DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

MISCELLANEOUS FIELD STUDIES
MAP MF-677

INTRODUCTION

This map shows various types of landslide deposits, scarps, and related topographic features, in addition to other types of surficial deposits, in northernmost Napa County, California. It was prepared by viewing overlapping vertical aerial photographs with a stereoscope. This method allows the geologist to see a three-dimensional model of the terrain to be analyzed and thereby permits him to map the distribution and infer the nature and origin of various landforms. Interpretations were checked by low altitude air reconnaissance in January 1975, but the deposits and features shown on this map have not been checked on the ground. They do, however, represent a consensus of judgment by both authors.

Landslides were recognized on aerial photographs by a combination of such general distinctive features as (1) small isolated ponds, lakes, and other closed depressions; (2) springs; (3) abrupt and irregular changes in slope and drainage pattern; (4) hummocky or irregular surfaces; (5) steep, arcuate scarps; (6) irregular or multiple radial drainage patterns; and (7) level areas within steeper slopes. Landslide deposits were differentiated into several types using the general features listed and more detailed criteria (see EXPLANATION) developed by Wright from field observations in the northern Coast Ranges of California, particularly in Sonoma and Marin Counties, over the past several years.

LANDSLIDE MAPPING

Thousands of landslides, recognized primarily by their resulting deposits, have been mapped in various upland parts of the San Francisco Bay region, indicating that landsliding has been one of the most important erosional processes in the region for at least the past 40,000 years (unpub. radiocarbon data). Since landslide susceptibility is generally higher within or adjacent to areas that have a history of landsliding, maps that show the distribution of landslide deposits also indicate areas of potential natural and artificially induced landsliding.

Different types of landsliding produce different topographic features and deposits, primarily reflecting the style of movement and the nature of the material involved. Recognition and differentiation of types of landslide deposits, scarps, and other related features provide information, beyond the delineation of the deposits themselves, basic to the understanding of the landslide process. Such information aids in predicting not only the location but also the nature of potential landsliding and general slope stability, particularly regarding possible hazards to life and property. In addition, such information is critical in predicting and planning for the specific nature and economic costs of prevention and control of various types of landslides and for land-use planning in landslide and landslide-prone areas.

FACTORS AFFECTING MAPPING AND MAP RELIABILITY

There are several problems in mapping landforms by photointerpretation alone, some of which can be resolved only through field checking. In general, these problems can be divided into two areas: those inherent in interpreting landforms, and those introduced by aerial photographs.

Problems in interpretation.--The basic reliability of this map rests on the observation that various processes produce characteristic topographic features or landforms that can be interpreted from aerial photographs. Accepting this, there are a number of problems in interpretation that are especially difficult. These include: (1) distinguishing alluvial fan deposits from mudflow deposits, particularly at the mouths of drainage basins whose upstream areas contain numerous earthflows and mudflows; (2) distinguishing nearly horizontal landslide deposit surfaces from alluvial terrace deposits where both are located adjacent to stream courses; (3) recognizing bedrock cropping out beneath surficial deposits, especially where a creek or stream has cut down through the overlying surficial deposits to expose bedrock along the streambed; (4) determining boundaries between adjacent surficial deposits that laterally grade into or interfinger with one another without leaving any easily discernible topographic feature, for example, the downslope gradation of colluvial deposits into alluvial terrace deposits; (5) recognizing landslide deposit boundaries, particularly in areas of extensive complex landsliding since, for example, the toes or downslope boundaries are sometimes not well defined and are difficult to locate exactly, whereas upslope boundaries are commonly defined by easily recognized scarps; (6) recognizing stable masses of bedrock within landslide deposits, especially where the bedrock may appear only as a large block within the surrounding landslide deposit; (7) distinguishing between irregular or hummocky topography caused either by variations in the erosional resistance of bedrock or by the erosion of landslide deposits; and (8) the assignment of relative age designations on the basis of the "freshness" of the observed landform, for example, one type of landslide deposit, formed at the same time as another type, may initially have more subdued features and, in addition, may be modified at a different rate under similar conditions, resulting in completely different and misleading degrees of "freshness".

Vegetation in the map area consisted predominantly of grass and brush and did not present a serious problem in the recognition of landforms. However, vegetation did limit the differentiation of some landslide deposits.

Problems associated with photography.--Most problems associated with the photography are related to scale and quality. Features less than about 60 m long are not shown on this map because they are too small to be clearly identified on the photographs or clearly portrayed on the topographic base map. Accuracy of the map varies directly with the clarity and contrast of the photographs used. Photographs used to prepare this map are of excellent quality.

It should be emphasized that the landslides, surficial deposits and related features shown on this map represent our interpretation of aerial photographs taken in May 1970 and June 1973 and checked by low altitude air reconnaissance in January 1975. Subsequent modification of the ground surface by various processes may have produced additional landslides and modified the landslides, surficial deposits, and related features shown on this map.

SOURCE MATERIALS

The following black-and-white vertical aerial photographs, scale approximately 1:12,000 and 1:80,000, taken for the U.S. Geological Survey in June 1973 and May 1970, respectively, were used in the preparation of this map: 1:12,000 series 3575 including numbers 1-261 to 263, 2-009 to 013, 2-112 to 122, 2-130 to 139, 2-271 to 281, 3-003 to 013, 3-142 to 151, 3-158 to 166, and 4-038 to 043 and 1:80,000 series GS-VCMI 3-94 to 96.

ACKNOWLEDGMENTS

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NOTE TO MAP USERS

This map was produced by photointerpretation and is, therefore, not a substitute for on-site investigations. However, the overall distribution of landslides is a measure of past slope failure as an erosional process and therefore is an indicator of the present slope stability of the area. In addition, the distribution of the different types of landslides is a measure of the nature of that slope failure and can be used as a crude indicator in predicting the nature of potential failures. This map identifies areas susceptible to various types of landslide activity that should be carefully studied before any site development.

Nomenclature of parts of a landslide (from Eckel, 1958).

EXPLANATION

Scarps and cliffs

Relatively steep to vertical slopes commonly related to landsliding and stream entrenchment. These include recognized main and minor landslide scarps, steep banks along entrenched streams, and cliffs facing the basalt cropping out in the Lone Pine Thicket area. Hachures delineate the area of scarp, and their length is directly proportional to the length of the slope and roughly inversely proportional to the steepness of the slope

Landslide deposits

Dismodified to highly modified landslide deposits representing a range in time of activity from 1973 to greater than 40,000 years ago. Deposits unconsolidated to semiconsolidated and of variable thickness; generally larger than 150 metres in longest dimension. Identification confident to probable. Arrows indicate direction of inferred downslope movement. Topographic expression and inferred dominant style of movement designated by numbers as follows:

Type 1 - Mudflow and earthflow deposits

Generally elongate, often sinuous, lobate, smooth-surfaced deposits. Generally associated with a prominent main scarp and characterized by multiple minor scarps and radial cracks. A characteristic drainage pattern parallel to the long axis of the deposits is often developed by gullying of radial cracks.

Probably consist predominantly of colluvial and soil material that have moved downslope in a manner similar to a viscous fluid, often relatively rapidly.

Includes areas of extensive soil creep, particularly south-east of Morgan Valley. Includes some large areas predominantly of type 1 that may contain stable bedrock

Type 2 - Debris flow, debris slide, and fragmented block glide deposits

Generally irregular to elongate, hummocky-surfaced deposits. Not generally associated with a main scarp. A characteristic irregular drainage pattern is often developed, probably by the erosion of finer grained debris from around larger fragments.

Probably consist predominantly of heterogeneous-sized fragments of fresh and weathered bedrock and associated surficial deposits that have moved downslope either relatively rapidly with significant amounts of water, or slowly to rapidly as a comparatively dry mass. The fragmented block glide results from the fragmentation of large coherent masses moving downslope by translation on bedding or structural surfaces.

Includes some large areas predominantly of type 2 that may contain stable bedrock

Type 3 - Rotational landslide, rotational slump, and block glide deposits

Generally triangular, with one apex upslope, to elongate, smooth to irregular surfaced, convex upward deposits. Generally associated with prominent single and multiple main scarps, transverse cracks, and depressions or benches resulting from the backward rotation of the displaced masses.

Probably consist predominantly of coherent or intact masses of bedrock that have moved downslope slowly to rapidly on curved, concave upward slip surfaces that underlie, as well as penetrate, the deposits. Block glide results from the downslope movement of large coherent masses by translation on bedding or structural surfaces.

Includes some large areas predominantly of type 3 that may contain stable bedrock

Type 4 - Rockfall and talus creep deposits

Generally irregularly shaped and surfaced deposits characterized by vegetation scars due to the periodic movement of debris downslope.

Probably consist of heterogeneous-sized fragments of bedrock that have moved by free falling from a cliff or by precipitous rolling or bounding down very steep slopes, including any debris mantle in transit downslope and deposits at the base of cliffs or steep slopes.

Type 4 deposits are common along drainages and on the steeper, upper slopes of Blue Ridge

Type 5 - Undivided complex deposits

Undivided complexes of types 1, 2, and 3 and related types whose individual boundaries are not recognizable with confidence. Most commonly includes combinations of type 1 with type 2 or 3; related types include those with some features characteristic of types 1, 2, or 3; may include areas of stable bedrock

Type 6 - Undifferentiated deposits

Undifferentiated deposits whose characteristic topographic expressions are not assignable to types 1, 2, 3, or 4; represent transitional types, with characteristic features different near the head of the landslide (often type 2) than near the toe (often type 1), and modified types

Small landslides

Predominantly flows and slumps of surficial materials too small to be delineated at this map scale. Landslides generally larger than 60 but smaller than 150 metres in longest dimension; represents both deposits and any associated scarps. Landslides smaller than approximately 60 metres in longest dimension are not shown. Identification confident to probable; arrows indicate direction of inferred downslope movement and are centered over location of slide

Anomalous topography

Anomalous topography of several possible origins. Includes isolated bowl-shaped areas exposing bedrock, probably resulting from the removal of surficial deposits or landslide deposits by predominantly mass-wasting processes, modified landslide scarps, and areas of irregular or hummocky topography, often adjacent to and containing landslides, resulting from the differential erosion of bedrock or representing highly modified, eroded landslides and landslide complexes

Alluvial fan deposit

Small, characteristically fan-shaped, irregularly stratified, unconsolidated, water-laid clay, silt, sand, and minor gravel deposits generally formed where ravines and gullies emerge onto more gently sloping valley floors. Fan deposits generally appear to overlap, but may grade into, colluvial, alluvial terrace, and alluvial deposits. May include some mudflow deposits

Alluvial deposit

Irregularly stratified, unconsolidated deposits of clay, silt, sand, and gravel being presently deposited by running water in stream and creek beds and on adjoining flood plains. Alluvial deposits less than approximately 60 metres wide, common along smaller intermittent streams, generally have not been mapped. May include some older alluvial deposits and colluvial deposits. Alluvial deposits commonly grade upslope into colluvial deposits and may grade into alluvial fan deposits

Alluvial terrace deposit

Irregularly stratified, poorly consolidated alluvial deposits that underlie horizontal to gently inclined flat surfaces adjacent to but above the present streambeds and valley floors of Putah, Bunting, and Eticuera Creeks. These deposits are generally not present sites of sedimentation, but represent older levels of stream deposition that have been abandoned as the stream continued to erode downward. Queried where uncertain; patterned where topographic evidence suggests location of former channel deposits. Along Putah Creek several terrace levels are present and are numbered sequentially by subscript from 1 (lowest and youngest) to 3 (highest and oldest)

Older alluvial deposit

Irregularly stratified, poorly consolidated deposits of clay, silt, sand, and gravel inferred to underlie nearly flat, slightly modified surfaces adjacent to and slightly above alluvial deposits. Patterned where topographic evidence suggests location of former channel deposits. Mapped only in Mysterious Valley and along Knoxville Creek near Knoxville; may include alluvial and colluvial deposits. Probably grades upslope into colluvial deposits

Colluvial deposit

Unstratified or poorly stratified, unconsolidated to poorly consolidated deposits composed of fresh and weathered rock fragments deposited chiefly by mass-wasting near the base of slopes or cliffs. Mapped only where they form a distinct apron near the base of slopes, or fill or flatten ravine and valley bottoms and upland flats, although they are probably present on almost every slope. Colluvial deposits less than approximately 60 metres wide have not been mapped. Colluvial deposits, particularly in some narrow stream valleys and ravines, may include alluvial fan deposits. Colluvial deposits commonly grade downslope into alluvial and older alluvial deposits

Questionable bedrock

Isolated ridges or mounds of inferred bedrock surrounded by or adjacent to landslides; have a very low probability of being landslide deposits

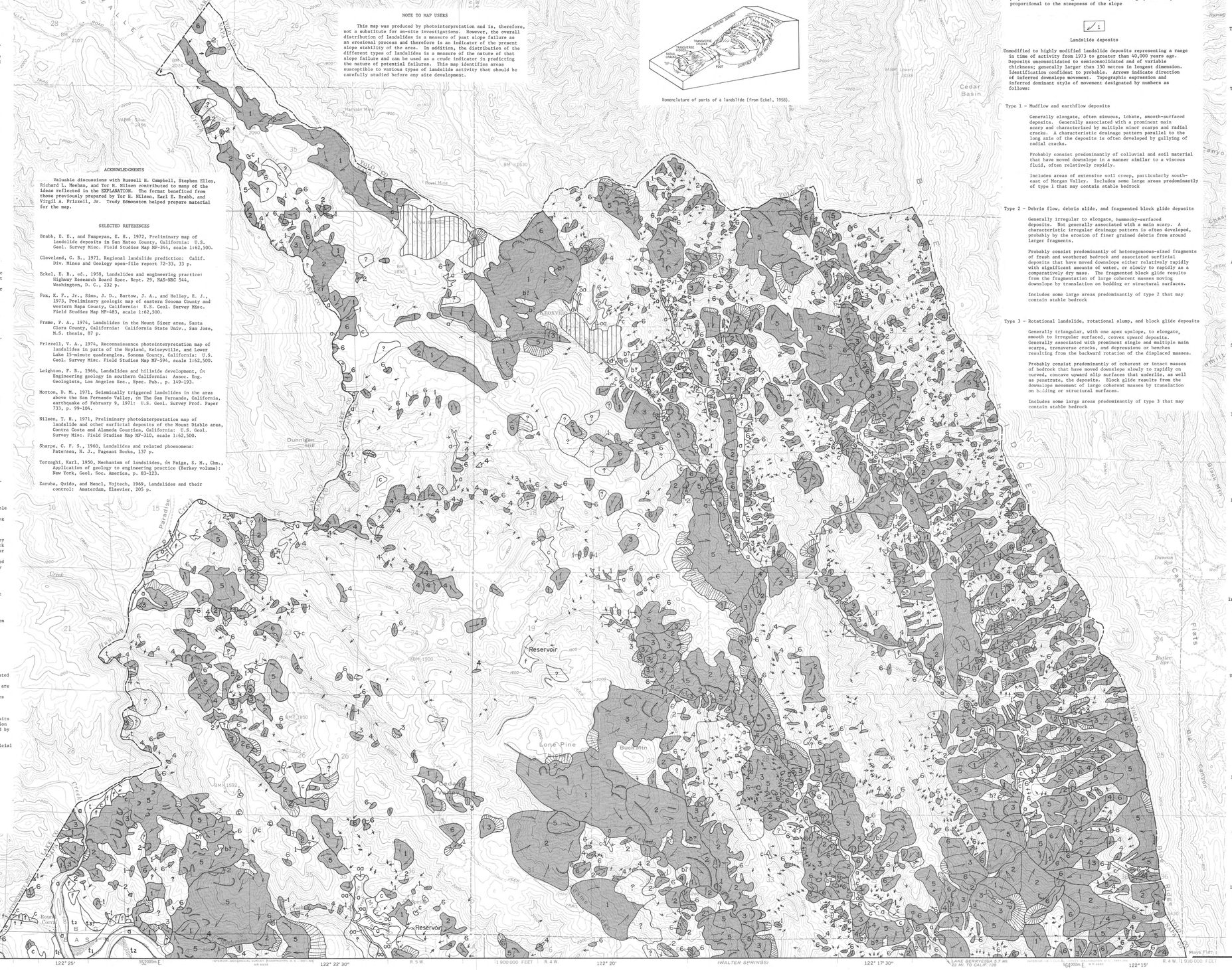
Modified topography

Topography in the Knoxville area extensively modified by mining activity. Identification of original topographic features impossible by photointerpretation

Bedrock

Igneous, metamorphic, and sedimentary rocks of various ages and physical properties. Areas not otherwise designated should be considered bedrock, either exposed at the surface or mantled by a thin veneer of surficial deposits, most commonly colluvial material

Springs



Base from U. S. Geological Survey 1:24,000
Jericho Valley, 1958, Knoxville, 1958, and
Guinda, 1959

UTM GRID AND 1958 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET

For sale by U. S. Geological Survey, price $.50

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PHOTOINTERPRETIVE MAP OF LANDSLIDES AND SURFICIAL DEPOSITS OF NORTHERNMOST NAPA COUNTY, CALIFORNIA

By
Robert H. Wright and George O. Reid

1975

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