DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
AND THE
COUNTY OF SAN MATEO

MISCELLANEOUS FIELD STUDIES
MAP MF - 344

122°30′ 1 450 000 FEET 15′ 1 500 000 FEET

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4. Photointerpretation by Brabb. A few small landslides and one large landslide mapped in reconnaissance fashion in the field by Brabb and R. J. McLaughlin, U.S. Geological Survey.
5. Extensive field studies by E. H. Pampeyan (see his map, 1970). A few large landslides added by Brabb from study of aerial photographs. Several small landslides in Portola Valley compiled from data provided by Town of Portola Valley. Some information derived from unpublished data by R. B. Weiss, 1970.

INTRODUCTION

Information on the extent and distribution of landslide deposits is necessary for sound land-use planning. This map, a preliminary compilation of such information, was prepared primarily by stereoscopic examination of aerial photographs, partly by compilation of information in County and public records, and only partly by fieldwork. Though it represents only the initial stage of an analysis of slope stability within the County, it provides immediately useful information about the location of landslide deposits and therefore about the distribution of potentially unstable slopes.

The term "landslide" denotes the process of downward and outward movement of slope-forming materials by falling, sliding, and flowing. Often the term "slope failure" is used synonymously with landslide, but sometimes its use is restricted to failures in artificial slopes, e.g., earth-fill dams, highway embankments, building-site fills, etc. In this report no distinction is made between these two terms.

"Landslide deposits" are the products of the landslide or slope-failure process. They are composed of fresh and weathered rock fragments, sediment, soil, or any combinations thereof, that have been transported downslope by falling, sliding, slumping, or flowing. They vary in appearance from clearly discernible, largely uneroded topographic features to indistinct, highly eroded features recognizable only by their subtle topographic configurations. Thickness ranges from a few feet to perhaps several hundred feet. Larger deposits are generally thickest; many of the small deposits are thin and involve only the uppermost few feet of earth materials.

Many of the natural factors that promote landsliding, such as steep slopes, heavy rainfall, and poorly consolidated bedrock, are present in San Mateo County. Man also may affect the potential for landsliding, in some cases decreasing it by leveling slopes, building retaining walls at the base of slopes, planting trees or other vegetation, as well as practicing soil conservation. However, others of his activities may increase the potential for slope failures, such as increasing slope angles for construction of roads or buildings; adding water to marginally stable slopes by watering lawns, by improperly handling rain-water runoff, and by choosing poor sites for septic tank drainfields; adding weight in the form of structures or fill to marginally stable slopes; and, removing natural vegetation. Thus, landsliding, a natural phenomenon that has occurred many times in the past throughout most parts of the County, may be promoted through improper land-use.

Little information is available, unfortunately, regarding the activity of the landslide deposits, especially the large ones. Some deposits are moving, and causing damage to streets and houses, whereas others apparently have not moved for thousands of years. In general, most landslide activity seems to take place within or adjacent to areas that have a history of landsliding. Even old and apparently inactive landslide deposits may be reactivated by either natural or artificial means because the materials that form them are commonly so broken up and disturbed that landslide activity is easily renewed, especially when slopes are steepened or their moisture content is changed. On the other hand, some areas within landslide deposits may be relatively stable and suitable for development, if certain precautions are followed. What precautions are necessary and what types of development may be feasible are best determined by detailed field study of the landslide area.

Nearly 2,000 landslide deposits are shown, over 10 times as many as on previously published geologic maps of the County. Even so, the information is not complete. (See discussion of factors affecting map reliability.) The map can be used to determine where landslides may cause problems in land development but not to prove that where none are shown none exist. The existence of a landslide deposit is best determined by field studies in conjunction with photointerpretation, and for San Mateo County this would require many man-years of effort.

PREPARATION OF THE MAP

Vertical aerial photographs taken in March 1941 by Fairchild Aerial Surveys (Job C-6660, scale 1:24,000) were borrowed from the San Mateo County Planning Department and used to make the original landslide photointerpretation. Stereo aerial photographs taken in July 1963 for the U.S. Soil Conservation Service (Mission 038, scale 1:21,000) were used to check and supplement the original interpretation. The landslide deposits are recognized on aerial photographs by a combination of such distinctive features as (1) small isolated ponds, lakes, and other closed depressions; (2) abundant natural springs; (3) abrupt and irregular changes in slope and drainage patterns; (4) irregular or hummocky surfaces; (5) smaller landslide deposits that are commonly younger and form within older and larger landslide deposits; (6) steep, arcuate scarps at the upper edge of the deposit; (7) irregular soil and vegetation patterns; (8) tilted trees and other signs of disturbed vegetation; and (9) level areas within steep slopes. Where most of these features were identified, the landslide was rated as definite. If several features were identified, the landslide was rated as probable, and if only a few features, questionable.

FACTORS AFFECTING MAP RELIABILITY

DATE OF PHOTOGRAPHY

Most of the large landslide deposits shown on this map were interpreted on aerial photographs taken in March 1941 and July 1963. Old landslide deposits, if substantially modified by pre-1941 grading operations, might not be visible on the early photographs; however, most of the landslide deposits shown probably formed before 1941 and have not been extensively modified.

SCALE OF MAPS AND PHOTOGRAPHY

Landslide deposits less than about 50 feet in maximum dimension are not shown because they are too small to be identified on the photographs used (1941, 1 inch = 2,000 ft; 1963, 1 inch = 1,750 ft) or clearly portrayed on the topographic base map (1 inch = 5,280 ft).

FOREST COVER

Dense forest cover in the southwestern part of the County and along drainage systems and watershed preserves in the central and northern part may conceal characteristic features of landslides, such as irregular or hummocky topography, scarps, ponds, lakes, and springs. Many landslide deposits in the forested areas have, therefore, probably been overlooked.

URBANIZATION AND FARMING

Landslide features can be obscured by modification of the natural land surface by (1) grading operations (leveling, cutting, filling, terracing, cultivating, etc.), and (2) covering it with man-made structures. Landslide deposits in urban or cultivated areas, therefore, may have been overlooked.

PROBLEMS OF INTERPRETATION

Mapping of landslide deposits by photointerpretation presents a number of difficult problems, some of which can only be resolved through extensive field checking. Problems that are especially difficult include: (1) the distinction of terrace-shaped slump deposits from alluvial terrace deposits adjacent to stream courses; (2) the recognition of landslide deposit boundaries that have been modified by natural processes and are no longer well defined--whereas the upslope boundary is commonly defined by an easily recognized scarp, the toe or downslope boundary is often poorly defined and difficult to locate exactly; (3) the recognition of small masses of bedrock surrounded by landslide deposits; and (4) the distinction of irregular or hummocky topography caused by variations in the erosional resistance of bedrock from that caused by landslide activity.

LOCATION OF FIELDWORK

Small, active landslides have been mapped systematically only in the San Francisco South and Palo Alto 7.5-minute quadrangles as part of the U.S. Geological Survey's ongoing program of providing general-purpose engineering-geology maps for certain urban areas. This concentration of effort explains why these landslides, shown as small black triangles on the map, are so much more numerous in the northern and eastern part of the County than elsewhere.

INFORMATION FROM PUBLIC AGENCIES

The small open triangles and circles with crosses on the map represent areas subject to landsliding and slumping that have come to the attention of public officials. They were plotted from data provided by the San Mateo County Engineer and Road Commissioner, County Planning Commission, The Town of Portola Valley, and the cities of South San Francisco, San Mateo, and Belmont. The information from the County pertains mainly to County roads west of Skyline Boulevard; no reports were received on roads east of Skyline, even though independent data indicate that some landslide damage has occurred there. No information was obtained about landslide damage to State-maintained roads. Many of the cities either had no information about landslides or were not contacted, and some provided information that did not distinguish between landslides (slope failures) in artificial fill, which are not shown on the map, and landslides involving natural bedrock.

Most of the landslides reported by public agencies correspond to those interpreted from aerial photographs or mapped in the field. This correlation indicates that the map shows many of the landslide problem areas that have adversely affected developments, and that developments in other landslide areas are likely to encounter similar problems.

In summary, landslide information from public agencies presented here is fragmentary and incomplete, but it shows many of the problem areas.

INFORMATION FROM CONSULTING FIRMS

A check of the files of a few of the engineering geology consulting firms in the Bay area indicates that there are probably several hundred reports on landslides in San Mateo County and that they would probably add substantially to the number of known landslides. In order to use most of these reports, however, permission must first be obtained from the client, a time-consuming procedure that precluded our obtaining this information. The report by Woodward-Lundgren and Associates were readily available from the City of San Mateo, and the landslides described in this report were added to our map.

SUGGESTIONS FOR MAP USERS

PLANNING DEPARTMENTS AND DEVELOPERS

The abundance and distribution of landslide deposits are crude measures of the importance of landsliding as an erosion process and, therefore, also of the overall slope stability of an area. This map, then, can be used to determine where landslides may be a problem in site development, and/or where investigations and reports by engineering geologists and soils engineers should be required prior to site development.

HOME-BUYERS

Areas of the map with relatively low densities of landslide deposits probably have good slope stability on the average, compared with areas with high densities of landslide deposits. However, it must be remembered that landslide deposits less than 50 feet in maximum dimension are not shown, and that the map is incomplete. This map, therefore, should not be used as a substitute for a more detailed investigation by an engineering geologist, because such detailed investigations are necessary for judgments about the slope stability of individual sites.

INSURANCE AND LOAN REPRESENTATIVES

This map cannot be used to determine the hazard to any individual structure because many of the landslides shown may be stable under present conditions, and others could be stabilized with little expense. Of equal importance is the fact that areas not shown as landslides could be rendered unstable by natural or artificial processes in adjacent areas. Some of the landslides observed on the 1941 photographs are now occupied by structures--the landslides may have been entirely removed or stabilized and thus no longer constitute a hazard. The map does show, however, by relative abundance of landslides, which areas are probably more hazardous than others.

ACKNOWLEDGMENTS

Nat Landes, Mayor of Woodside and Chairman of the San Mateo County Council of Mayors, and C. M. Wentworth and D. R. Nichols of the U.S. Geological Survey were instrumental in obtaining landslide information from some of the cities in San Mateo County. Among these, the information provided by R. H. Anderson, Mayor, and Frank Cauthorn, Building Inspector, Town of Portola Valley, was especially pertinent and useful. Alex Hoksmp, Building Official and Zoning Administrator, provided data on landslides in the City of Belmont; John Watt, Building Official, provided information for San Mateo; and A. M. Kebarchik, Assistant City Engineer, provided the data for Burlingame. S. S. Johnson, Associate Highway Engineer, San Mateo County, and Wentworth facilitated the acquisition of information about landslide problems from County road maintenance foremen. The explanation for the map and the methodology in identifying landslide deposits benefited greatly from discussions with and materials provided by T. H. Nilsen and Wentworth. F. A. Taylor, T. R. Simoni, Jr., and B. R. Hamachi helped prepare materials for the map.

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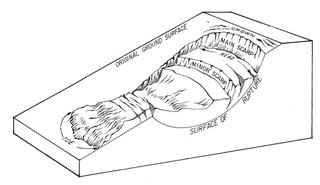

Landslide terminology (after Eckel, 1958)

MAP SYMBOLS

LANDSLIDE DEPOSITS MAPPED BY PHOTOINTERPRETATION

D-A?

Large landslide deposit

More than 500 feet in maximum dimension. Arrows indicate general direction of downslope movement (omitted for lack of space on some landslides). D, definite landslide deposit; P, probable landslide deposit; ?, questionable landslide deposit; A, landslide features on photos suggest that the landslide may be active. Hachured line shows the approximate position of an inferred main scarp

Small landslide deposit

50 to 500 feet in maximum dimension. Arrow indicates general direction of downslope movement and is centered over location of deposit

LANDSLIDE DEPOSITS MAPPED IN THE FIELD

Small landslide deposit

50 to 500 feet in maximum dimension

FA

Large landslide deposit

More than 500 feet in maximum dimension. F, mappee in field; A, active

LANDSLIDE INFORMATION FROM PUBLIC SOURCES

Subsidence of road or ground

Active landslide

Area greater than 100 square feet

LANDSLIDE INFORMATION FROM PRIVATE CONSULTING FIRMS

Landslide

50 to 500 feet in maximum dimension

TRUE NORTH
MAGNETIC NORTH
17°

SCALE 1:62500

1 1 0 1 2 3 4 MILES
3000 0 3000 6000 9000 12000 15000 18000 21000 FEET
0 1 2 3 4 5 KILOMETERS

PRELIMINARY MAP OF LANDSLIDE DEPOSITS IN SAN MATEO COUNTY, CALIFORNIA

by

Earl E. Brabb and Earl H. Pampeyan

1972

Base from U.S. Geological Survey 1:125,000
San Francisco Bay Region, sheet 2, 1971;
City boundaries from information provided by San Mateo County Planning Commission, December, 1971