RESIDENTIAL ILLS

in the Heartbreak Hills of Southern California

by Richard H. Jahns

The house shuddered slightly to the tune of creaking joists and a low background rumble that Earnest Winner, half-rising from his comfortable pillow, fuzzily identified with a modest earthquake. A mumbled comment to his wife, a few muscular twitches after reassuming a horizontal position, and he was again asleep. Presumably his rest was a pleasant and untroubled one, for Mr. Winner was yet unaware that he had become a serious loser.

Early the next morning, his young son burst excitedly into the bedroom, shrilling, "Daddy, Daddy, the garage is gone!" And this disquieting message proved to be quite accurate, as the almost-new garage and its contents, including the family automobile, two bicycles, and a beloved assemblage of power tools, had indeed vanished from sight of the house—along with the rearward one-third of the entire lot.

What had appeared the previous afternoon as an irregular "settling crack" that traversed the back lawn and garden was now the ragged edge of a sheer drop-off, at which the remaining segment of the driveway terminated absurdly. One can imagine Mr. Winner's emotions when he looked over the edge and saw that he had lost a substantial part of his property to the deep canyon lying behind it. The missing part of his backyard now formed an uneven bench part way down the canyon wall. There, tilted at crazy angles about 50 feet below him, rested the dislocated elements of his garage. One headlight of his car seemed to peer inquiringly at him through the wreckage.

The unhappy Winner didn't yet know that his contribution to the canyon was merely the latest of many in this small part of the Pacific Palisades district, not a few of the slides having occurred during the years since settlement of the Greater Los Angeles area began to expand in this direction. He was soon to find out, though, that some of his neighbors had been suffering even more serious losses from successive slides nibbling away at their properties. He also was to discover that several lots, *including his own*, had been occupied by houses at least once before! Fissuring, settling, and gross migration of the ground had damaged these structures and had withdrawn so much support from beneath them that they had been condemned as unsafe for further occupancy. All had been removed, down to the last shingle and stud, then the lots had been regraded and sold to the next persons desiring a fine view of the Pacific Ocean. These transactions, of course, were unaccompanied by pertinent comments on recent geologic history.

This is where Mr. Winner had come in. Now, as he contemplates his personal disaster, he wonders why he wasn't made aware of what he tardily recognizes as obvious. Possibly he also is thinking in terms of whom he can sue, for what, and on what grounds.

Meanwhile, Mr. and Mrs. Purdy Gesser have just reached an agonizing decision as to the disposition of their modern home in the Portuguese Bend area of the Palos Verdes Hills. They reflect, as they look through their enormous picture window across moonlit waters toward the dark silhouette of Catalina Island, that this is their "dream house," built to their own plans at a lovely spot of their own choosing. They recall how they had "thought of everything"—an area with mild climate and relative freedom from smog, a quiet, pleasant neighborhood within easy driving distance of schools, church, shopping centers, and Purdy's office, a large view lot with all utilities available, and a fine home that they could afford through careful management of their resources. But now, after less than three years, the picture window is badly cracked, the walls and floors are buckled, the patio and adjacent ground are warped and ruptured, and the kitchen and living room are held six feet above the sagging foundation by enormous jacks. The house is a split-level structure, though it wasn't built that way!

Two years ago the Gessers, along with many neighboring families, had begun to realize that something was terribly wrong. Doors that had been sticking no longer could be closed, tiny cracks in the walls had become inch-wide gaps, the roof had developed a dozen unaccountable leaks, and water and gas pipes had been broken several times, generally at points of minimal accessibility. Soon the word was out—the Gesser home was one of many built on an enormous landslide mass, a mass that, somehow reactivated, was now moving slowly toward the nearby sea. It didn't help to learn that geologists had long ago recognized and described the area as one of ancient landsliding, and that this particular slide was discussed in several published reports readily available to the public.

"When will the movement stop? Will it stop in time for us to save our home?" These questions were asked again and again by the Gessers as they clung to living in a wracked house that was disintegrating a bit more each day. Having gone completely through the emotional wringer, they finally supply their own answer: "Not soon enough." They will salvage what furniture, fixtures, and materials they can, and will make a fresh start somewhere else. However, any start on a new home must be deferred, perhaps for many years. The financial loss must be recouped, as insurance barely will cover the costs of moving, demolition, and storage of possessions, and the intrinsic value of the ground itself is understandably limited.

The location of the Heartbreak Hills

The Winners and the Gessers are just two families among thousands who have taken up residence in the Heartbreak Hills of southern California, and their personal tragedies constitute a small sample of what has happened or is likely to happen to those others who have not given appropriate thought to the ground on which they live. But what and where are the Heartbreak Hills? This figurative name can be given to those areas of irregular terrain in which problems of stability confront the developer of building sites; such problems include elements of surface erosion and deposition, undesirable settling, and mass movements of material, acting either singly or in some combination, slowly or rapidly, and on a small or large scale. It should be added that flat ground itself is no guarantee of complete stability, as the foundation engineer can testify.

Heartbreak Hills are present in most areas of the world, and numerous situations justifying such identification could be cited for nearly every major urban locale. However, the name can be properly applied only to specific parts of these areas, and such geologically unfavorable parts generally are small. Thus unsafe foundation conditions begat of landsliding are restricted to local portions of the Pacific Palisades area, just as most of the Palos Verdes Hills and even some of the Portuguese Bend area itself are geologically safe for homesite development. On the other hand, these are only two of many areas in southern California where significant geological hazards have been recognized.

The fundamental problem

The fundamental problem is one of distinguishing the naturally safe from the naturally unsafe locality, and of identifying the naturally safe locality that can be made unsafe through the actions of man. Often the problem is easily solved, but at times it involves the interpretation of complex geological relationships that challenge the most competent investigator. The general situation in southern California has been outlined by one geologist as follows: "The highly varied topography and climate of the region, together with the complexity of its rocks and their structure, form a background of physical factors that cannot be ignored in the development of this region by man. Some of these factors are related directly to floods, earthquakes, mass movement of ground, and other recurring events over which man has little fundamental control, and others are developed by some of man's own activities. Failure to anticipate or properly to evaluate these factors during past development of the region has led to unfortunate, and at times disastrous, consequences . . . Only during recent years has there been widespread recognition of the need for careful geologic appraisal of engineering problems in southern California. Normal study of the positive factors in location and design of buildings, dams, aqueducts, and other structures, for example, is now being supplemented by consideration of the nature and movement of solid and liquid materials in the subsurface, the position and behavior of active faults in the area, the movement of surface water in the area during previous centuries, and other features that are likely to have significant long-term effects."

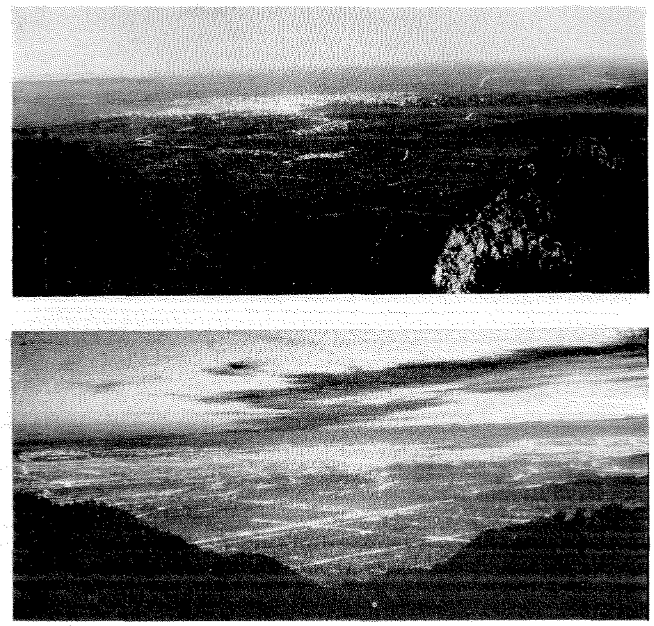
The burgeoning population of southern California, especially during the past two decades, has revealed in various painful ways the locations of more and more Heartbreak Hills. Nearly six million persons now reside in the Greater Los Angeles area alone, and current predictions are focusing upon ten million persons by 1980. As settlement has spread for many square miles across the basin and valley areas (see p. 15), increasing numbers of people almost literally have been driven into the intervening and surrounding hills. Hillside living has real advantages, too. The higher areas offer the last available residential sites within reasonable distances of major employment centers, and they make it possible for families to live away from the congestion, noises, odors, and other objectionable features of metropolitan districts. They also provide excellent views for the home owners, and the topographic irregularities broaden the possibilities for architectural expression in the homes themselves.

For decades southern Californians, while making jokes about their well-known dry rivers and arroyos, have built many of their homes across and within these obvious lines of drainage, evidently on the naive assumption that surface waters nevermore would put in an appearance. That this approach lacks certain elements of wisdom has been demonstrated in forceful ways by several floods. The extraordinary New Year's Day flood of 1934, for example, ravished the valley occupied by La Cañada, La Crescenta, Montrose, and Tujunga, smashing or undercutting some homes and filling many others with coarse debris. Even more impressive was the havoc wrought by the great flood of March 1938, especially in the San Fernando Valley area. Here extensive settlement during the 20's and 30's had superimposed entire communities upon the natural pattern of drainage, and numerous channels had been modified or even eliminated by artificial fills without adequate provision for future runoff. Flood waters spread widely across the valley floor, scouring deep gullies in streets and yards, destroying many structures, and depositing thick accumulations of gravelly muck over large areas.

Flood-control installations

Some storms in southern California bring several inches of rain within periods of an hour or less, and twenty inches in twenty-four hours has been recorded more than once in the mountain areas. Most of these storms occur during the winter months, when the ground already is saturated or nearly so, and the problems of runoff are complicated in the lowland areas by a steadily expanding blanket of pavement, buildings, and other impervious works of man. Fortunately, many of these areas in the coastal region are now protected by flood-control installations of various kinds, but it may be several decades before such works are widely introduced elsewhere in southern California, especially in communities where more realistic homesite and grading regulations are needed.

Man has been surprisingly sluggish in extending the lessons of lowland drainage to the hillside areas, where topography accentuates the potential dangers to residential structures. During the period since World War II, heavy earth-moving equipment has been widely used in reshaping the landscape for development of residential sites in the Santa Monica Mountains, the foothill fringe of the San Gabriel Mountains, the Puente and San Jose Hills, and many



Population growth in Greater Los Angeles. Top, a moonlight view of Pasadena and Los Angeles in 1908. Bottom, essentially the same area in 1950.

other parts of the Greater Los Angeles area. Ridges and slopes have been notched with little regard for the nature of the materials removed or newly exposed in the cuts, and canyon bottoms have been filled to provide additional sites for homes and other structures. Disaster has been inevitable.

The heavy rains of January and March 1952 sent tremendous volumes of water down the bare surfaces of raw cuts and fills, gullying them deeply and moving huge quantities of muck and debris around and into homes and streets, so that many recently opened hillside tracts appeared as "seas of mud." What man had done to modify the terrain was vigorously extended by nature. In many places, temporary remedial measures merely aggravated the situation, as damaging runoff from subsequent storms was diverted to other vulnerable targets. Even those canyon dwellers who had relaxed in the assumed protection of debris-collecting basins that had been developed up-drainage from them found that their safety was transitory. Many of the basins were quickly filled to capacity with solid matter, which eliminated their protective function.

Uncontrolled flow of water does far more than scour the surface in one place and deposit objectionable debris in another. When it enters the subsurface, especially in and near fresh cuts and loose masses of fill, it can contribute forcefully to gross instability of the ground. Not only does it add weight and pressure as a pore-filling fluid, but it can seriously weaken the ground through lubrication of potential slippage surfaces and the scouring away of interstitial fine-grained matter. Its effects upon the volume, plasticity, and other characteristics of clay minerals can be disagreeably significant. Thus it has been a major factor in

Settlement of coastal terraces in the Pacific Palisades area, 1946. Large landslide masses (X) face the ocean, and a steep-walled cut (C) exposes old slide debris.

most types of ground failure. The exact subsurface paths of water circulation often are difficult to establish, but it generally is possible to predict the gross effects of artificial cutting or filling.

Many homes have been damaged by essentially local settling of the foundation materials, in amounts ranging from an inch to several feet. Often this is attributable to the placing of fill on natural slopes from which neither existing vegetation nor soft soils were removed; these natural unconsolidated materials tend to promote settling and slippage beneath the fill. The excavation of some cuts has exposed avenues of natural groundwater drainage, so that seeps have appeared in the cut faces. Not only do such seeps have undesirable effects upon lawns, gardens, and the foundations of structures, but the water commonly migrates downward beneath the structures and lubricates potential surfaces of slip in the underlying bedrock. All too often, one effect triggers off another.

Homes in some hillside areas have been erected upon soft, unconsolidated materials that are quite unable to bear the additional load. Downslope migration is the inevitable result. Although southern Californians have learned to live with earthquakes and have made admirable progress in the construction of earthquake-resistant buildings, they have given little thought to the intrinsic stability of the soft ground upon which many of them have built their homes. Nor, in general, have they considered the possible triggering effects of earthquakes upon subsidence and lateral movements of such ground.

By far the most spectacular examples of mass movement in southern California are landslides that involve large bodies of bedrock. Although specific conditions vary from one occurrence to another, all these slides can be ascribed to an unfavorable relationship between steepness of slope and inherent strength of the rocks beneath the slope. On this score, the most troublesome rocks in the Greater Los Angeles area are siltstones and sandstones whose shaly structure permits slippage along their surfaces of stratification. Many other kinds of rocks also are liable to sliding where they are soft or are weakened by the presence of numerous bedding planes, fractures, faults, or other structural discontinuities.

On October 28, 1937, surface cracks were observed on the hillside above Riverside Drive, not far from the Los Angeles Civic Center, and soon it became apparent that a huge section of the hill was slowly moving downward toward the nearby Los Angeles River. On November 26 more than a million tons of soil and rock suddenly moved downward, covering Riverside Drive and seriously damaging buildings and utility lines. About half a million dollars was expended in removing the slide material and in making major repairs. The event made interesting news, but to most persons it was only a temporary nuisance that soon was forgotten.

Some years ago the old highway between El Monte and Pomona was covered by a slide mass on Kellogg Hill. Study of this mass showed that its removal probably would do little more than make room for additional material poised higher on the slope, so highway engineers relocated the road around the toe of the slide.

The Pacific Palisades area recently has become well known for its large slides, although geological evidence indicates that sliding has occurred again and again in this locality for thousands of years. As shown above, human settlement has extended over a broad, *Landslide mass covering U.S. Highway 101 in the Pacific Palisades area, March 1958. Note that somewhat earlier sliding has concealed the cut (C) shown on the page opposite.*

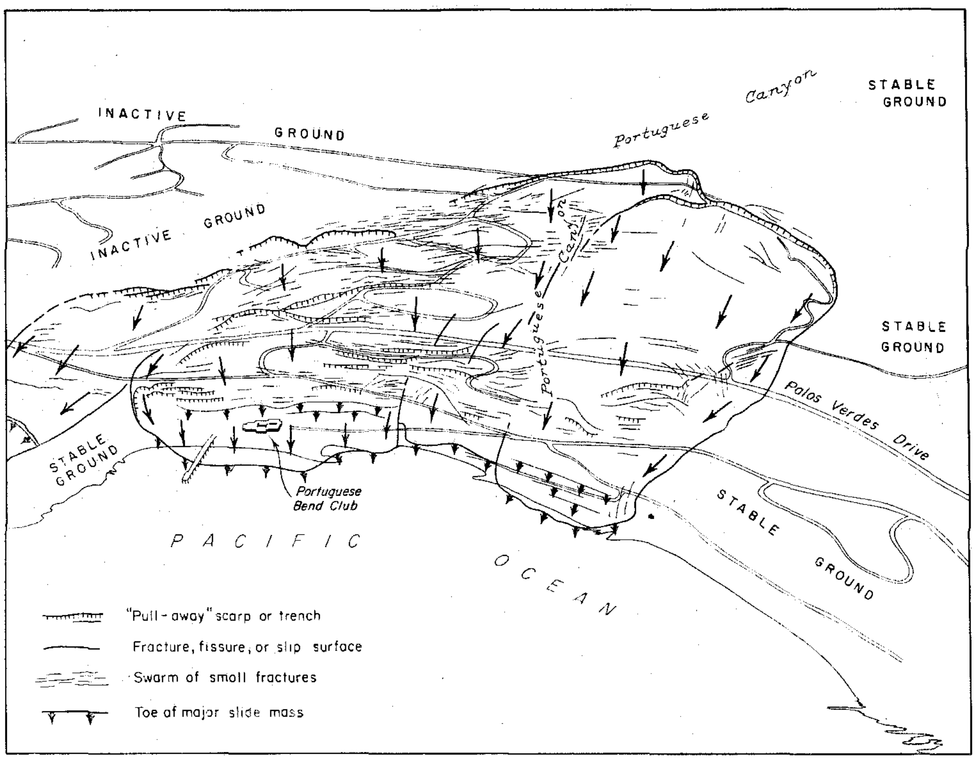
terrace-like area that is gashed by several deep, steep-walled canyons and is bounded on one side by a high sea cliff. This surface is underlain by sands and gravels whose stratification is essentially horizontal. These materials are relatively stable, and in the eastern part of the area, where they are very thick and form the entire sea cliff, little major landsliding has taken place during the past century. In the western (or left-hand) part of the area shown on page 16, the sands and gravels form a rather thin veneer over older and weaker shaly rocks. These rocks have been tilted and folded, and along much of the ocean front, where their bedding planes dip at moderate angles toward the beach, slippage has been promoted by water introduced through the overlying pervious sands and gravels, and also by wave erosion that has removed support from the base of the sea cliff. The natural erosion by wave action has been largely eliminated through the development of beaches and the construction of embankments along U.S. Highway 101, but man has increased the contributions of water to the structurally weak shaly rocks, chiefly through the irrigation of his lawns and gardens.

Sliding has occurred at points along the ocean front and along the sides of tributary canyons wherever the structure of the bedrock is unfavorably oriented. The crescentic expression of one large slide can be seen on page 16; this mass is traversed by the loops of road extending from the edge of the cliff downward to Highway 101. Mass movements have occurred repeatedly during recent years, the latest episode following heavy winter rains in 1958. The position of this slide and its effect in trimming back the edge of the sea cliff are shown above. To the left of this mass are several other, slightly older slides.

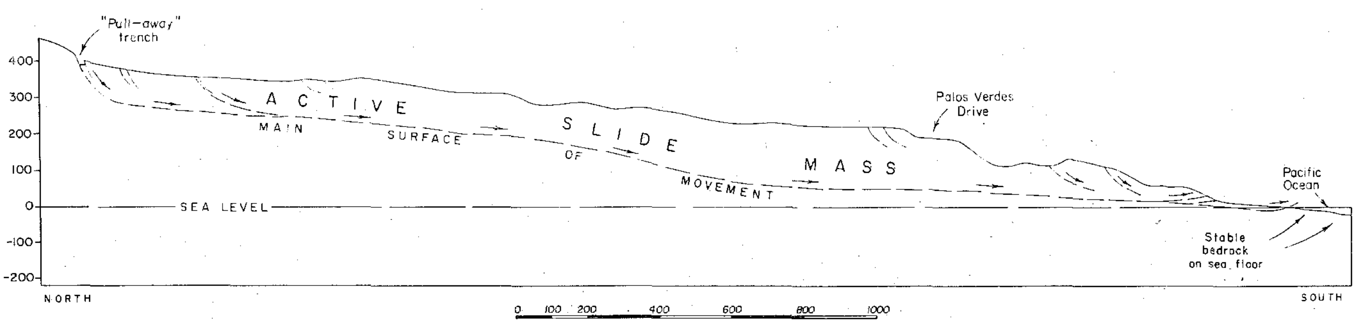
Failure in seaward-dipping shaly rocks also has been responsible for landsliding at Point Fermin, in the Palos Verdes Hills. Movement of an enormous mass was first recognized in 1929, and sliding toward the ocean reached major proportions a little more than a decade later. The migrating mass is about 1,000 feet long and 50 to 400 feet wide, and its upper surface, originally about 100 feet above sea level, is now depressed 10 to 40 feet beneath the level of the adjacent ground to which it formerly was attached. Fortunately, the early movements were sufficiently slow to permit evacuation of the area without serious injury or loss of life. All buildings on the slid block have been removed, and the fissured surface is now a weed-grown "no man's land."

The most spectacular and damaging of southern California's recent slides is that in the Portuguese Bend area. Here a broad, platter-like mass of deformed soft shaly rocks has been sliding intermittently toward the ocean for a long period of time, probably measured in thousands of years. The latest episode of movements, which began in July 1956 and is continuing today, involves only the eastern part of this ancient slide mass. The moving ground occupies an area of nearly 200 acres, on which more than 150 homes rest in various stages of destruction. The currently active mass, 100 to 200 feet thick, is easing itself seaward over a gently undulating surface of major slippage. It is no accident that this surface conforms in a general way to the attitude of stratification in the underlying rocks, and corresponds in general position to the occurrence of a lubricating layer of altered volcanic ash. This ash consists largely of clay minerals. It is soft and slippery when wet, and has been encountered in numerous test holes bored through the slide.

The Portuguese Bend area in the Palos Verdes Hills, looking north-northwest, 1955. Most of the homes in the central foreground and middle distance are now abandoned.



General features of the active slide mass within the area shown above. Arrows indicate major directions of slide movement.



Generalized section through the Portuguese Bend area in the vicinity of Portuguese Canyon, showing the undulatory surface of principal slippage beneath the active slide mass. The toe of the mass curls slightly upward over stable bedrock along the ocean shore.

The principal features of the slide mass are shown on the page opposite. Its curving upper margin is characterized by a series of fresh scarps and "pull-away" trenches. Preserved along the walls of these trenches are grooves and striations that indicate the downward movement of the migrating ground (see below). The lateral margins of the active slide mass are marked by zones of profound shearing. The eastern part of the mass, which has moved farther than the other parts, is separated from the remainder of the slide by a shear zone in the vicinity of Portuguese Canyon (see p. 18). Maximum horizontal movement has amounted to nearly 30 feet. The entire mass is thoroughly fissured and fractured, like the ice in a glacier that is flowing over a very uneven bedrock surface, and it is marked by many structural complications. The snout of the slide appears along the sea coast, in most places as a low ridge of crushed and broken material in the zone of wave action. It is being thrust upward along stable bedrock that forms the sea floor (shown at the bottom of page 18) where it is being attacked by the marine waters.

Damage to structures in the Portuguese Bend community has been so extensive that many of them have been condemned for further occupancy. All have been wracked to some degree, and several have been almost literally torn apart by differential movements of the ground beneath them. An interesting type of failure has occurred near the shoreward end of the pier at the Portuguese Bend Club. The outer part of this pier rests upon stable ground, the inner part on the snout of the slide mass; the resulting compression has caused the buckling shown in the photo above. A large swimming pool near this pier was so severely fissured by the ground movements that it was replaced by a new concrete pool with a plastic liner; despite subsequent movements of the concrete shell, amounting to several feet locally, the plastic liner held water satisfactorily until the whole installation was recently abandoned.

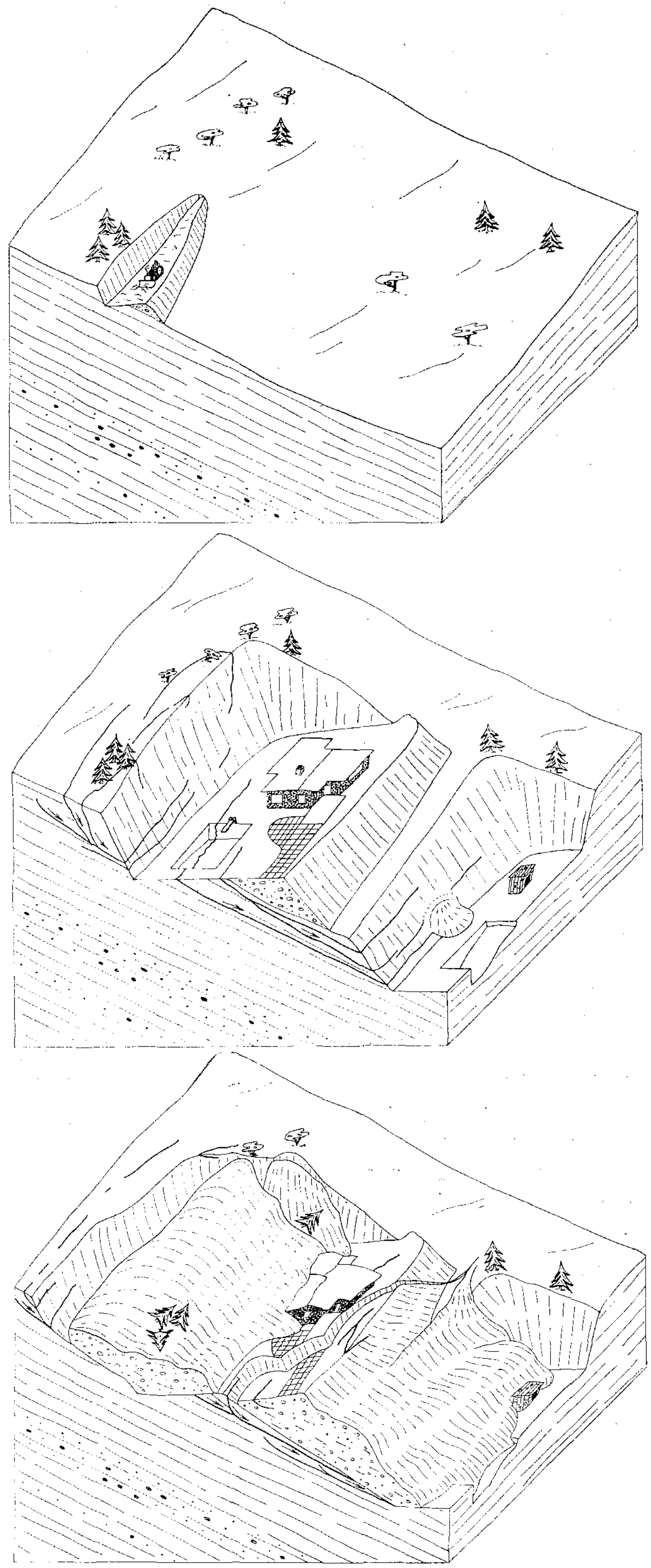
Exposed part of the main slip surface at the head of the Portuguese Bend slide mass. Note the steeply-inclined grooves on this otherwise smooth surface.

Coastwise view of the Portuguese Bend area, December 1956, showing the slide mass in left foreground. The snout of the mass emerges on the ocean bottom along the surf zone between the pier in the foreground and the white breakers in the right distance. Buckling of the pier can be seen near its shoreward end.

The entire Portuguese Bend settlement is rapidly becoming a ghost community. A supplemental tragedy is the effect of the landsliding upon the newly developed tract immediately to the east, which appears within the area of curving streets in the middle distance above. Although these new homes rest upon stable ground, their proximity to the slide has had unfortunate effects on current estimates of their value by the general public.

The basic factors responsible for the present sliding in the Portuguese Bend area probably are little different from those prompting similar movements at this locality during the geologic past, but it is possible that man may have triggered-off the latest movements in any of several ways. Introduction of water to the subsurface, as from irrigation and septic tanks, is particularly suspect. No one can predict with confidence when the movement will cease, but it is almost certain that, once having ceased, it will begin again at some future time. An interesting effort to stop the sliding was made by the County of Los Angeles during 1957, when fifteen caissons of reinforced concrete, each about 4 feet in diameter and 20 feet long, were set in vertical holes bored through the main surface of slippage from points near the toe of the mass. It was hoped that these gigantic pins would have a holding effect akin to that of toothpicks in a Denver sandwich. But this project failed, owing largely to the weakness of the slide materials, which flowed around the pins and tilted some of them in the process.

Man's remarkable capacity for troubling himself has been nowhere more clearly shown than on numerous "dip-slope" hillsides, where the stratification in the underlying rocks is essentially parallel to the ground surface. Excavation of cuts at such localities has caused much damage, particularly in the Santa Monica Mountains and on some of the hills rising



Three stages in the dynamic development of a "dip slope" hillside. Top, a bulldozer cut is made. Middle, two benches have been completed, and the upper one is already occupied by a house and pool. Slippage within the bedrock is beginning to occur, and cracks are appearing on the ground surface. Water, leaking from the upper swimming pool, is soaking into the bedrock and promoting further sliding. Bottom, sliding has occurred on a large scale as nature tries to reestablish a relatively stable dip slope.

above the broad Los Angeles Plain. At the left is a typical story in the form of three episodes. Lot pads are graded in a dip slope, and homes are built on them. Within a short time, generally less than five years, the beds begin to move past one another, much like the slippage within a tilted deck of cards that is unsupported along its lower edge. As shown in the middle and lower diagrams, cracks and fissures are the surface expressions of slip zones at depth, and the total movement ultimately results in transfer of ground from some parts of the properties and encroachment of enormous slide masses onto other parts. Hundreds of major failures in the Greater Los Angeles area can be attributed to this general situation. It seems plain that cuts should not be developed in hillsides underlain by rocks liable to bedding-slippage, and where the geometric relationships between surface slope and rock structure are essentially as shown in the upper diagram.

It seems obvious that man cannot take for granted the ground he lives on, and that responsibility for troubles stemming from a careless attitude rarely can be fixed upon someone else, legally or otherwise. The geologist has long been aware of stability problems, although not all geologists have enjoyed uniformly pleasant experiences with their own properties! Geologic relationships in the Heartbreak Hills are now receiving fuller attention from the engineer, who recognizes that it is more satisfactory to prevent or avoid conditions of instability than to deal with their unfortunate results after they have occurred. The responsible public official, having learned that wise development of hillside land can be insured only by regulation, is continuing to press for grading requirements that are realistic and broadly applicable. He has had strong opposition from many quarters, but fortunately has been able to take advantage of public reaction to several disasters. Thus Gilbert E. Morris, who heads the Department of Building and Safety of the City of Los Angeles, was able to put through a forceful and effective grading ordnance as a result of the 1952 floods, and thousands of persons already have been protected through denial of building permits for sites where hazardous conditions exist or would have been created through proposed development.

The public itself must become more aware of the general problem and more sympathetic toward existing and future regulatory measures, lest the disastrous effects of instability continue their alarming increases of the past decades. One may well be sincerely sorry for the individual victims—for all the Winners and all the Gessers—but it also is well to note that everyone ultimately pays the piper in numerous indirect forms, including increased tax, insurance, and utility rates, and, in many instances, lowered property values. All of us, therefore, will have to give more attention to the matter of keeping our property where it belongs if we are to enjoy what amounts to peaceful coexistence with southern California's geology.