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CALIFORNIA DIVISION OF MINES & GEOLOGY
THE RESOURCES AGENCY
DEPARTMENT OF CONSERVATION

SOUTHERN CALIFORNIA LANDSLIDES —1978—

SLOPE INSTABILITY AND DEBRIS FLOWS

Los Angeles Area

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RECORD RAINFALL

Record precipitation in the Los Angeles region during 1977–78 followed unexpectedly on the heels of near–disastrous drought. By March 6, 1978, 30.06 inches of rain had fallen at Los Angeles Civic Center and more in the surrounding hill and mountain regions. Two periods of generally light rainfall, the first in early February and the second in late February –early March, climaxed respectively on February 9–10 and on March 3–4 in intense, destructive rainfall. These storms caused mud and debris flows and bedrock landslides on saturated slopes.

SAN GABRIEL MOUNTAINS

Ten people were killed in the San Gabriel Mountains when intense rainfall during the earliest hours of February 10 caused a torrent of water and debris derived from an extensive, recently burned area to rip through the hamlet of Hidden Springs in the upper Big Tujunga Canyon drainage. The burned over area extends from La Crescenta northwestward along the steep western slope of the San Gabriel Mountains for approximately 8 miles to Lakeview Terrace; it extends northward into the granitic and metamorphic terrain of the mountains for several miles.

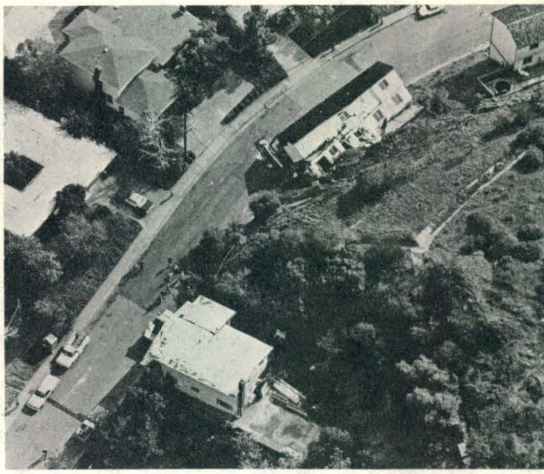
View north shows house in Tujunga at mouth of small canyon on south side of San Gabriel Mountains. House was inundated both by debris from flooding in the canyon and from debris flows from slopes above on the south edge of Verdugo Hills cemetery. The terrain in this area was burned over by a large fire in 1975. Similar damage was widespread in the region.

Similar debris flooding derived from other parts of the burned area caused considerable damage to communities along the front of the mountains between Lakeview Terrace and La Crescenta. The communities are situated along the base of the mountains and are built principally on coalescing alluvial fans, which extend outward from the mountains. North–dipping faults of the Sierra Madre–San Fernando fault zone extend along the front of the mountains.

SANTA MONICA MOUNTAINS

Many landslide and debris flow problems occurred in the Santa Monica Mountains, an area where development is locally very dense and the geologic conditions can be complex and uncompromising. The damage from the early February storm period occurred primarily in the eastern Santa Monica Mountains where high–intensity rainfall caused flooding in Laurel Canyon and Nichols Canyon, washing away numerous parked cars. In contrast, the March 3–4 rains caused widespread damage throughout the Santa Monica Mountains and Malibu Coast area. Debris flows were numerous and bedrock landslides were reactivated. The two deaths in the area directly attributable to storms resulted from debris flows sweeping down from natural slopes into the houses below.

View west across Benedict Canyon, eastern Santa Monica Mountains, City of Los Angeles. Soil slip scars which severely damaged houses are shown at left. Path of debris flows, which followed the existing canyon drainage, can be seen in left center of photo.



Tarzana area, City of Los Angeles; north flank of Santa Monica Mountains. Bedrock landslide (block glide), moving down slope (south to north) severely damaged houses at toe of slide. Houses out of view at head of slide were also damaged. The house that is pushed off its foundation and the house shown in upper right corner of photo were built within the last few years. *Photo by Mark Malone, KMPC.*

Bedrock landslides on the northern side of the Santa Monica Mountains mostly occurred as block glides along gently north–dipping bedding planes in shale of the Modelo Formation. This slide potential has been a long recognized problem. Numerous problems also occurred on slopes of the Santa Monica Slate of Mesozoic age and in the siltstone and sandstone of the Topanga Formation (middle Miocene).

In the coastal area of Malibu, Pacific Palisades, and Santa Monica, damage was caused by debris flows and flooding, sloughing of sea cliffs, reactivated bedrock landslides, and erosion by ocean waves. In this area along the upper plate of the Malibu thrust fault, the steep natural slopes consist very commonly of large older bedrock landslides or in–place bedrock weakened by tectonic shearing and fracturing, and subsequent deep weathering.

Hacienda Heights, Puente Hills; view southwest. Erosion and supersaturation of slopes beneath bench drains resulted in sloughing and debris flows which seriously damaged house in tract developed during 1970s. This was a widespread problem in this region.

BALDWIN HILLS

Damaging shallow debris slides and debris flows from steep cut–and–fill slopes occurred in residential areas of the northern Baldwin Hills of the central Los Angeles basin. Most steep slopes in the area were graded during the 1950s in already steep natural terrain underlain by very poorly indurated silty sand (Pleistocene). This material is particularly susceptible to liquefaction when over–saturated with water. Local grading codes of the Los Angeles region now require a more gentle grade and drainage installation in slopes graded in poorly indurated or otherwise weak rocks.

OTHER AREAS

Slope failures also caused damage in the Puente, San Jose, Palos Verdes, and Coyote Hills, in the Verdugo and Santa Susana Mountains, and in the Newhall–Saugus, Anaheim, Ventura, and Santa Barbara areas. Debris flooding caused damage near Ojai and at Fillmore. Damage to fill slopes was very common in the Puente Hills, even in newer housing tracts, and especially to such slopes composed of shale of the upper Miocene Puente Formation. This formation is generally comparable in lithology and age to the upper Miocene Modelo Formation (marine shale, siltstone, sandstone, and some conglomorate) to the west. In the Newhall–Saugus area, surficial sloughing and slumping occurred in relatively new cut–and–fill tracts.

GENERAL RECOMMENDATIONS

The intense rainfall of February 10–11 and March 3–4 and the ground saturation accumulation by early– to mid–March caused widespread damage in southern California, although much of the damage was not unexpected under the circumstances. In addition, none of the damage was regionally calamitous, as it would have been without aggressive flood control programs of the last 40 years and the grading codes developed in the last 25 years. These measures generally have given residents of the region relief from the fear of large–scale disaster caused by heavy winter storms. In the future new and revised city and county ordinances will help to alleviate damage to structures and mitigate hazards in existing hillside areas (see article, p. 8).

Flood–watch Programs for Fire Areas

Burned–off areas are extremely vulnerable to debris flooding, debris flows, and even bedrock landsliding. The disaster from debris flooding at Hidden Springs in the San Gabriel Mountains and elsewhere suggest that to cope with the potential flood hazards of certain areas, additional control measures should be initiated. These measures might include procedures for better coordination of flood control agencies and other agencies with responsibility for evaluating the potential hazard, and more involvement in the evaluation by scientific and engineering professionals.

Additional flood control measures to be taken in burned areas might include: (1) construction of temporary flood control facilities, and (2) continued cleaning of debris basins approximately between December 15 and March 15.

Recognition of Unique Geologic Hazards

The peripheries of building sites should be evaluted for dangerous slope conditions. For example, building sites may be endangered by collections of colluvium which may lie several hundreds of feet or more up slopes or canyons, perhaps even out of view of the site. Slope angles, rock types, attitude of bedding, and other factors are evaluated routinely in tract and individual site development, but unique geologic factors may be overlooked. For example along the Malibu Coast, rocks in the upper plate of a reverse fault zone may be extremely faulted, sheared, and fractured in such a way that recognition of all bedrock landslides may be difficult. Such areas are prone to rain–related problems as well as to earthquake shaking. The general recognition of special problems could be very important for the safe development of the terrain.

Areas with unique geological problems could be designated as special districts or zones, wherein specific measures would have to be taken in development and construction, even on an individual residential site basis.

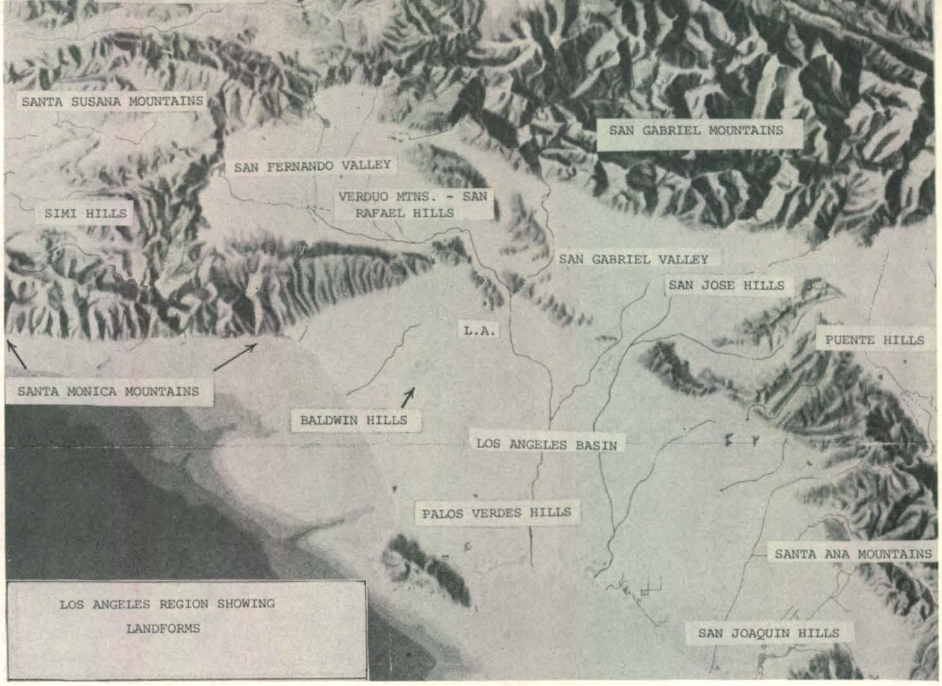
Geologic Mapping

Available geologic maps for use in planning and development of some hilly and mountainous regions may be out of date. The most up–to–date and best possible regional geologic mapping is needed to identify existing geologic problems prior to development plan, design, and construction. Both multiple and individual dwelling sites in hills and mountains are commonly in the most uncompromising terrain, yet geologic knowledge of the region may not be detailed enough for proper evaluation of grading plans by local governments.

In addition, there is a need for up–to–date specialized geologic knowledge in order to mitigate already existing problems, such as up–slope collections of colluvium or undercut bedrock outcrops which may give way in the future. A special case can be made for the Los Angeles City portion of the Santa Monica Mountains where remaining building sites are very expensive and are very difficult to engineer for construction purposes. A detailed, systematic, regional geological mapping program at a suitably large scale would be of minimal expense compared to the cost and value of future development and the cost of mitigating already existing problems.

New Construction on Previously Graded Area

Where new construction is planned for areas graded prior to enactment of current grading codes or where new construction could be affected by older grading, the older grading should be reevaluated.



LOS ANGELES REGION SHOWING LANDFORMS

BLUEBIRD CANYON LANDSLIDE OF OCTOBER 2, 1978

LAGUNA BEACH, CALIFORNIA

By
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California Division of Mines and Geology

At about 5:55 am on Monday morning, October 2, 1978, residents began to report unusual happenings in the area of Bluebird Canyon to the Laguna Beach Police Department. In the next few hours, 19 homes and parts of 14 others on the north side of Bluebird Canyon rode down the hill on a landslide at an initial rate of about 40 feet per hour, slowing finally to a few inches per day. By the end of the day it had been determined that a total of 50 homes had been destroyed or affected.

Although the Bluebird Canyon landslide covered an area of approximately 3.5 acres, it was suspected by geologists that it was but a portion of a larger, ancient landslide (figure 1). If this was true, the other homes sitting on the unmoved portion of the older slide then were endangered by the possibility of further landslide reactivation. Evidence of the slip surface of this older landslide was found during early examination of the headscarp area of the new slide (photo 1). The landform shown in photo 2 could then be interpreted as possibly the headscarp of this prehistoric slide. In any case the homes immediately uphill from the landslide were in danger from further degrading of the steep headscarp, which is as high as 35 feet.

On October 12, ten days after the slide began moving, a small section of ground gave way in the headscarp, taking with it another house (photo 3).

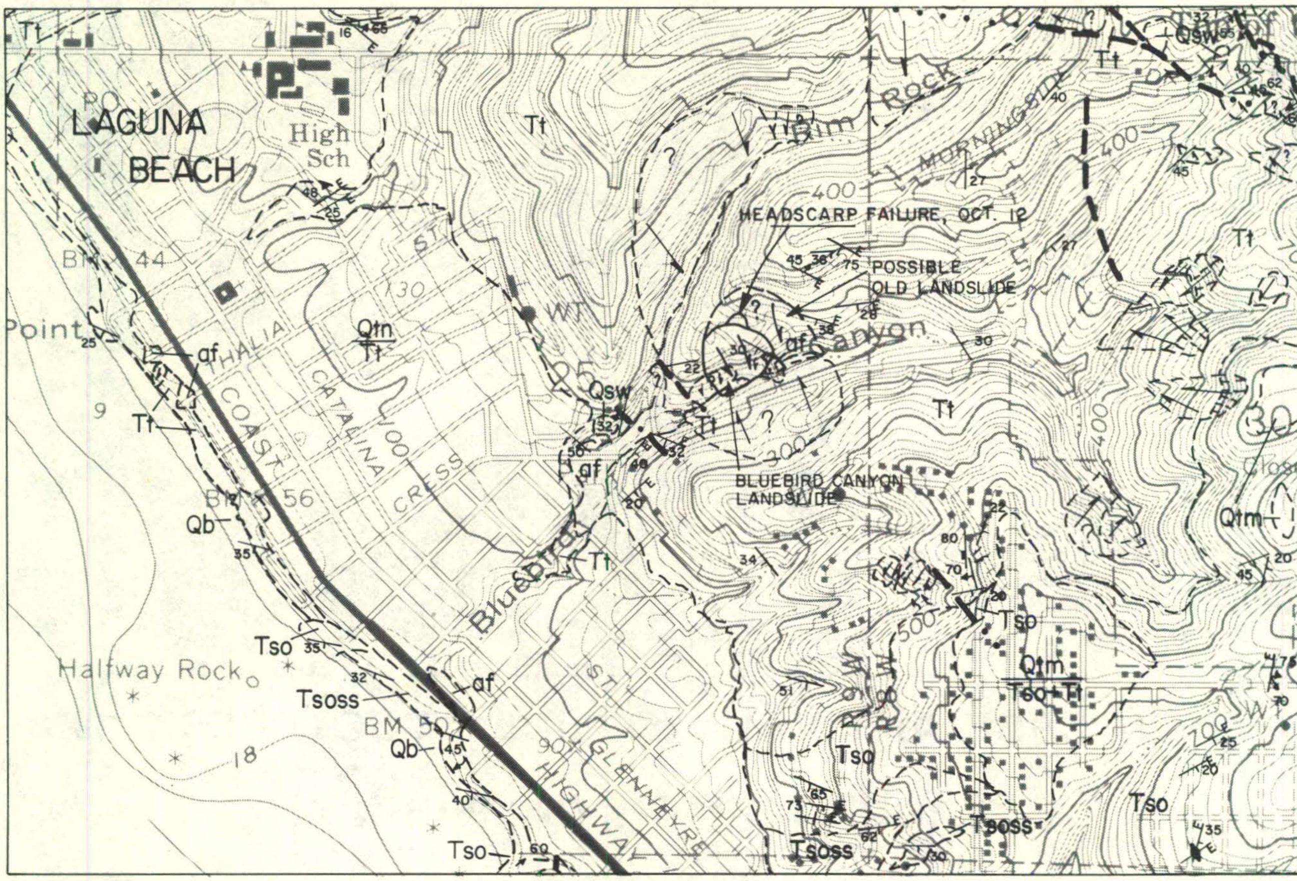
Tiltmeter monitoring equipment was installed on the upslope areas as part of the geological investigation being conducted for the City of Laguna Beach. This monitoring will continue until there is no further indication of on–going movement.

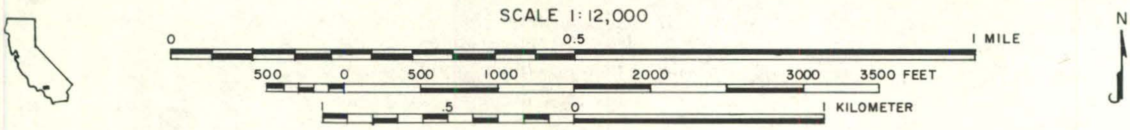
The Bluebird Canyon landslide was determined to be a "block glide" or "rock block" slide — a slide with little or no rotational movement. The slide mass remains fairly intact during its descent (photos 4, 5).

The basal slip surface of the slide apparently lies along a bedding plane in the underlying bedrock, as the attitude of the surrounding Topanga Formation (Miocene) is close to being parallel with the slope of the hillside. This unstable "dip slope" condition was recorded in previous geological surveys of the area; however, the tract of ill–fated homes was built long before these reports were published and prior to the institution of grading and building codes.

Another possible factor contributing to the cause of the landslide was extant ground water from the unusually heavy spring rains of March 1978. The final cause of any landslide is the accumulation of contributing factors until the limit of

Photo 1. Closeup of headscarp, looking northeast. Arrow pointing to area above concrete slab shows where evidence of older slide plane was found. Exposed bedrock in the headscarp is silty sandstone of the Miocene Topanga Formation. *Photo courtesy City of Laguna Beach.*





SYMBOLS

Contacts; dotted where concealed; dashed where approximated; queried where inferred; solid where located with certainty.

Faults: dotted where concealed; dashed where approximated; queried where inferred; solid where certain; arrows show direction and numbers show amount of dip of fault plane and fault striations; U=upblock relative to downblock - D.

24 Attitude of bedding

24 E Attitude of bedding taken from excavation

Vertical bedding

78 Attitude of shear surface

78 E Attitude of shear surface taken from excavation

Vertical shear surface

80 Attitude of joint surface.

Qtm/Tt Developed area of artificial cut and fill with surficial unit thinly overlying bedrock unit

Bedrock landslide; arrows indicate direction of failure; scarp hachured where apparent; queried where uncertain; superimposed where failure has occurred on older landslide debris

EXPLANATION

SURFICIAL UNITS *

QUATERNARY

Holocene

- af — Artificial fill and cut areas (shown superimposed over rock units) af=mappable artificial fill
- Qsw — Slopewash debris
- Qb — Beach sediments; Qbs - mainly sand; Qbg - mainly gravel; Qbs+g - mainly sand & gravel
- Landslide debris

Pleistocene

- Qtn — Nonmarine deposits on marine terrace deposits (subscripts indicate relative level with 1 the lowest).
- Qtm — Marine terrace deposits (without nonmarine cover).

BEDROCK UNITS *

TERTIARY

Miocene

- Tso — San Onofre Breccia; Tso-ss - sandstone
- Tt — Topanga Formation

Figure 1. Bluebird Canyon landslide. *Map adapted from California Division of Mines and Geology Special Report 127, Plate 1.*

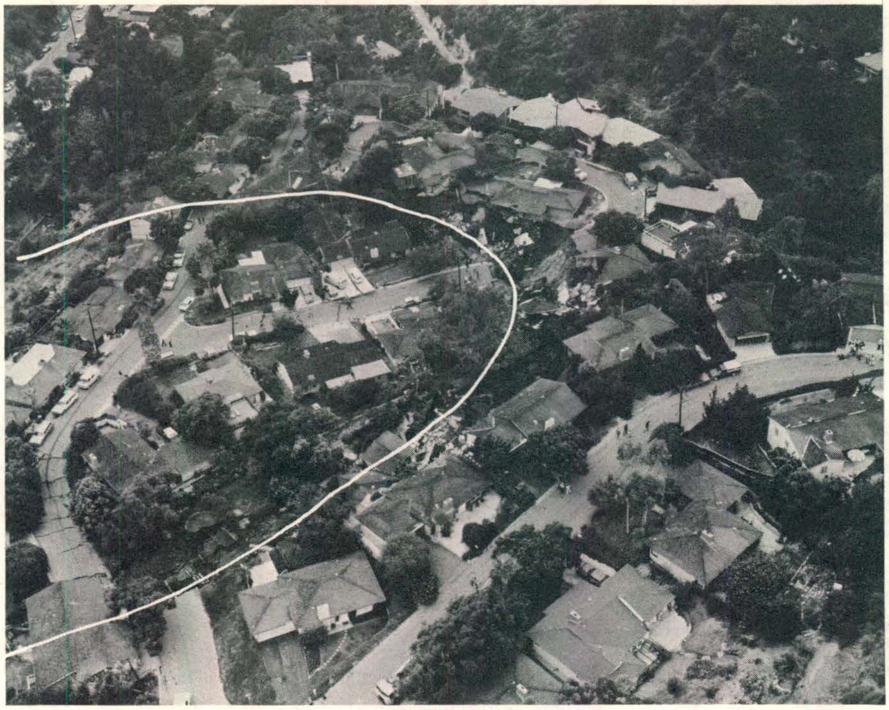


Photo 2. Aerial photo of Bluebird Canyon landslide, looking northeast. *Photo courtesy of City of Laguna Beach.*

Photo 3. Aerial photo of headscarp area taken the day of the slide (October 2, 1978). Dashed outline is the area which failed 10 days later, illustrating the instability of the ground behind the October 2 headscarp. View looking northeast. *Courtesy of City of Laguna Beach.*

failure is exceeded. In many cases the rapid input of a single factor can be cited, such as ground shaking during an earthquake or high rainfall; in this event, however, the causes at work were not obvious.

ACKNOWLEDGMENTS

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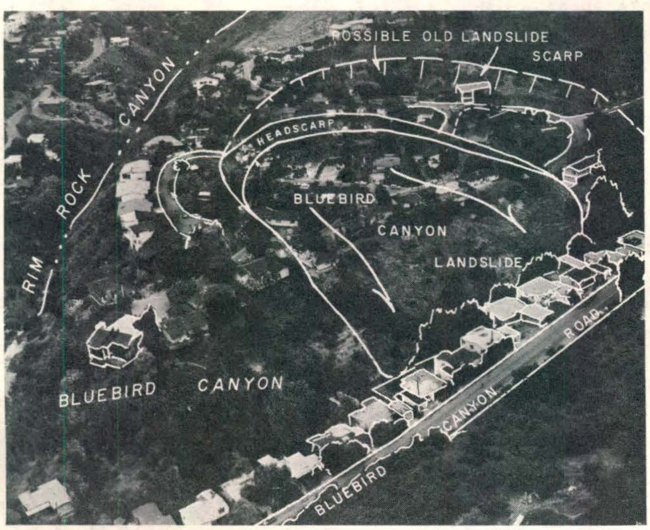
Photo 4. Aerial photo of slide looking southwest with Bluebird Canyon and Bluebird Canyon Road in the upper left corner. Solid line delineates the slide area. Note that the central portion of the slide is intact and the lack of tilting as evidenced by still-vertical telephone poles. *Photo courtesy City of Laguna Beach.*



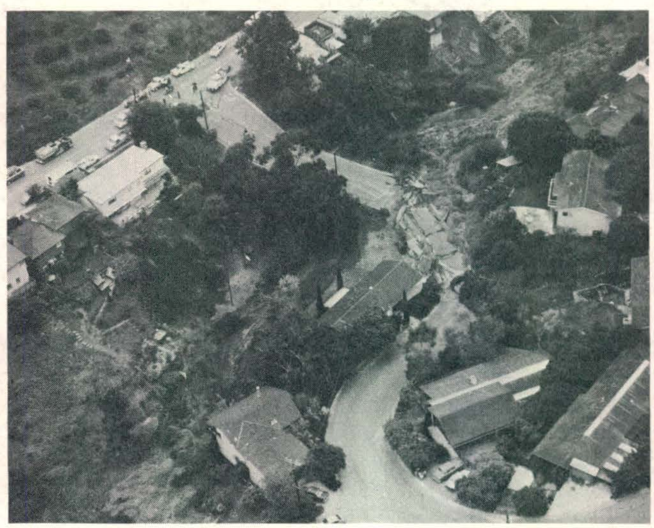


Photo 5. Aerial photo of easternmost toe area of slide. Note buttressing effect of road fill ("af" on figure 1) where Oriole Drive crosses Bluebird Canyon. View toward the southwest. *Photo courtesy City of Laguna Beach.*

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The Bluebird Canyon landslide damaged or destroyed more than 50 homes in a Laguna Beach hillside development. This house was destroyed when landslide movement began on October 2, 1978. For location of house, see upper left quadrant of lower left photo on front cover; see article, p. 5. *Photo courtesy Slosson and Associates.*