from liquefaction of shallow sand deposits. The lateral offsets along the margins are consistent with an overall movement of the valley deposits to the west, which is downslope. The United States Geological Survey (USGS) has completed extensive mapping and trenching of the canyon (Personal communication with David Schwartz, 1994). Trenching on the southern margins of the canyon exposed vertical cracks extending into bedrock bedding plane shears whose orientations support dynamic compaction. Bedrock offsets and infilled cracks reveal two prior tectonic events which produced approximately the same magnitude of vertical offsets. These events are being dated, and preliminary results indicate that the most recent event occurred approximately 1200 years ago, and the earlier event occurred during late Holocene. Investigation of the mechanisms which produced the ground deformation at Potrero Canyon are ongoing by several groups.

Coastal Areas

Sand boils, settlement and lateral spreading were observed in a number of coastal areas including Santa Monica, Marina Del-Ray, Redondo Beach, and the Port of Los Angeles. At the Santa Monica Municipal Pier parking lot, liquefaction resulted in pavement cracking subparallel to the coast from lateral spreading, as well as a number of sand fissures and sand boils. Further inland, ten breaks occurred at various points in the City's water distribution system, suggesting possible localized ground failure at these locations as well. Investigations into the potential causes of these inland ground failures are ongoing.

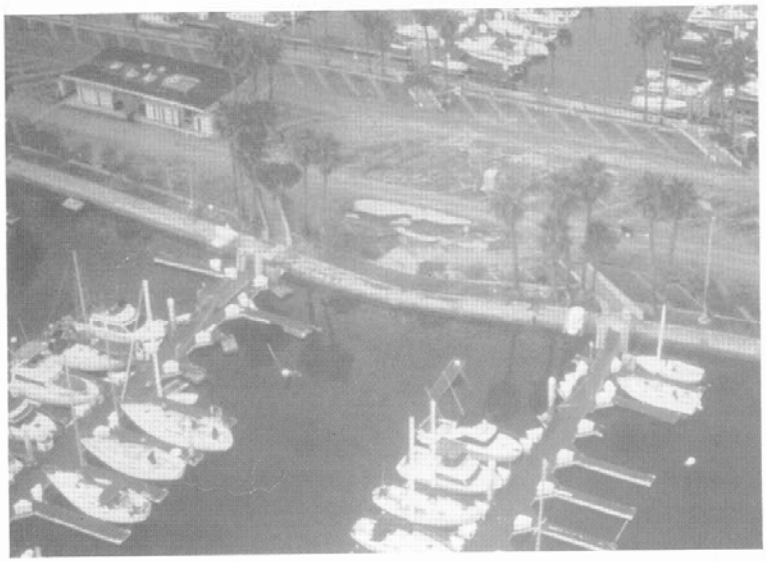

Figure 11. Aerial view of Mole B at King Harbor, Redondo Beach. Note movement of bulkhead wall and ground distress in parking area behind wall. (photo courtesy of Dr. John Tinsley, U.S. Geological Survey)

Further south, liquefaction was reported to have caused a large ground fissure in an artificial beach area between Palawan Way and Panay Way in Marina del Rey. In Redondo Beach, at the Mole B area of King Harbor, liquefaction-induced settlement and lateral spreading of loose sandy fill materials ruptured a number of utility lines and lead to the failure of a bulkhead wall as shown in Figure 11.

Modest liquefaction of soils at the Port of Los Angeles' America President Lines container terminal was reported to have caused lateral movements of a pile-reinforced dike which resulted in up to 1 foot of settlement of the backfill soil. This damage resulted in closure of the berth for about 4 days as repairs were made.

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Landslides

Gretchen Rau, Scott Ashford, Nicholas Sitar, and Jorge Zornberg

The Northridge Earthquake caused scattered rockfalls and landslides throughout Los Angeles and Ventura Counties. The landslides were distributed across an area radiating approximately 25 kilometers from the epicenter. Major landslides occurred in the Santa Monica and San Gabriel Mountains, causing road closures and destroying homes. Most of the other landslides occurred in non-urban regions such as the Santa Susana Mountains.

Figure 12. Aerial view of landslide at Pacific Palisades

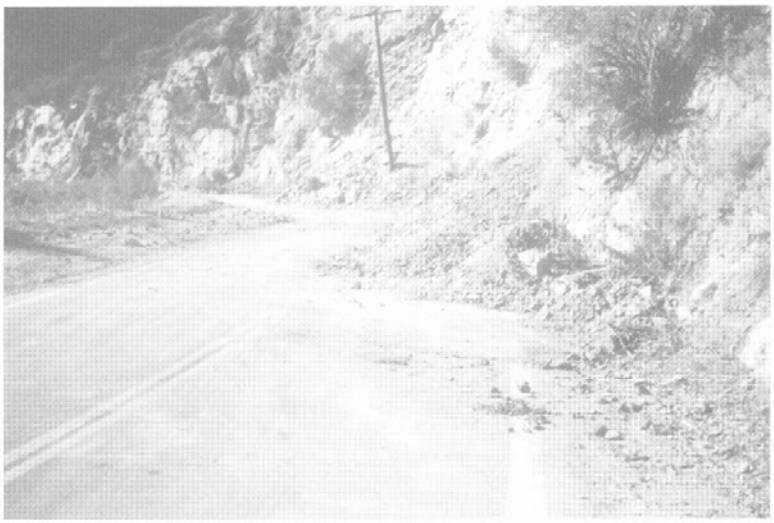

Figure 13. Road closure at Dillon Divide, Little Tujunga Road. (photo courtesy of Ray Salehpour, County of Los Angeles Department of Public Works)

Numerous rockslides and landslides which occurred in the largely unpopulated mountainous areas were not specifically observed since they did not cause an impact on the human population, but they were visible from large distances after the main shock and aftershocks in the form of rising dust clouds.

Four large landslides, along with several smaller slides, closed the northbound lanes of the Pacific Coast Highway along the coastal bluffs of the Pacific Palisades in Santa Monica, between Temescal Canyon Road and Chautauqua Boulevard, for at least 4 days. The most damaging of these landslides occurred just north of Chautauqua Boulevard on the Pacific Coast Highway (Figure 12). The slide carried a portion of a house down the slope, and on adjacent properties, shallow concrete piers and H-piles were observed to be hanging in mid-air near the crest of the slope. Three homes at the crest of the bluff were condemned. The bluffs consist of Quaternary age deposits of weakly cemented sand and are on the order of 120 to 200 feet in height. The slopes on which the failures occurred are moderately steep (between 45 and 60 degrees), and the failure masses appeared to be only a few yards thick, subparallel to the slope, and had widths on the order of 300 feet. The slide debris was predominantly loose sand. Some evidence of topographic amplification of shaking was also observed in this residential development, as the most severe damage to homes tended to be near the crest of the bluffs.

Several earthquake-induced landslides were observed in the Angeles National Forest of the San Gabriel Mountains. Two major rockslides occurred at Dillon Divide, along the Little Tujunga Road that links Interstate 210 and Highway 14 (Figure 13). One of the larger rockslides occurred in a roadcut through fractured granitic rocks. The volume of debris and the large size of the fallen rocks kept the road closed for four days. Once reopened, this road served as a main alternative access to Santa Clarita. At least 10 other slides were observed along the Little Tujunga Road.

Also along the Little Tujunga Road, major pavement cracks were observed at Bear Canyon and Sand Canyon. These fresh cracks were up to 1-1/2 in wide, with up to 2 in of vertical offset, indicating deformation of the underlying fill. Retaining structures, consisting mainly of reinforced concrete crib walls, were inspected and no damage was observed. Several reinforced concrete crib walls, built by the Angeles National Forest as debris basins along Schoolhouse Canyon and the West Fork canyon, were reported to have suffered no damage by local authorities.

Other landslides were observed in the general area north of the San Fernando Valley. A major rockslide occurred on Placerita Canyon Road. Large landslides also occurred at Castaic Junction, just northeast of the Inter-

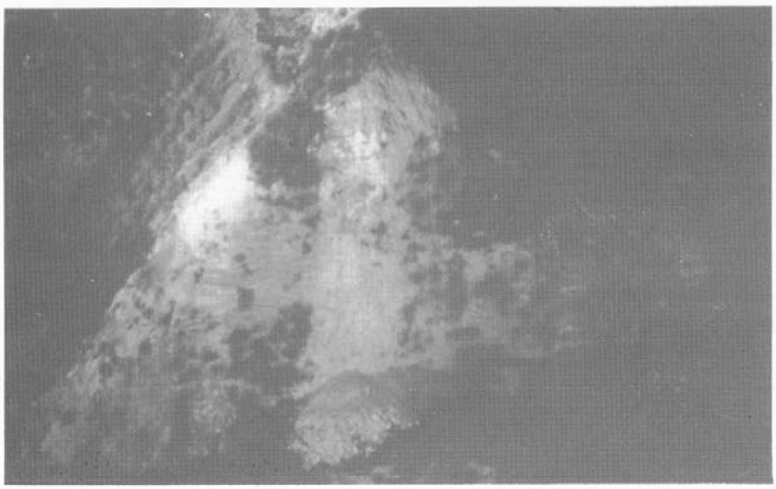

Figure 14. Rockfall, Santa Susana Mountains

Figure 15. Rockslide along Santa Susana Pass Road, near the pass.

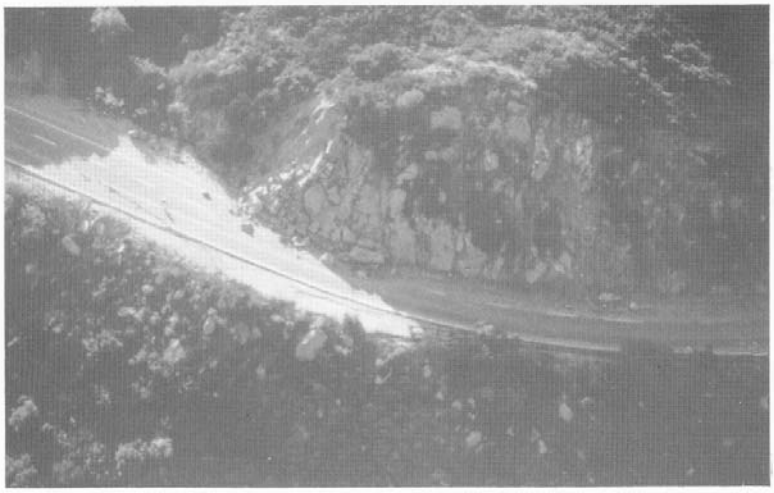

Figure 16. Ravelling along Highway 126, near the Santa Clara River

state 5/State Highway 126W intersection, and on Interstate 5, north of the Interstate 5/ State Highway 14 intersection. An apparent bedding plane slip, occurred just west of this interchange in the Santa Susana Mountains, causing a large offset of a fire road. Several other rockslides and rockfalls were also noted in the Santa Susana Mountains (Figure 14).

A section of the Santa Susana Pass Road, a two-lane roadway that parallels Highway 118 and connects the San Fernando Valley with Simi Valley, was closed due to slides. The road is approximately 5 miles from the epicenter and is cut into cemented sand and weak sandstone canyon walls that slope at 2H:1V and greater. Slope failures and landslides occurred both downslope and upslope of the road, and varied from 25 feet to more than 100 feet in height (Figure 15). Debris from upslope failures was generally large enough to block the near lane of the road. Blocks as large as 5 feet in diameter were noted and at least one of the slides appeared to be a failure along intersecting joint planes. Downslope failures created extensional cracks 10 to 30 feet away from the edge of the slope and parallel with the road. One larger slide caused vertical subsidence of 5 inches in the roadway and an additional 12-18 inches along the shoulder.

Several shallow rockslides were also observed along the hills on the north side of Highway 126 between Fillmore and Interstate 5 (Figure 16). At least one of these failures occurred in weathered sandstone. In urban areas, earthquake-induced landsliding was observed in Universal City, where a 24-foot high landslide was observed on Cahuenga Blvd. Preliminary information from the City of Los Angeles Department of Water and Power indicates that landslide activity factored into pipe breaks along Mulholland Drive in Encino and led to its closure after the earthquake.

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