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## 2. LANDSLIDES

The January 13, 2001 Off the Coast of El Salvador Earthquake



Cars destroyed in the slid soil mass, Las Colinas

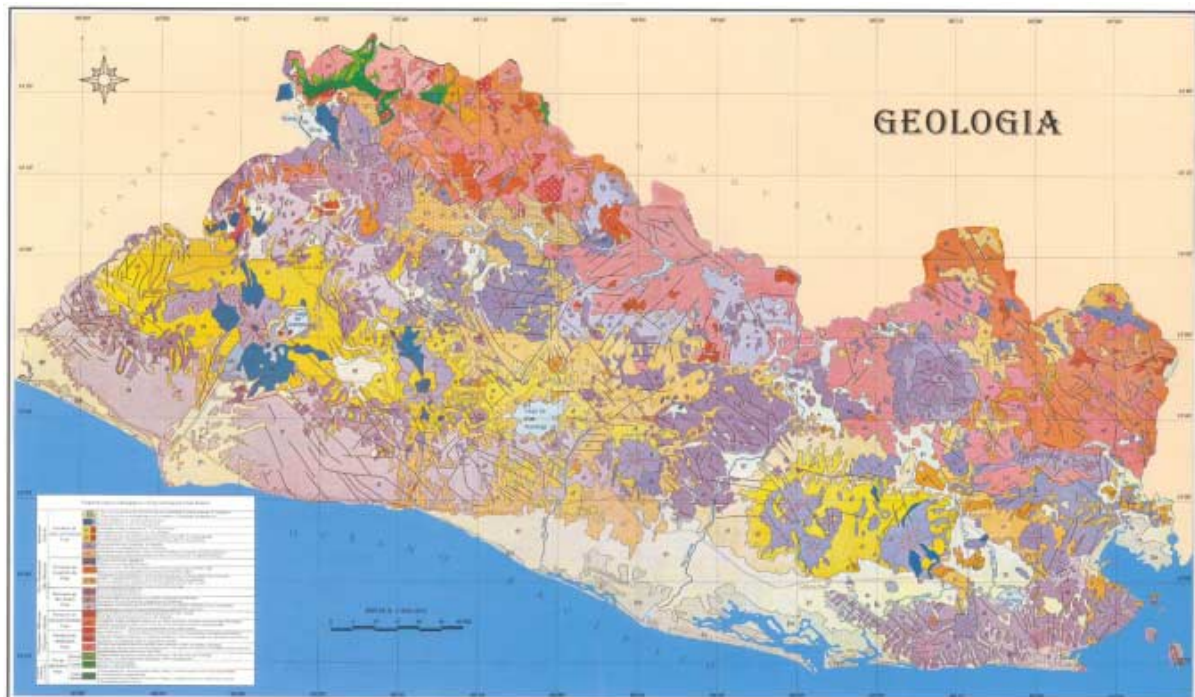


## 2.1 INTRODUCTION

One of the most spectacular aspects of the January 13 earthquake was the damage inflicted by landslides. Among them, Las Colinas landslide was the most tragic. A huge amount of soil mass (about 200,000 m<sup>3</sup>) was thrown off the rim of a mountain ridge rising south behind Las Colinas area of Nueva San Salvador (Santa Tecla), and destroyed many houses causing more than 500 deaths. The intense shake was also responsible for total 445 landslides in El Salvador. This chapter describes some important features of these landslides highlighting the Las Colinas landslide, and discusses possible measures for reducing loss of human lives and social disruptions.

## 2.2 GEOLOGY

**Figure 2.1** is a surface geological map of El Salvador (Ministerio de Economía, 2000). The oldest formation in El Salvador from the Jurassic period (208 ~ 146 Ma) is found around Metapan, a city in the northern part of El Salvador, while the youngest formation at San Salvador is from the Holocene period (after 0.011 Ma). The geology of El Salvador can be outlined as follows: The formations spreading over both the south coastal region and the mountainous region north of the San Salvador (Morazan group) are from the Holocene period, and they were formed during the Oligocene to the Miocene periods. The middle region of the country consists of the Balsamo group formations from the Pleistocene period. Volcanic and igneous rocks are distributed nation-wide in El Salvador. Basalts, andesites, rhyolites, lavas and pyroclastic rocks are found in mosaic. Alluviums are found spread only along the southern part of the coastal region. Granites and limestones are found isolated in a small region at the northwest end of the country.



**Figure 2.1** Geological map of El Salvador (Ministerio de Economía, 2000)

## 2.3 LANDSLIDES DISTRIBUTION

Landslides caused by the January 13 earthquake were found nationwide. The statistics from the National Emergency Committee, COEN (**Table 2.1**, Comité de Emergencia Nacional) shows that the majority of the total 445 landslides occurred in La Libertad, La Paz, Sonsonate, Santa Ana, Usulután, San Salvador and San Miguel.

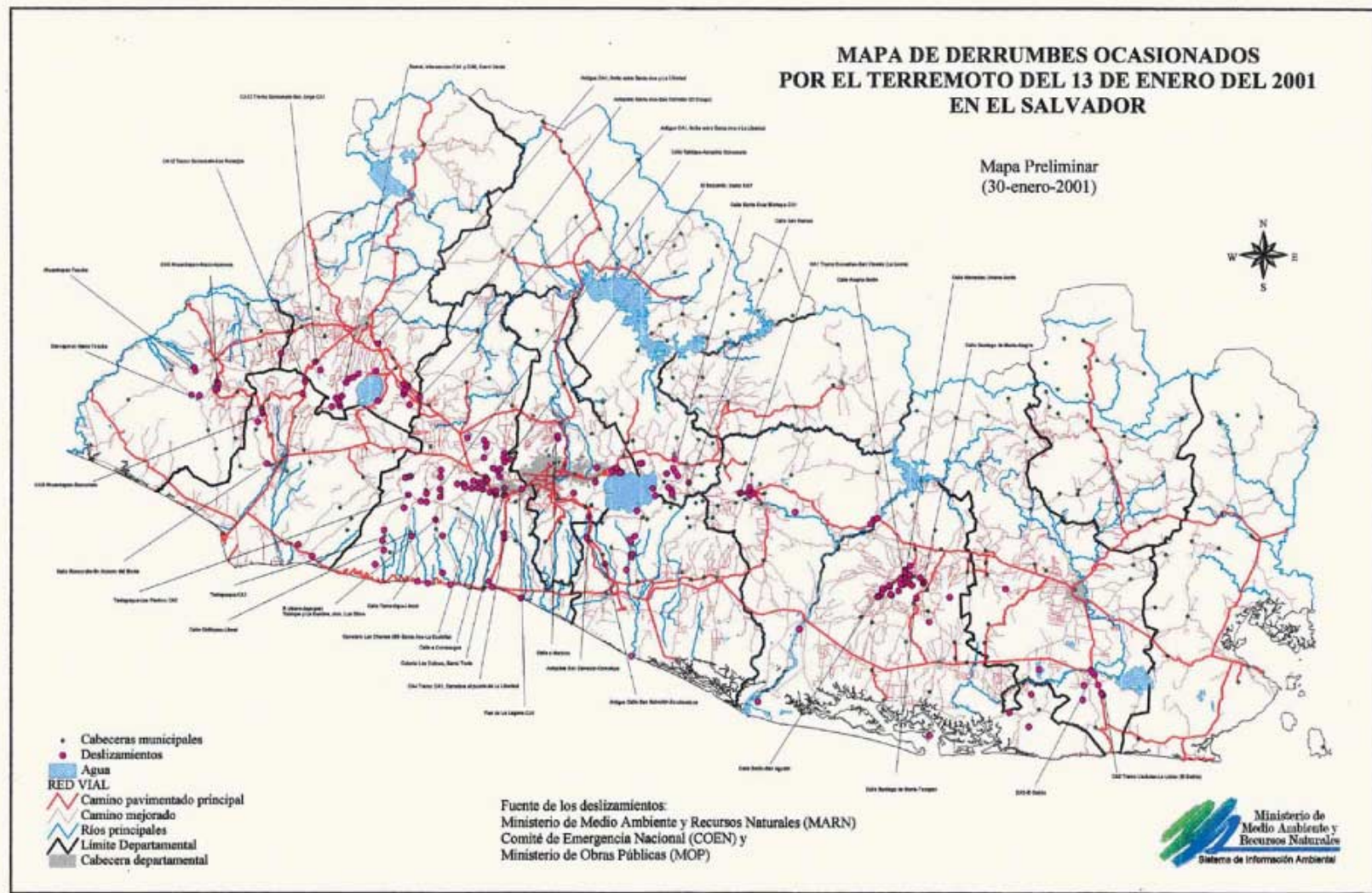
The Las Colinas landslide in La Libertad was one of the largest landslides. Another large landslide to the west of San Vicente blocked the Pan-American Highway.

Ministry of Environment, MARN (Ministerio de Medio Ambiente y Recursos Naturales) built up a GIS (Geographical Information System) database of earthquake-inflicted landslides (**Figure 2.2**) immediately after the Jan. 13 event. The database describes landslides in terms of their locations, scales, instabilities and diagnoses. The database covers the information not only from MARN, but also from COEN and MOP (Ministerio de Obras Públicas). In **Figure 2.2**, purple dots show the locations of all registered landslides on the GIS database (January 30, 2001). Both **Figures 2.3** and **2.4** show locations of landslides on topographical and geological maps, respectively (Ministerio de Medio Ambiente y Recursos Naturales, 2001). The landslides are mostly found:

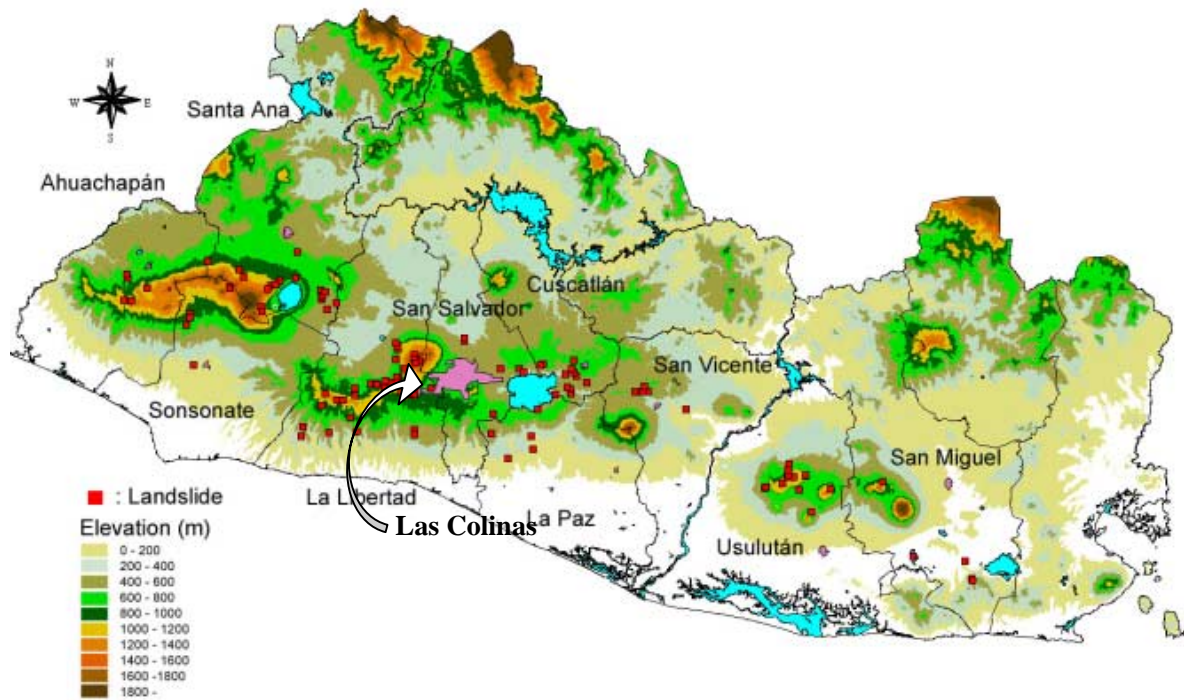
1. on some mountainsides of such volcanoes as Santa Ana, San Salvador, Chichontepec and Tecapa, and thus,
2. on some pyroclastic and/or volcanic epiclastic deposits such as "tierra blanca" and "tobas color cafes".

**Table 2.1** Damage statistics (Comité de Emergencia Nacional, 2001)

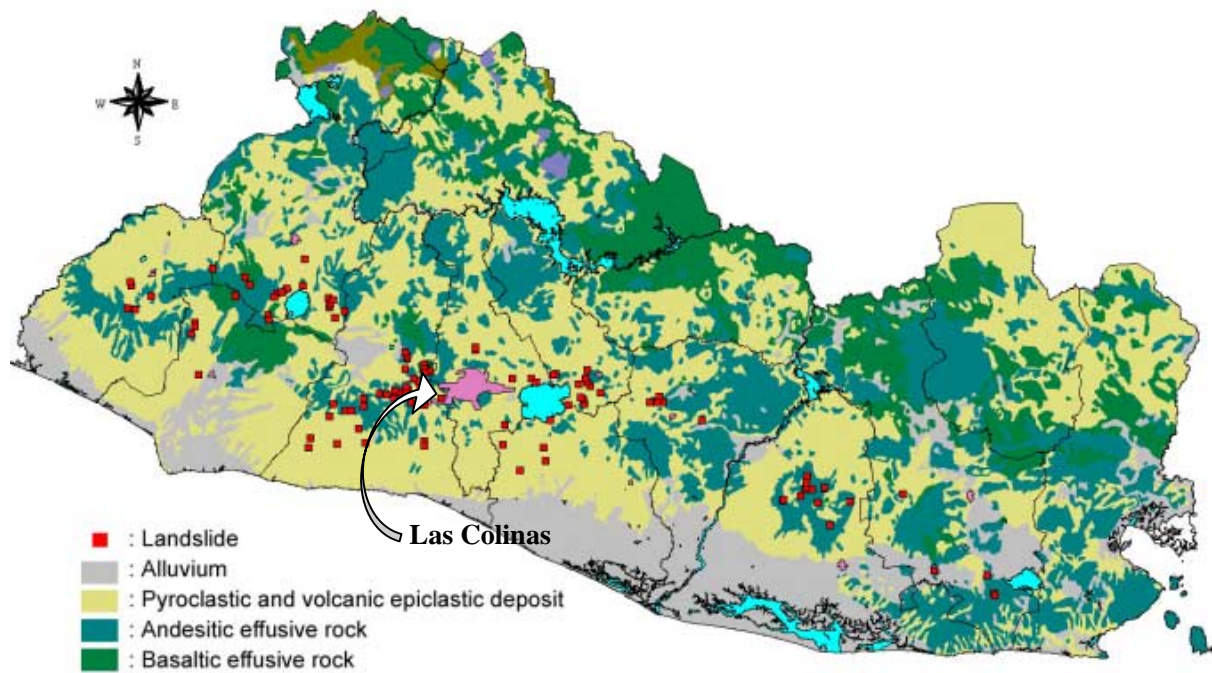
Prefecture	Death	Injured	Damaged public buildings	Damaged houses	Collapsed houses	Buried houses	Landslide
La Libertad	685	2183	48	14558	15723	687	20
La Paz	44	147	272	25076	17996	0	75
Sonsonate	48	1295	38	17773	10501	0	82
Santa Ana	47	327	5	13925	4823	0	27
Cuscatlán	20	43	47	4762	4282	0	17
Usulután	27	786	335	30716	29293	0	38
San Salvador	24	391	76	12836	10372	0	133
San Miguel	19	43	23	10624	2902	0	26
San Vicente	29	81	40	17292	5218	0	4
La Unión	1	8	98	2136	268	0	1
Ahuachapán	0	247	60	18540	6553	0	12
Cabañas	0	7	31	1153	309	0	4
Morazán	0	3	35	94	5	0	1
Chalatenango	0	4	47	307	16	1	5
<b>TOTAL</b>	<b>944</b>	<b>5565</b>	<b>1155</b>	<b>169692</b>	<b>108261</b>	<b>688</b>	<b>445</b>



**Figure 2.2** Distribution of landslides  
(Ministerio de Medio Ambiente y Recursos Naturales, 2001)



**Figure 2.3.** Landslides locations plotted on a topographical map (Topographical map: Ministerio de Medio Ambiente y Recursos Naturales, 2000)



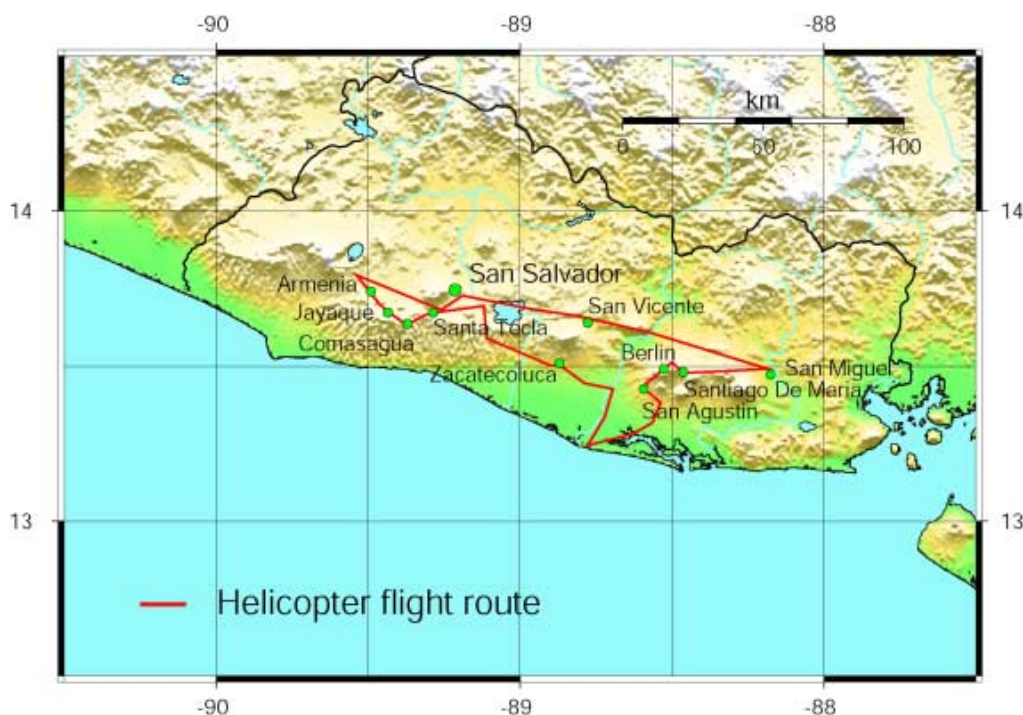
**Figure 2.4.** Landslides locations plotted on a geological map (Geological map: Ministerio de Medio Ambiente y Recursos Naturales, 2000)

## 2.4 AERIAL VIEWS OF LANDSLIDES

Some members of the JSCE reconnaissance team made a quick inspection with a helicopter provided by the Salvadorian National Army on February 3 to get an overview of the nationwide geo-hazards, damage to buildings and infrastructures. The team, after departing from San Salvador military base, took the path shown in **Figure 2.5** counterclockwise first toward San Miguel and then back toward Armenia. They flew over some large cities including Santa Tecla, San Salvador, Zacatecolca and San Miguel as well as some small towns such as Jayaque, Comasagua, San Agustín and Santiago De María. Damage to buildings and infrastructure will be described in the following sections.

Most landslides are found in vicinities of volcanoes. The overviews of these landslides follow area by area:

1. Sonsonate: Small slides of rock and soil occurred around the Lake Coatepeque in a crater to the east of the Santa Ana Volcano.
2. La Libertad: Many landslides including Las Colinas landslide occurred around the San Salvador volcano and other mountains (**Figures 2.6** and **2.7**). Traffic on mountain roads leading to small towns was suspended by these slope failures. The western stretch of the Pan American Highway from San Salvador was blocked at several points in Los Chorrros. **Figure 2.8** shows the Las Colinas landslide, which was responsible for the loss of more than 500 lives. Details of the Las Colinas landslide will be described in the next section.
3. Cuscatlán: Young pyroclastic deposits ("tierra blanca") slid down steep crater walls of Lake Ilopango (**Figure 2.9**).
4. San Vicente: A great amount of soil mass blocked the Pan American Highway (**Figure 2.10**). Bulldozers were removing the slipped soil mass.
5. Usulután: Rocks fell down slopes of Tecapa Volcano near Belrin.
6. San Miguel: Very few landslides were reported in the eastern part of the country.



**Figure 2.6** Helicopter flight route



**Figures 2.6 (left) and 2.7 (right).** Landslides on mountain slopes, La Libertad



**Figure 2.8** Las Colinas landslide, La Libertad



**Figure 2.9** Steep slope failures around Ilopango Lake, Cuscatlán



**Figure 2.10** Blocked PanAmerican Highway, San Vicente



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