Prepared in cooperation with the

RESEARCH INSTITUTE FOR HYDROGEOLOGICAL PROTECTION IN CENTRAL ITALY
NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES
AND THE
NEW MEXICO STATE HIGHWAY DEPARTMENT

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

SHEET 1 OF 4
OPEN-FILE REPORT
90-293

NEW MEXICO

ESCARPMENTS AND LANDSLIDE SCARPS

PRELIMINARY MAPS SHOWING LANDSLIDE DEPOSITS AND RELATED FEATURES IN NEW MEXICO

By

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1990

Scale 1:500,000
1 inch equals approximately 8 miles

10 0 10 20 30 40 Miles
10 0 10 20 30 40 50 Kilometers

EXPLANATION

ESCARPMENT OR LANDSLIDE SCARP - Hachures point downslope. Double hachures indicate a narrow ridge with escarpment or landslide scarp on both sides. Star-like symbol indicates pinnacle; opposing hachures indicate steep-walled canyon.

PRELIMINARY MAPS SHOWING LANDSLIDE DEPOSITS AND RELATED FEATURES IN NEW MEXICO

INTRODUCTION

These maps show the many places in New Mexico where there is evidence of past or present landslide movement. They are compiled from all readily available geologic and engineering literature and maps, supplemented as well by systematic examination of aerial photographs. The four map sheets show deposits or features related to different kinds of landslide movement that pose different hazards, but constitute an inventory of landslide-related features that may be helpful in identifying areas of relative degrees of current or future susceptibility to landsliding.

The maps are from a broad-scale inspection of the State. The broad scale provides an appraisal that is considered adequate for large areas but that lacks the detail necessary to evaluate either site conditions or the effects of potential or incipient large landslides. Consequently, the maps are suitable for subtle or incipient large landslides only preliminarily, NOT AS A SUBSTITUTE OF LANDSLIDE STUDIES ON THE MAPS DONE NOT INCLUDED IN THE MAPS OF LANDSLIDE PROBLEMS.

BACKGROUND

The map project began in 1985 with discussions between Fausto Guzzetti of the Research Institute for Hydrogeological Protection in Central Italy and Earl Brabb of the U.S. Geological Survey about cooperative work on regional landslide analyses. They selected New Mexico as a project area because of the paucity of information about landslide processes in arid and semi-arid regions of the United States and Italy; because they wished to compare techniques of displaying landslide information at small (broad) scale that might be applicable to Italy; and because Brabb had already prepared a map at the same scale for another project (Brabb, 1987) and a report by Brabb and others (1989). Guzzetti visited the New Mexico State Highway Department and Bureau of Mines and Mineral Resources and offered to lend them his aerial photography, which he used in the study. Work began in October, 1985, and resulted in maps showing deposits and features related to landslide movement (Cardinali, Guzzetti, and Brabb, 1987) and a report by Brabb and others (1989). Cardinali and Guzzetti published a report in Italian in 1988 and in English in 1990 that includes photographic prints of the maps, which are at the same scale as those of the United States, plastic-sheet overlays, and annual rainfall, and other aspects of climate.

In June of 1988, high-quality, infra-red color photographs for most of New Mexico not mapped by Guzzetti and Brabb were purchased by the U.S. Geological Survey and lent to Italy for Mauro Cardinali to study. Cardinali's work to finish the maps took much longer than scheduled. From October of 1989 until February of 1990, Cardinali worked full time in the United States with Brabb to complete the landslide inventory.

INVENTORY

Landslide names used in this report follow the usage of Varnes (1978) unless otherwise noted, except that we use the term "landslide" to encompass all types of slope movement designated on the maps. We also use the term "complex block" as defined by Baiche (1977) for a rock slump or series of rock slumps that have developed along the slopes of mesas and buttes that are capped with a resistant rock, commonly basalt or sandstone. If the association of the slumped material with a resistant rock is not present or is not clear, we use the term "rock slump" rather than "complex block." We use the term "rock fall" here to refer to steep slopes or cliffs adjacent to or within landslides and produced by landslide movement, and the term "escarpment" refers to steep slopes or cliffs apparently formed principally by differential erosion and not directly related to large landslides.

We distinguish landslides of different depths to separate the typically shallow and rapid processes of debris flow and rock fall which may still be active landslides that may pose hazards to life, property, or both, from deeper slumps but generally not sliding people for many years. The scale (1:500,000) of most of the maps (sheets 1 and 2) and the data probably presented us from making this distinction consistently in several places, but our field observations generally indicate that the general depth distinctions we have made are valid.

Similarly, the small scale of most photos and the reconnaissance nature of mapping have probably caused us to underestimate the number of debris flows, debris slides, and earthflows exposed by fall deactivation of observations (1979). Consequently, some of the landslides may not be recognized as active or potentially involved. In general, landslides and especially resistant bedrock like basalt and sandstone, can be distinguished relatively easily on the photographs where the rocks are being shaped at a high elevation. On gentle slopes at low elevation, especially if the bedrock is shale and other less resistant rocks, landsliding may have been mistaken for debris and earth.

MAPPING AIDS

All of the landslide deposits shown on maps and in reports listed by Alger and Brabb (1985, p. 6-8) were plotted on 1:125,000-scale base maps. Most of the landslide deposits mapped by geologists in the vicinities of the New Mexico State Highway Department (1971-1981), as a part of an aggregate resources study, would provide sufficient data that could be transferred with confidence from aerial photographs. As we began checking these and other landslides, however, we became convinced that only a few of the landslides had been plotted on the basis of photographs and that most had been identified in the course of geologic or other information related to uniform results for landslides of escarpments, hummocky topography, and alluvial fans. Secondarily, we recognized landslides by systematically identifying landslide and other features on aerial photographs and plotting them directly on the maps. Finally, we used maps, and, more substantially, new information to the data from published reports.

The substantially different kinds of aerial photographs were used for the mapping. Black-and-white aerial photographs flown in 1953 and 1954 at 1:31,000 scale by the Army Map Service (AMS) were the principal photographs used by Guzzetti and Brabb in the northwestern part of the State and in a few other areas (see index maps). Color infra-red photographs flown at 1:58,000 scale, flown in 1982 and 1983 under the auspices of the Soil Conservation Service (now called Natural Resources Conservation Service), were used for most of the remaining mapped areas. This photography is well suited for broad-scale landslide analysis.

The resolution of USGS photography is 5 to 10 lines/mm, equivalent to 2 to 3 ft on the ground, and that of SCS photography, according to D. L. Light of the U.S. Geological Survey, is about 1 mm. We have identified debris flows that are probably as small as 5 ft in width, but the much greater length and other clues, such as association with alluvial fans, have helped with the construction of these narrower features. We have probably missed many landslides that have a maximum dimension of less than 50 ft.

The landslide information on the 1:100,000-scale base maps was reduced photographically to 1:500,000 scale and then drafted onto a stable mylar base. Landslides smaller than 1 mile in maximum dimension are represented by a symbol; the center of the symbol is placed at the center of the landslide deposit, except for debris flows, in which case the symbol is placed at the center of the source area. Landslides larger than 1 mile in width or length are commonly too large to be small to permit a symbol for each landslide, a number is used beside the symbol to indicate the total number of such landslides recognized within the area.

The time required to interpret, plot, reduce and draft the landslide information for approximately fifty-seven 1:100,000-scale maps was about 1 man-year. This estimate is comparable to the 7 days per 1:24,000-scale quadrangle mentioned by Campbell (1980) and the U.S. Geological Survey (1982, p. 22). Thus, cursory landslide inventories of large areas at 1:500,000 scale can be prepared in about the same time as more detailed, larger-scale inventories of smaller areas.

USES AND LIMITATIONS OF THE MAPS

The maps provide much new information about landsliding in New Mexico. To begin with, they document a surprising abundance and variety of landsliding in the State. They offer consistent broad-scale information that is well suited to general uses. They are, for example, suitable for regional planning and for the selection of areas where more detailed studies may be needed and where more detailed studies are needed to determine the hazard. They can be used for the preparation of broad-scale landslide susceptibility maps and for studies of factors that control the areal distribution of landslides. If landslides are shown at or near sites where development is planned, engineering geologic studies should be made to be certain that the extent of any landslide problem is recognized and that appropriate site investigations measures are considered.

The same qualities that make these maps suitable for some uses makes them unsuitable for others. The small scale of the maps and of the aerial photographs, the rapid pace of mapping, and the limited amount of field checking limit the maps to MORE SENSITIVE FOR SOME AREAS THAN OTHERS. Landslide inventory maps at 1:24,000 scale or larger commonly have more than twice as many landslides recognized as those considered unsuited for hazard evaluation at site scale (Smith, 1985).

The use of photography as old as 1953 and at scales as small as 1:58,000 has created an uneven landslide inventory. Many of the debris flows and other landslides that have been mapped in the Rio Grande valley and elsewhere on the 1:31,000-scale 1953 photography were not recognized on the 1:58,000-scale photos in areas where only the 1983 photos were used. The field checking in 1987, 1989, and 1990 has corrected some of these problems and in relation to the landslide information provided: Debris flows not detected on the 1:58,000-scale photos were nearly always mapped debris flows and landslides, rather than in areas not recognized as having landslides. Also, most landslides appear to be older than 1953.

Deep-seated landslides are probably adequately represented on the maps, but shallow landslides (especially debris flows and rock falls and topples) are probably under-represented. Many of these features are probably large enough to pose serious hazards. SOME DETAILED LANDSLIDE STUDIES ARE STILL NEEDED TO DETERMINE THE FULL EXTENT OF THE LANDSLIDE HAZARD IN NEW MEXICO.

Scarps and escarpments are mostly vertical or very steep rock walls that may topple or fall on adjacent areas. Talus slopes underlain by rock debris and boulders downhill from these scarps and escarpments are especially hazardous. Boulders derived from the scarps and escarpments are likely to bounce onto nearby flat areas, but nearly all of the sites we investigated had boulders only on the talus slopes.

Some of the escarpments, especially those in the northern Sangre de Cristo Mountains, are associated with earthquake and large-scale, deep-seated distortions of steep-sided ridges (Varnes and others, 1989). The earthquake, accompanying distortions, and the rock falls and topples that result from the distortions may pose hazards to the slope, one to a few meters high, trending subparallel parallel with topographic contours and commonly somewhat convex downslope in plan; 2) A graben or grabens along the ridge crest, commonly with closed contours and upthermal ponds; 3) Double-crested ridges; 4) Bulging of the lower parts of the slopes; 5) Occurrence on the upper flanks of glaciated valleys; 6) Local relief more than 300 m; and 7) concentration in areas of massive and bedded rocks, such as sandstone and shale, and lava flows. Structures associated with deep-seated landslides have been mapped in an entire state in less than 2 years. The maps are suitable for regional planning and to identify broad areas of the State where processes are or have been concentrated, and where more detailed studies are needed to determine the hazard.

ACKNOWLEDGMENTS

We are grateful to Warren H. Anderson of the New Mexico State Highway Department for his help in locating the black-and-white aerial photographs used in some of the maps. He also provided complete set of geologic maps at 1:190,000 scale used in making an aggregate survey for the State. David W. Love, Gary D. Shipman, and Jo Anne C. Wells of the New Mexico Bureau of Mines and Mineral Resources kindly loaned us photographs, helped order the SCS photos, provided transportation to Soil Conservation Service offices to view SCS photos, provided transportation to Socorro, and offered advice on the text and reviewed the map and explanation. Peggy Johnson of the U.S. Geological Survey, Menlo Park, California, helped in all, we are grateful to Prof. Lucio Ubaldini, Director of the Research Institute for the Hydrogeological Protection in Central Italy, for providing the opportunity and funds for Guzzetti and Cardinali to work in the United States on this project.

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This map is preliminary and has not been reviewed to conformity with U.S. Geological Survey editorial standards or with the North American Stratigraphic Code. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

INTERIOR-GEOLOGICAL SURVEY, WASHINGTON, D.C.-1990

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