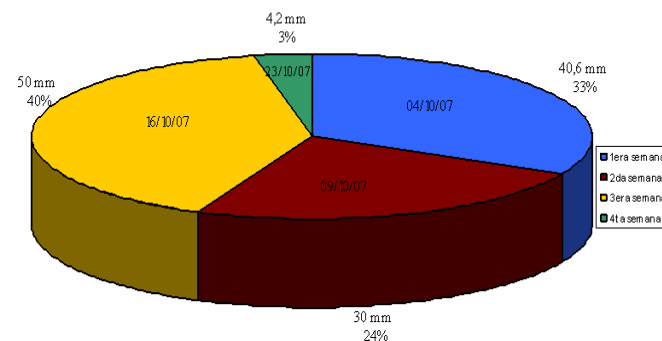
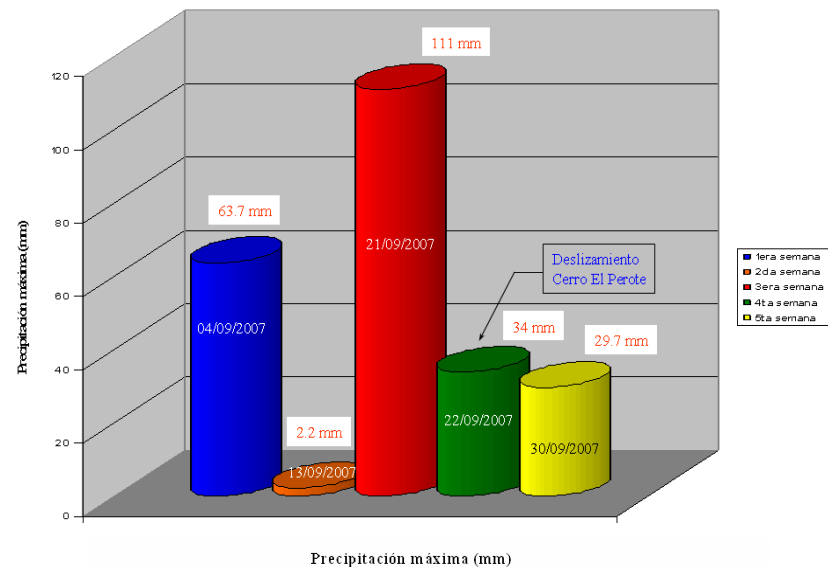


## □ Registration of meteorological variables:

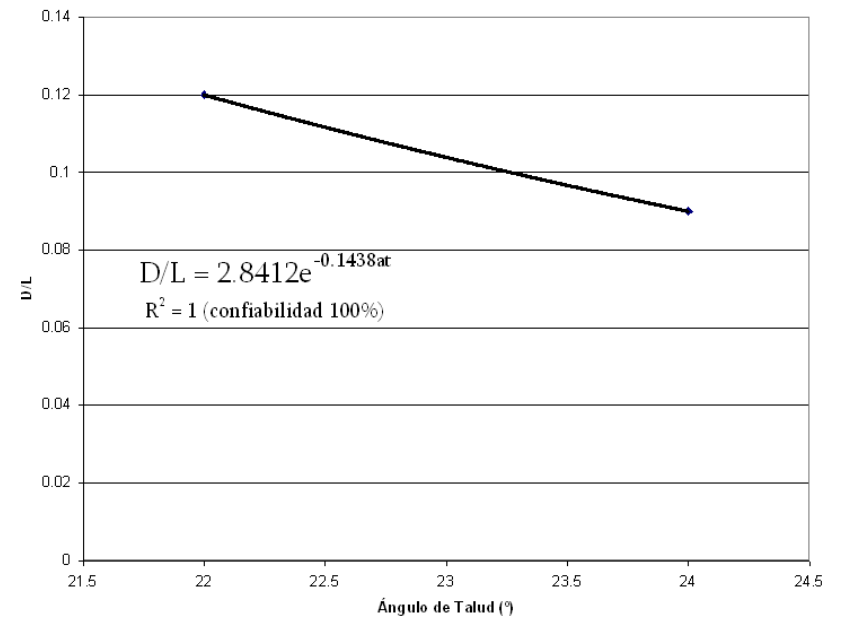
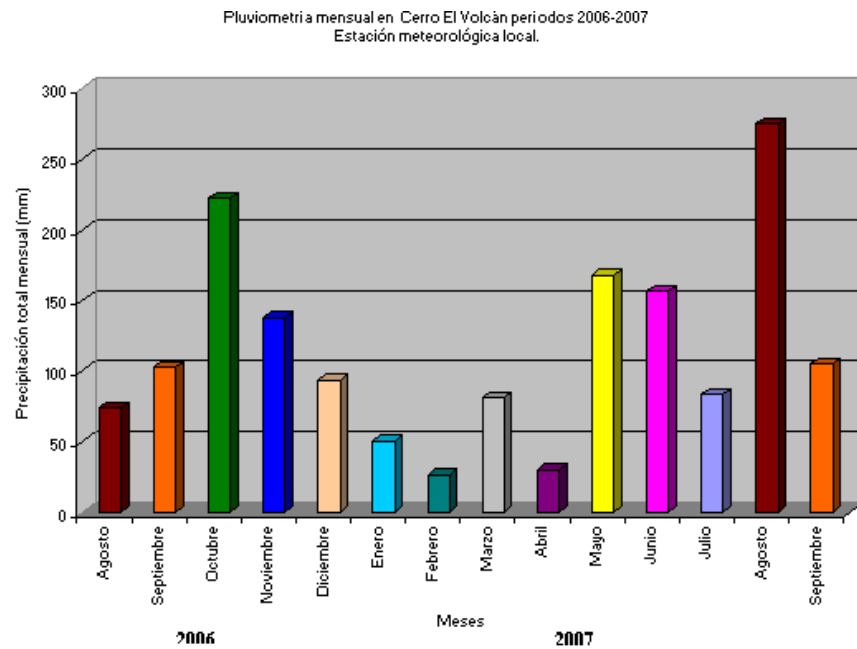
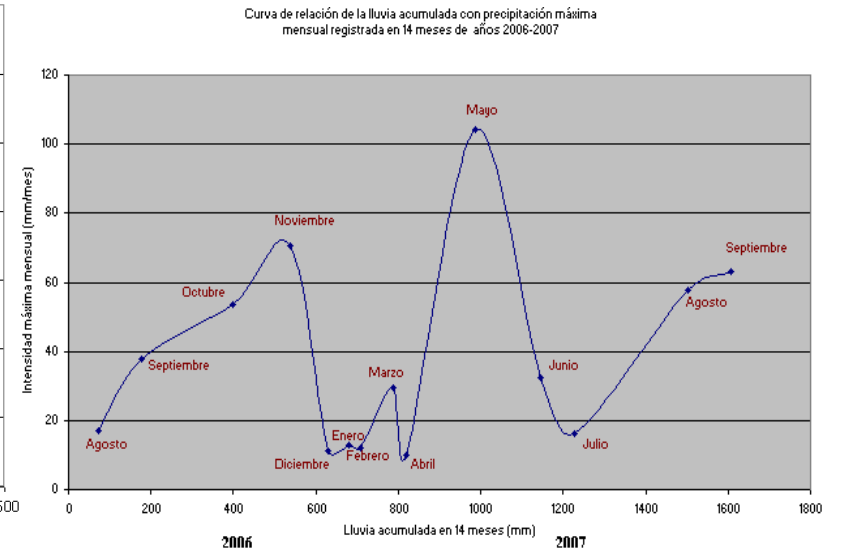
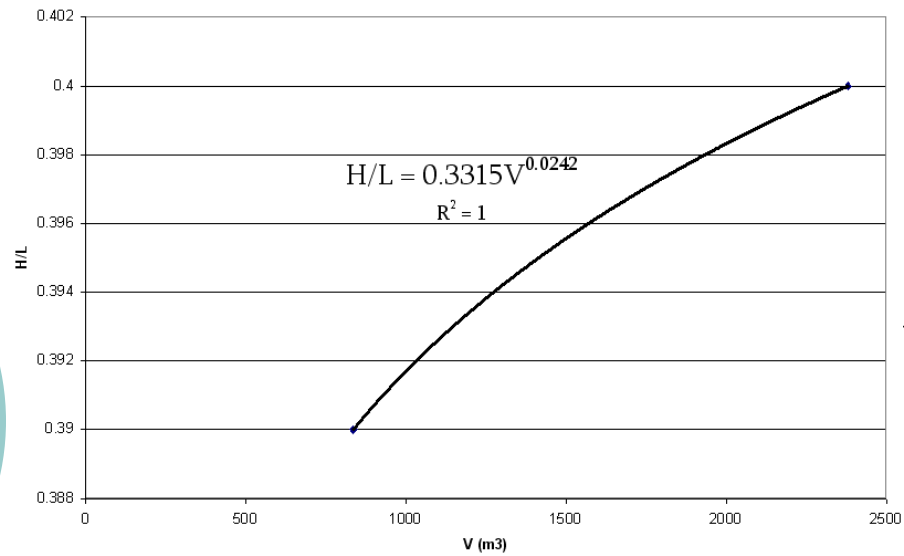
In this place, it's recorded in format digital data based on weather conditions, temperature, humidity, velocity and direction of wind, and the quantity of daily accumulated rain.



Dipilto, Nueva Segovia







## □ Field geology

Santa Teresa, Carazo



Estelí, 2008



San Juan de Río Coco, Madriz, 2008



Volcán Mombacho, Granada, 2008



Centro de Salud de Murra, Matriz, 2008



San José de Cusmapa, Matriz. 2008



## Proposition of Systems of Detection of Landslides



**Extensometer tape**



**Inclinometer**



**Piezometer**



**Extensometer**

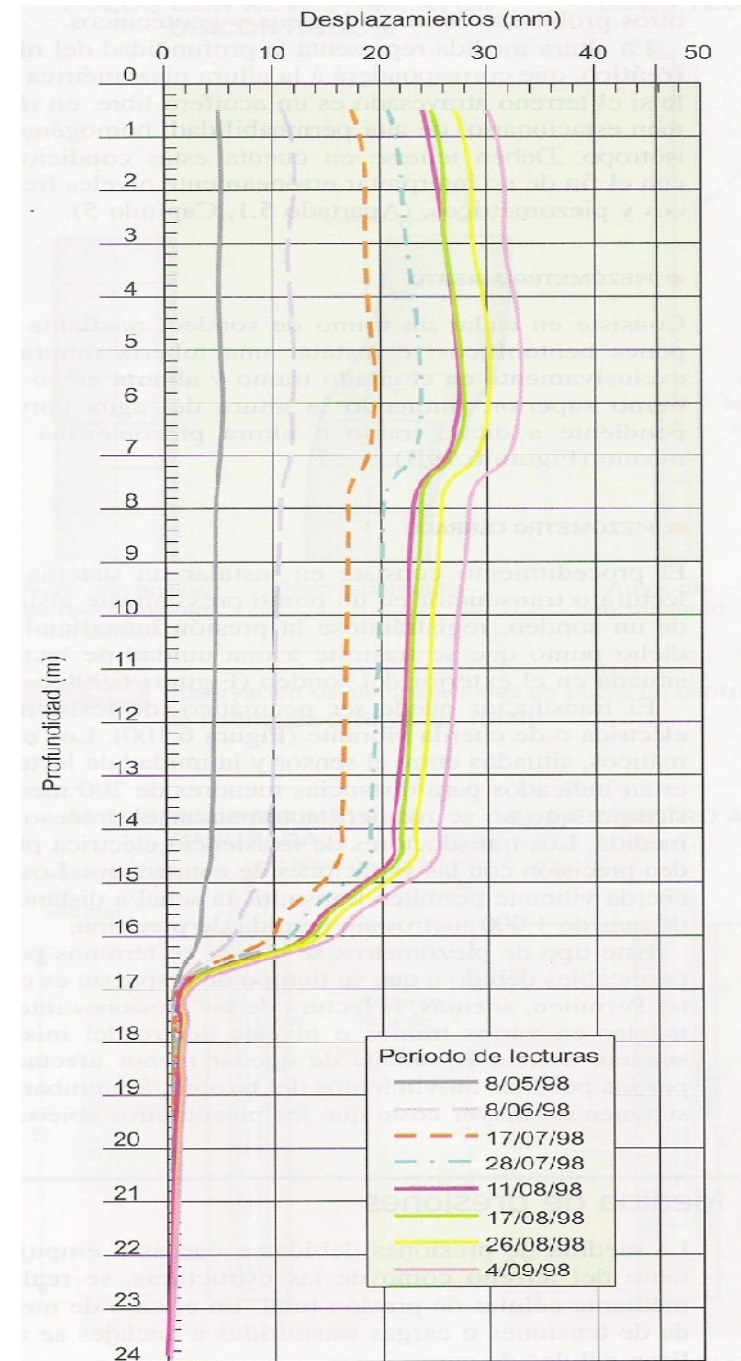
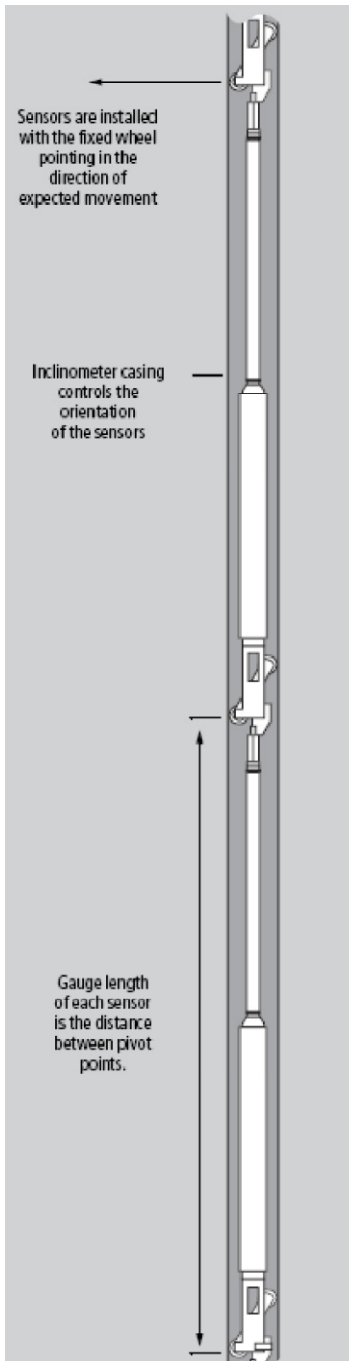




## GEOTECHNICAL INSTRUMENTAL TO:

- ☐ Locate rupture areas in depth
- ☐ Quantify the movements against time
- ☐ Calculate velocity and direction of displacement of landslides (that is, to locate the most instability area)
- ☐ Predict the rupture of soil

# INCLINOMETER



Equipo	Funciones/Características	Imagen
<b>Inclinómetro vertical biaxial Sisgeo Accutilt RT-20MS</b>	Sonda inclinométrica biaxial, rango de medida 50° respecto la vertical. Resolución: $\pm 0.02$ mm por 500 mm. Dimensión del cuerpo central f 25.4 mm.	
<b>Central inclinométrica Sisgeo C800U</b>	Equipo de medición y adquisición de datos inclinométricos, modelo ACCULOG-X, con puerto de comunicación RS-232 con batería recargable.	
<b>Inclinómetro horizontal uniaxial Roctest RT-20 HM</b>	Sonda inclinométrica uniaxial, rango de medida 50° respecto la vertical. Resolución: $\pm 0.02$ mm por 500 mm., f 42 mm largo 790 mm y distancia entre rozamientos 500 mm.	
<b>Central inclinométrica Roctest Acculog-X</b>	Equipo de medición y adquisición de datos inclinométricos con lectura simultánea de los ejes A/B en gráficos LCD. Menú interactivo. Incrementos automáticos después de la validación de cada punto.	

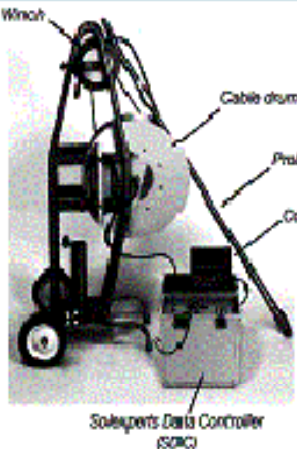

# Inclinometer

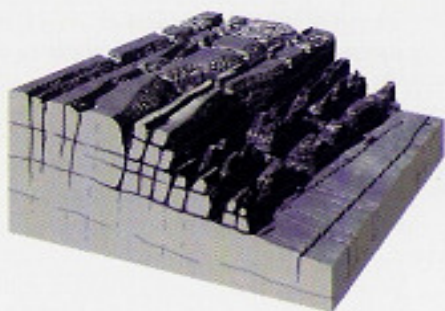
Equipo	Funciones/Características	Imagen
<b>Extensómetro de Cable Flexible Roctest WR-Flex</b>	Medidor de asientos con rango de lectura 25, 50, 100, 150, 250 y 300 mm Precisión 0.1 a 0.5%F.S. con resolución 0.01 a 0.025 mm	
<b>Central de Toma de Datos Automatizada Roctest SENSLOG 1000X</b>	Datalogger para monitorización remota de hasta 225 canales. Ver ficha técnica adjunta.	
<b>Extensómetro de Varillas Sisgeo</b>	Medidor de asientos con rango de lectura 25, 50, 100, 150, 250 y 300 mm Precisión 0.1 a 0.5%F.S. con resolución 0.01 a 0.025 mm	
<b>Automatic Read Out</b>	Unidad de lectura portátil, registra los datos de posición, fecha y tiempo de lectura en formato transferible a PC	

# Extensometer

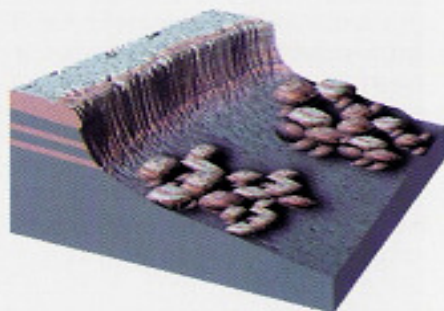


# Micrometer

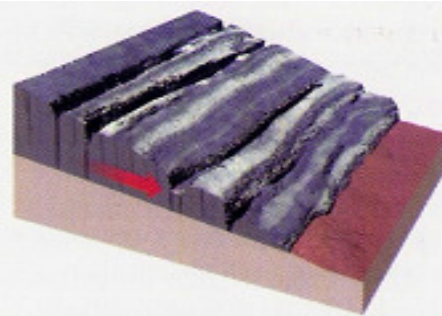
Equipo	Funciones/Características	Imagen
<b>Sliding Micrometer Solexperts</b>	Medidor de la distribución de deformaciones y de los desplazamientos axiales en suelo, roca o hormigón. Rango de medida de 10 mm ( $\pm 5$ mm), exactitud $\pm 0.003$ mm y precisión de 0.001 mm	
<b>Read out sliding micrometer SDC</b>	Unidad de lectura portátil con interfase serie RS-232, memoria de almacenamiento del orden de 8000 valores, acumulador y medida en los tres ejes (x, y, z)	



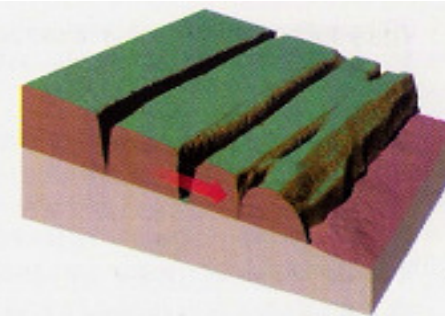
Desprendimiento tipo Vuelco



Desprendimiento tipo Desplome

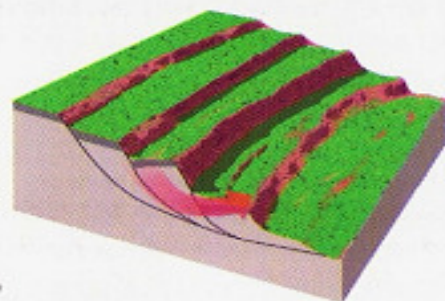


Deslizamiento Traslacional en roca

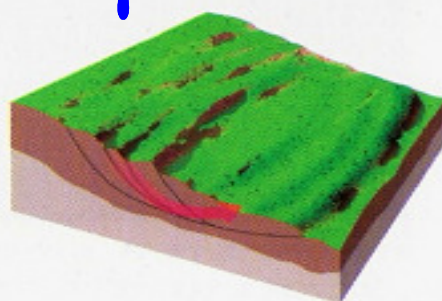


Deslizamiento Traslacional en suelo

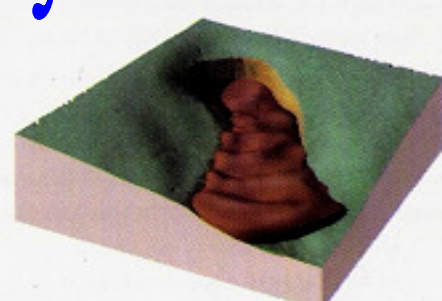
¡Thank you!



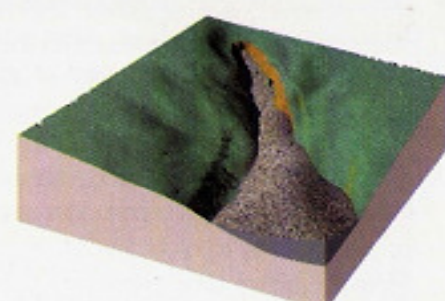
Deslizamiento rotacional 1



Deslizamiento rotacional 2

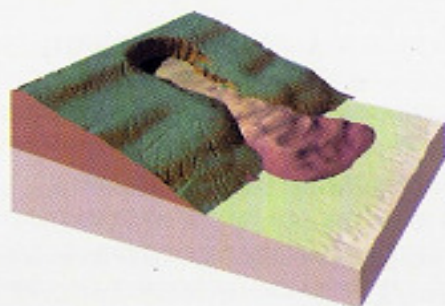


Colada tipo Flujo de Lodo



Colada tipo Derrubio

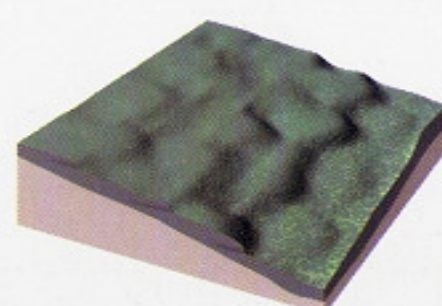
Roture Mechanism



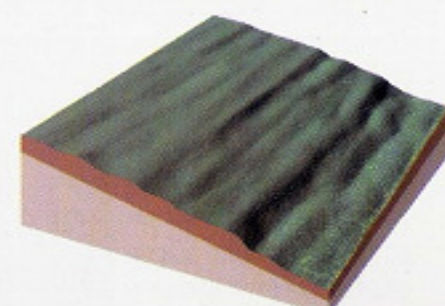
Flujo de Suelo



Flujo de Derrubios



Colada tipo Solifluxión



Colada tipo Reptación