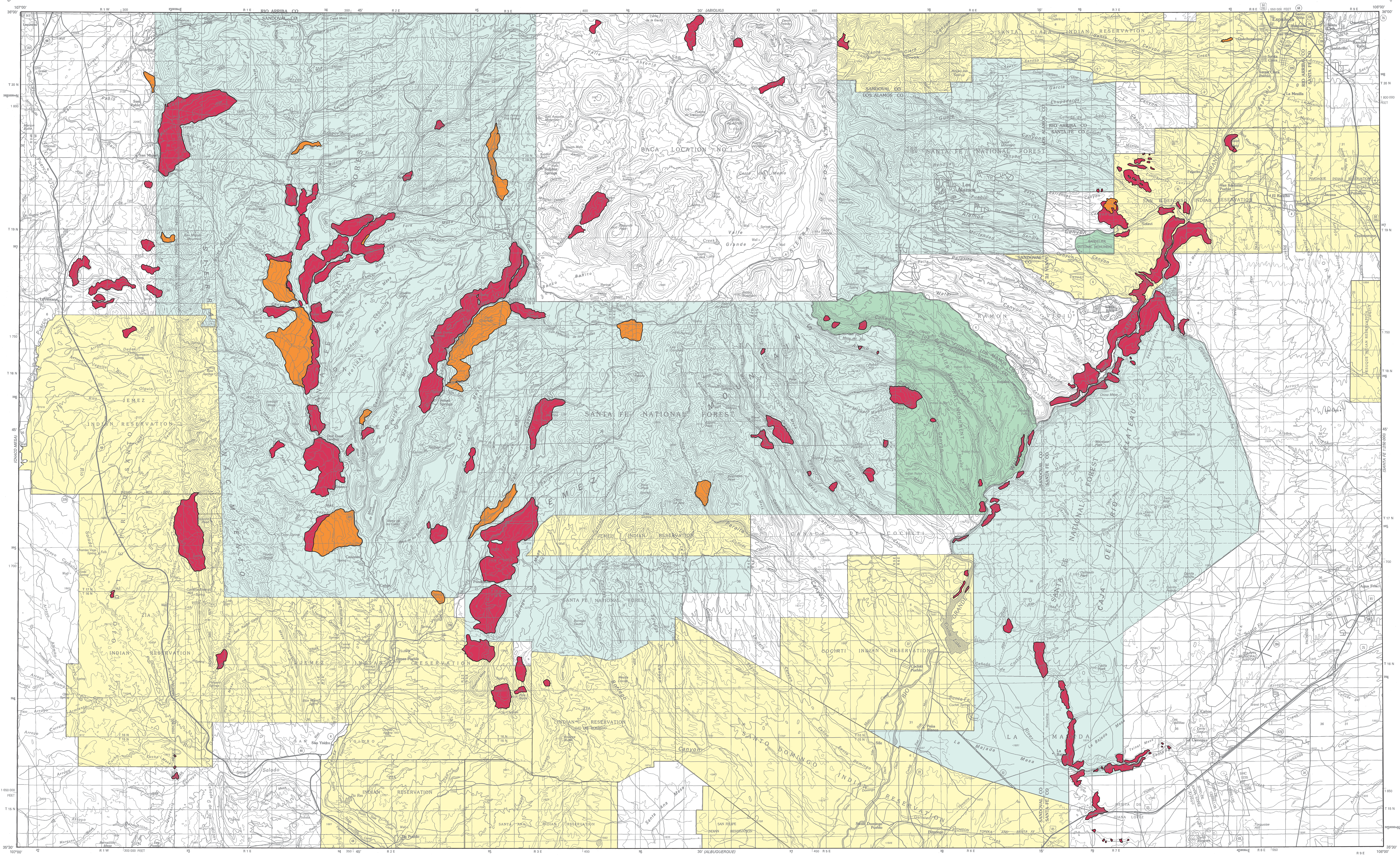
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF–2328



Base from U.S. Geological Survey, 1978.
Projection and 10,000-meter grid, zone 13: Universal Transverse Mercator.
50,000-foot grid ticks based on New Mexico coordinate system, central zone.
1927 North American datum

QUADRANGLE LOCATION

SCALE 1:100 000

1 0 1 2 3 4 5 6 7 8 MILES

1 0 1 2 3 4 5 6 7 8 9 10 KILOMETERS

CONTOUR INTERVAL 50 METERS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

TRUE NORTH — MAGNETIC NORTH — 12°
APPROXIMATE MEAN DECLINATION, 1978

Geology mapped by P.E. Carrara, July–September 1997.
Manuscript approved for publication August 27, 1999

DESCRIPTION OF MAPPED LANDSLIDE DEPOSITS

Landslide deposit (Holocene to middle Pleistocene)—Unit displays well-defined geomorphic features that may include: headwall scarp, hummocky topography, prominent toe, and deflection of drainage. Unit consists of a heterogeneous mixture of unconsolidated surficial materials and rock fragments in a wide range of sizes. The size and lithology of the rock fragments and the grain size of the matrix depend on the various bedrock and surficial units involved in the landslide. Unit includes earth flows, rotational slides, translational slides, debris avalanches, and complex landslides (Varnes, 1978). Identified areas commonly contain multiple landslide masses that may have moved at different times. Thickness of larger landslides exceeds 200 m

Possible landslide deposit (Holocene? to middle Pleistocene)—Unit does not display well-defined geomorphic features typical of landslides; features are muted. Many of the areas mapped as this unit may be old landslide deposits whose distinctive form has been subdued by erosive processes

DISCUSSION

GEOGRAPHY AND GEOLOGY

The Los Alamos 30′ × 60′ quadrangle, an area of about 5,000 km^2 in northern New Mexico, includes Bandelier National Monument, Los Alamos National Laboratories, portions of Santa Fe National Forest, and all or portions of 10 Indian Reservations (Cochiti, Jemez, Pojoaque, San Felipe, San Ildefonso, Santa Ana, Santa Clara, Santo Domingo, Tesuque, and Zia).

Much of the landscape in the map area consists of mountains and plateaus incised by canyons as much as 550 m deep. Altitudes in the map area range from 3,430 m at Redondo Peak, in the north-central map area, to below 1,600 m at Santa Domingo Pueblo, along the southern border of the map. In the western map area is the north-trending Sierra Nacimiento, where Precambrian igneous and metamorphic rocks are overlain unconformably by younger sedimentary strata (Woodward, 1987). The central map area is dominated by the Jemez Mountains, consisting of an approximately 20-km-diameter caldera and a thick sequence of volcanic rocks that were erupted between about 13 and 0.06 Ma (Goff and others, 1989; Reneau and others, 1996). In the eastern map area, the plateaus flanking the Rio Grande are underlain by Pliocene basaltic lavas and Pleistocene tuffs (Smith and others, 1970). The area along the eastern edge of the quadrangle covers the Española Basin, which is underlain by Santa Fe Group sediments of Miocene and Pliocene age (Smith and others, 1970).

LANDSLIDE DEFINITION

Landslide is a general term for landforms produced by a wide variety of gravity-driven mass movements, including various types of flows, slides, topples and falls, and combinations thereof produced by the slow to rapid downslope transport of surficial materials or bedrock. Landslide movement takes place on an inclined failure surface that separates the displaced material above from intact substrata below. At the scale of this map, only the larger, well-defined landslide deposits are shown, such as earthflows, rock and earth slumps, translational slides, debris avalanches, or combinations thereof (complex slides) (Varnes, 1978). Areas of talus (rockfall) and debris flows are not shown.

LANDSLIDE RECOGNITION

About 150 landslides, including many previously unrecognized and unmapped deposits have been identified in the Los Alamos 30′ × 60′ quadrangle by reconnaissance surficial geologic mapping. These landslides range in size from small earthflows and rock slumps (less than 0.10 km^2) to large earthflows, rock slumps, translational slides, debris avalanches, and complex landslides greater than 10 km^2 (Varnes, 1978). Landslide deposits underlie about 4 percent of the map area, and about 230 km of roadways are either underlain by landslides or are within 100 m of a landslide. This estimate was calculated on the basis of all roadways indicated on the Los Alamos 30′ × 60′ quadrangle base map (primary and secondary hard-surfaced highways, light-duty roads, unimproved roads, and trails).

Landslide deposits shown on the map were identified and mapped by a variety of methods including: (1) compilation from existing geologic maps, (2) stereoscopic analysis of 1:40,000-scale black and white aerial photographs, and (3) reconnaissance fieldwork. Low sun angle in the early morning and late afternoon enhanced the subdued topography of many older landslide deposits and was a useful aid to their identification in the field. Physical characteristics common to landslides that aided in their identification included: (1) headwall scarps, (2) hummocky topography, including closed depressions on hillsides, (3) bulging landslide toes, (4) deflection of stream channels by landslide toes, (5) vegetation differences between landslide and adjacent stable areas, (6) bedrock blocks with anomalous dips and strikes, and (7) displaced coherent masses of geologic units downslope from their sources. Landslide scarp height, morphology, and topographic relief between the head and toe suggest that many of the larger landslide deposits are more than 200 m thick (Reneau and Dethier, 1996a, b).

LOCATION OF LANDSLIDES IN THE MAP AREA

Landslides occur throughout the Los Alamos 30′ × 60′ quadrangle. East of the Sierra Nacimiento they are concentrated along the edges of volcanic mesas above major canyons. These landslides formed where steep cliffs of resistant volcanic rock are underlain by weakly indurated sedimentary rocks of low shear strength. In many cases, large blocks of volcanic rock have broken away from the cliffs and slumped downward, the top of the block rotating back toward the mesa. In the eastern map area along the Rio Grande, many of the failures occur in clay-rich units within the Santa Fe Group. Extensive landslide deposits in White Rock Canyon were mapped by Smith and others (1970) in their overview of the Jemez Mountains and later studied in detail by Reneau and others (1995), Reneau and Dethier (1996a), and Dethier and Reneau (1996). Massive landslides also exist along: (1) the Jemez River in the Cañon de San Diego, (2) Vallecito Creek, and (3) the Rio Guadalupe and its two major tributaries—the Rio Cebolla and the Rio de las Vacas. Here, landslides occur within sedimentary rocks of low shear strength within the Pennsylvanian Madera and Triassic Chinle Formations, and the Santa Fe Group. Along the flanks of the Sierra Nacimiento, where sedimentary rocks overlie Precambrian crystalline rocks, the landslides occur mainly in the Madera and Chinle Formations (Woodward, 1987). In places, landslides form continuous, or nearly continuous, deposits for as much as 10 km along the sides of these canyons.

AGE OF LANDSLIDES

Landsliding on the Los Alamos 30′ × 60′ quadrangle probably began in the early to middle Pleistocene and was probably more active during the Pleistocene Epoch, which ended about 10,000 years ago, when the climate was relatively wetter than the present day. Hence, many of the landslide deposits shown on the map may now be relatively stable. In White Rock Canyon, extensive landsliding is thought to have begun in the middle Pleistocene, after the Rio Grande had incised through Pleistocene volcanic rocks and into weakly indurated sediments of the Santa Fe Group (Reneau and Dethier, 1996a). However, landsliding continues to be an ongoing process, as indicated by the damage to State highway 126 along the western side of the San Antonio Creek valley during the spring of 1998. Active slides also occur along the margin of Cochiti Lake and at Otowi along the Rio Grande.

FACTORS CONTRIBUTING TO LANDSLIDES

Several factors are thought to be responsible for many of the landslides in the Los Alamos 30′ × 60′ quadrangle including: (1) downcutting of canyons through volcanic rocks exposing underlying weakly indurated sedimentary rocks of low shear strength, (2) continued downcutting and removal of lateral support during times of high stream flow, resulting in the maintenance of steep slopes, and (3) increases in pore water pressure in bedrock and surficial deposits, particularly during pluvial periods of the Pleistocene Epoch (Reneau and Dethier, 1996a). Because the map area is traversed by part of the Rio Grande rift, a seismically active area containing numerous faults with Pleistocene offset (Olig and others, 1996), many of the landslides may have been triggered by earthquakes.

IMPORTANCE OF LANDSLIDE RECOGNITION

Recognition of these landslides is important because natural and human-induced factors can influence slope stability. Reduction of lateral support (by excavations or roadcuts), removal of vegetation (by fire or development), or an increase in pore pressure (by irrigation or lake-level fluctuations) may result in reactivation of these landslides or parts of these landslides. The damming of a drainage by a landslide can create a temporary lake that overflows and bursts the dam, flooding downstream areas. Landsliding in White Rock Canyon is known to have dammed the Rio Grande at least four times between 12,000 and 18,000 radiocarbon years ago, and at about 40,000 radiocarbon years ago, and doubtless many times before that (Reneau and Dethier, 1996a).

LIMITATIONS OF MAP

Landslide deposits shown on this map are thought to underrepresent the actual number and aerial extent of landslides present for several reasons: (1) many small landslide deposits (<0.01 km^2) probably were not recognized because of the scale (1:40,000) of the air photos used in this study, (2) extensive areas of shadows on some air photos made interpretation difficult, and some landslide deposits in these shadowed areas may not have been identified, (3) small or shallow landslide deposits in the higher parts of the map area, covered by thick forest, may not have been recognized, (4) older landslide deposits whose original topography has been extensively modified by erosion may not have been identified, and (5) various types of mass movement deposits are clearly underrepresented on this map. Because of the small scale of the map, talus and debris flow deposits are not shown.

This map has been prepared to provide a regional overview of the distribution of landslide deposits in the Los Alamos 30′ × 60′ quadrangle, and as such constitutes an inventory of landslides in the area. The map is suitable for regional planning to identify broad areas where landslide deposits and processes are concentrated. It should not be used as a substitute for detailed site investigations. Specific areas thought to be subject to landslide hazards should be carefully studied before development. S.L. Reneau and other investigators from Los Alamos National Laboratory have discussed landslides and rates of slope retreat with respect to environmental remediation work (for example, Reneau and others,1995). Additional studies are described in the 1996 New Mexico Geological Society field trip guidebook to the Jemez Mountains (Goff and others, 1996).

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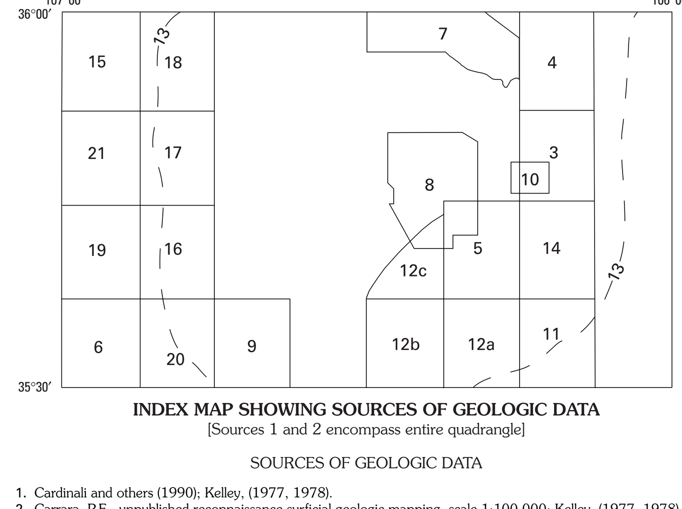

INDEX MAP SHOWING SOURCES OF GEOLOGIC DATA
[Sources 1 and 2 encompass entire quadrangle]

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PRELIMINARY MAP OF LANDSLIDE DEPOSITS IN THE LOS ALAMOS 30′ × 60′ QUADRANGLE, NEW MEXICO

By
P.E. Carrara[1] and D.P. Dethier[2]
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[1]U.S. Geological Survey, Denver, Colo.
[2]Department of Geosciences, Williams College, Williamstown, Mass.

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