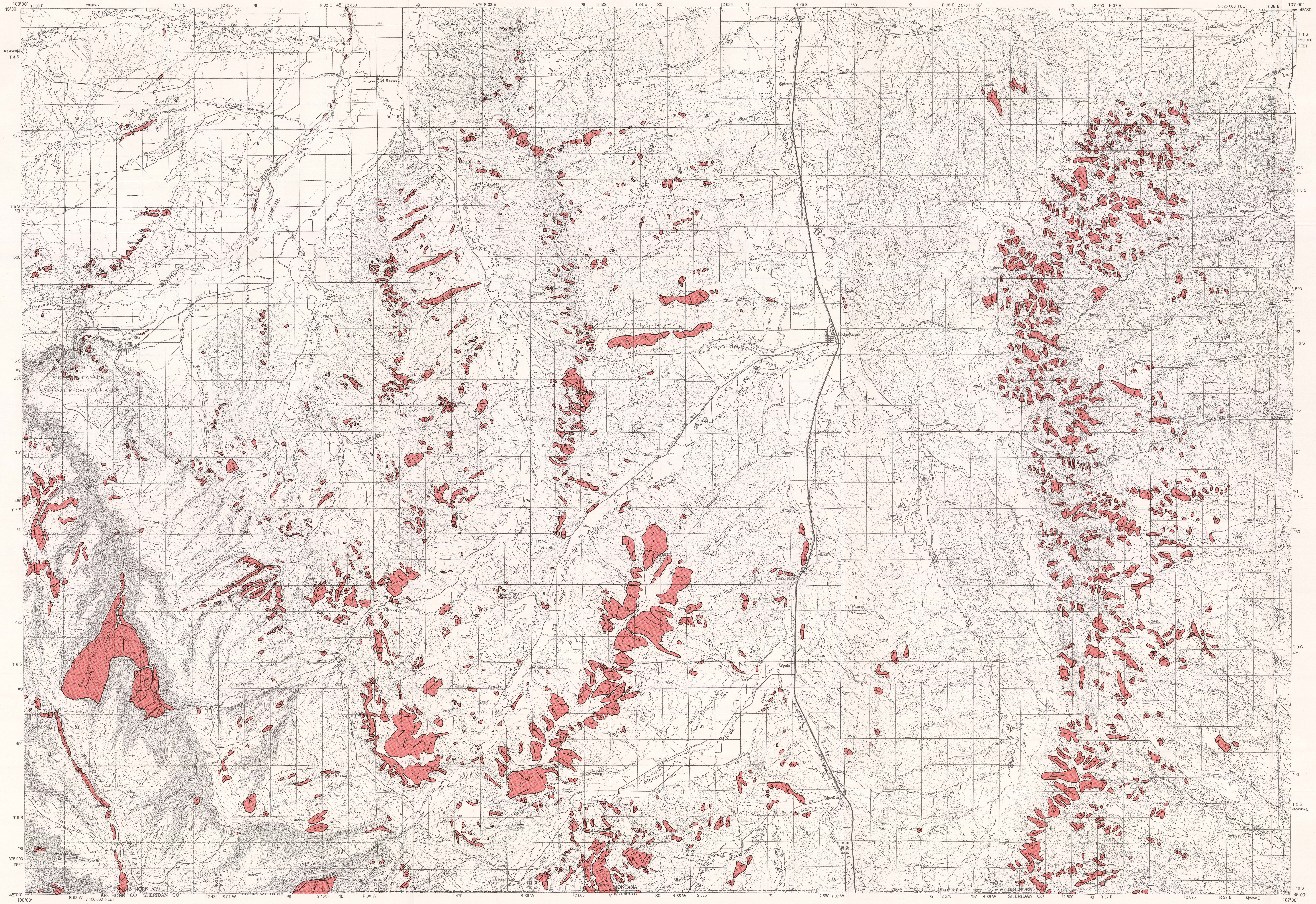
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE MONTANA BUREAU OF MINES AND GEOLOGY

MISCELLANEOUS FIELD STUDIES
MAP MF-1928



Base from U.S. Geological Survey, 1980

SCALE 1:100 000

CONTOUR INTERVAL 50 METERS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

EXPLANATION

Landslide deposits—Areas underlain by landslide deposits resulting from falls, slides, slumps, or flows in earth materials, as determined from air photo interpretation and field reconnaissance. Deposits smaller than 500 feet (150 m) in longest dimension are not shown on the map. In some areas, colluvium or other unconsolidated surface deposits are included. Movement within the landslide deposits varies from none (inactive slides) to slow (less than 5 ft/yr, 1.5 m/yr) to rapid (greater than 5 ft/day, 1.5 m/day); rates of movement may also vary in any given landslide within the same year. Most landslides in the area of the map are currently inactive or moving very slowly (imperceptible to less than 5 ft/yr). The thickness of the deposits (as measured in field or estimated from relief of deposit) varies from about 5 feet (1.5 m) to more than 150 feet (50 m); larger landslide deposits are generally thicker. Ages of deposits (based on relative position in landscape and freshness of surface features) range from early Pleistocene to Holocene, including some historical deposits; large, complex slide deposits represent multiple ages. Arrows indicate general direction of movement (not shown on small landslides). Landslide deposits shown having contiguous boundaries represent discrete deposits of different ages or having different directions of movement

IDENTIFICATION AND ORIGIN OF LANDSLIDE DEPOSITS

Landslide deposits result from the downslope movement of earth materials in response to gravity. Many occur in or adjacent to areas where movement has occurred before, and old deposits may be reactivated by natural or man-made causes. Therefore, it is important to recognize their presence and to understand some of the conditions that may trigger them.

Landslide deposits can be identified by anomalous topography, drainage, or vegetation patterns as compared to adjacent terrain. These features vary with the type of slide movement, material, age, and other factors, but usually include some of the following: (1) prominent scarp(s) at the head of the slide; (2) surface cracks within the deposit; (3) hummocky ground surface or anomalous topography; (4) anomalous stratigraphy and structure; (5) disrupted, erratic, or internal drainage, including undrained depressions and seepage zones; (6) lack of vegetation or abrupt changes in type or growth habit of vegetation (curved or tilted trees, for example); and (7) displaced cultural features.

Landslides are classified by type of movement (fall, topple, slide, slump, lateral spread, or flow) and kind of material (rock, debris, or earth). Most landslide deposits are complex and involve a variety of materials and types of movement. Slump-earthflow deposits (fig. 1) are particularly common in this area.

Landslides are caused by a combination of geologic, topographic, and climatic conditions that increase the stresses acting on the material and (or) decrease the frictional resistance of the material. Some of the conditions favorable to landsliding include (1) soft, weak materials such as shale or weathered rock, especially when overlain by hard, resistant units such as sandstone or gravel deposits; (2) steep slopes, particularly on weak rock or soil units; and (3) the presence of surface or ground water, which adds weight to the material and reduces its internal strength. In addition, man's activities may alter otherwise stable conditions and induce new slides or reactivate old ones; the two most common activities are (1) addition of water, such as from irrigation systems, leaking pipes, and canals, and (2) undercutting or oversteeping of potentially unstable slopes by construction projects.

SUGGESTIONS FOR MAP USERS[1]

The purpose of this map is to provide a regional overview of the distribution of landslide deposits as a measure of overall stability. Because this map is based chiefly on photointerpretation and is at a scale of 1:100,000 (where 1 inch (2.54 cm) on the map equals about 1.6 miles (2.5 km) on the ground), it should not be used to determine the probability of future landsliding. Although landslides often recur in areas where conditions have been favorable in the past, geologic, climatic, and land use conditions have changed over the last few hundred thousand years since many of the landslides occurred. Thus, the presence of landslide deposits does not necessarily mean that landsliding will occur nor does the absence of landslide deposits indicate that landsliding will not occur. This map does not provide the detailed information about composition, geologic setting, type and rate of movement, or current stability conditions of individual landslides that can only be acquired from detailed site investigations by engineering geologists and soils engineers. Rather, the map should be used in conjunction with topographic, slope, surficial geology, bedrock geology, and soils maps, aerial photographs, and other available information for interpreting detailed site studies within a regional context.

COMPILATION OF THE MAP

Landslide deposits shown in the east half of the Lodge Grass 30′ x 60′ quadrangle were interpreted by R. B. Colton in 1976 from vertical and oblique aerial photographs at various scales (1:80,000, 1:60,000, and larger). The 1:60,000-scale aerial photographs were taken in August and September of 1953 (Army Map Service Project No. 125). Landslide areas marked on aerial photographs were initially compiled on a 1:125,000-scale topographic base map (enlarged from 1:250,000) and later transferred to the 1:100,000-scale topographic base map. Some additional landslide deposits were mapped by S. P. Kanizay in 1977 from 1:32,000-scale aerial photographs (U.S.G.S. project GS-VBLR, July 1967) and compiled on a 1:50,000-scale topographic base map. Field reconnaissance was conducted by Kanizay during 1977 and 1978.

Landslide deposits shown in the west half of the Lodge Grass 30′ x 60′ quadrangle were interpreted by S. S. Agard from 1981 to 1983 from black and white positive transparencies of 1:76,000-scale aerial photographs (U.S.G.S. project GS-IND-MT, June and July 1973). Landslide areas were mapped directly onto 1:24,000-scale topographic base maps using a Kern[2] PG-2 stereoplotter and were later photographically reduced to 1:100,000. Detailed (Yellowtail Dam quadrangle and adjacent areas) and reconnaissance field investigations were conducted from 1981 to 1984.

FACTORS AFFECTING MAP ACCURACY[1]

Map accuracy varies according to date, quality, and scale of the aerial photographs used for photointerpretation and the type and amount of field investigations. Landslides that post-date the photography or field work are not shown. Landslide deposits smaller than 500 feet (150 m) in longest dimension are not shown because they are too small to be clearly identified on the photographs or clearly portrayed on the topographic base map. Haze, cloud cover, poor sun angle, and shadows may also make photointerpretation difficult. Delineating landslide deposits by photointerpretation also presents many problems that may only be resolved through careful field checking, such as (1) distinction between terrace-shaped slump deposits and alluvial terrace deposits where both are adjacent to stream courses; (2) recognition of landslide deposit boundaries; for example, the upslope boundary is commonly well defined by a prominent scarp, but the toe or downslope boundary is seldom well defined and thus is difficult to locate exactly; (3) delineation of boundaries between adjacent surficial deposits that grade laterally into or interfinger with one another; (4) recognition of stable masses of bedrock surrounded by landslide deposits, especially where only small knobs project through; and (5) separation of landslide deposits from other hummocky surficial deposits or features, such as glacial deposits or irregularly eroded bedrock.

REFERENCES CITED

Nilsen, T. H., 1972, Preliminary photointerpretation map of landslide and other surficial deposits of the Mount Hamilton quadrangle and parts of the Mount Boardman and San Jose quadrangles, Alameda and Santa Clara Counties, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-339, scale 1:62,500.

Varnes, D. J., 1978, Slope movement types and processes, *in* Schuster R. L., ed., Landslides—Analysis and control: Washington, D. C., Transportation Research Board, National Research Council, Special Report 176, Chapter 2, p. 11-33.

[1]Modified from Nilsen (1972).

[2]Any use of trade names in this report is for descriptive purposes only and does not imply endorsement by the U.S. Geological Survey.

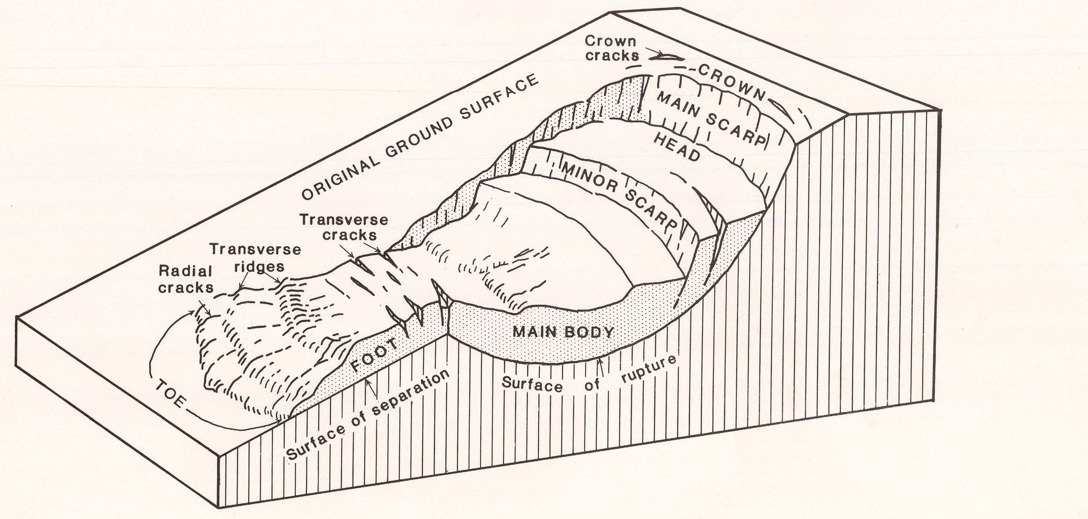


Figure 1.—Features of slump-earthflow. (Modified from Varnes, 1978.)

108°00′ / 45°30′			107°30′				107°00′
1, 2, 4, 6, 9, 10, 12	1, 2, 4, 6, 9, 10, 12	1, 2, 4, 6, 9, 10, 12	1, 2, 6, 9, 10, 12	1, 2, 5, 6, 12	2, 5, 12	2, 5, 7, 12	2, 5, 7, 12
Camp Four	Lemonade Springs	St. Xavier	St. Xavier NE	Benteen	Lodge Grass NE	Thompson Creek NW	Thompson Creek
1, 2, 3, 4, 6, 9, 10, 12	1, 2, 3, 4, 6, 9, 10, 12	1, 2, 3, 4, 6, 9, 10, 12	1, 2, 3, 4, 9, 10, 12	1, 2, 5, 6, 12	1, 2, 5, 6, 12	2, 5, 7, 12	2, 5, 7, 12
Yellowtail Dam	Mtn Pocket Creek	Mission Coulee	Schick Ranch	Good Luck Creek	Lodge Grass	Wolf Mtn Lookout	Spring Creek Ranch
45°15′							
2, 3, 9, 12	2, 3, 6, 9, 10, 12	1, 2, 3, 6, 9, 10, 12	1, 2, 5, 6, 9, 10, 12	1, 2, 5, 5, 12	1, 2, 5, 12	2, 5, 12	2, 5, 12
Peyote Point	Limestone Canyon	Dry Soap Creek	Willow Creek Dam	Wyola	Wyola NE	Kid Creek	Bar V Ranch NE
2, 3, 11, 12	2, 3, 12	2, 3, 12	2, 3, 4, 12	2, 5, 6, 12	2, 5, 12	2, 5, 12	2, 5, 12
Bear Hole	Red Springs	Willow Creek Dam SW	Black Gulch	Pass Creek West	Pass Creek East	Little Bear Creek	Bar V Ranch
45°00′							

INDEX TO 7 1/2-MINUTE TOPOGRAPHIC QUADRANGLES AND SOURCES OF GEOLOGIC INFORMATION

[Numbers refer to sources listed in "Sources of Geologic Information." Most sources do not include landslide data but do show formations susceptible to landsliding]

SOURCES OF GEOLOGIC INFORMATION

1. Alden, W. C., 1932, Physiography and glacial geology of eastern Montana and adjacent areas: U.S. Geological Survey Professional Paper 174, 133 p., plate 1, scale 1:500,000.
2. Bergantino, R. N., 1980, Geologic map of the Hardin 1° x 2° quadrangle, southeastern Montana: Montana Bureau of Mines and Geology Map Atlas 2-A, scale 1:250,000.
3. Darton, N. H., 1906, Geology of the Bighorn Mountains: U.S. Geological Survey Professional Paper 51, 129 p., plate 58, scale 1:250,000.
4. Hamilton, L. J., and Paulson, Q. F., 1968, Geology and ground-water resources of the lower Bighorn valley, Montana: U.S. Geological Survey Water-Supply Paper 1876, 39 p., plate 1, scale 1:125,000.
5. Kanizay, S. P., 1986, Preliminary geologic map of the Lodge Grass area, northwestern Powder River Basin, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF-1822, scale 1:50,000.
6. Knechtel, M. M., and Patterson, S. H., 1956, Bentonite deposits in marine Cretaceous formations, Hardin district, Montana and Wyoming: U.S. Geological Survey Bulletin 1023, 116 p., plates 1 and 2, scale 1:62,500.
7. Mapel, W. J., 1978, Preliminary geologic map of the Crow Reserve area, Big Horn County, Montana: U.S. Geological Survey Open-File Report 78-998, scale 1:24,000.
8. Moulder, E. A., Klug, M. F., Morris, D. A., and Swenson, F. A., 1960, Geology and ground-water resources of the lower Little Bighorn River valley, Big Horn County, Montana: U.S. Geological Survey Water-Supply Paper 1487, 223 p., plates 1 to 4, scale 1:31,680.
9. Richards, P. W., 1955, Geology of the Bighorn Canyon-Hardin area, Montana and Wyoming: U.S. Geological Survey Bulletin 1026, 93 p., plate 1, scale 1:62,500.
10. Richards, P. W., and Rogers, C. P., Jr., 1951, Geology of the Hardin area, Big Horn and Yellowstone Counties, Montana: U.S. Geological Survey Oil and Gas Investigations Map OM-111, scale 1:63,360.
11. Stewart, J. C., 1959, Geology of the Dryhead-Garvin Basin, Big Horn and Carbon Counties, Montana: Montana Bureau of Mines and Geology, Geologic Map 2, scale 1:63,360.
12. Thom, W. T., Jr., Hall, G. M., Wegemann, C. H., and Moulton, G. F., 1935, Geology of Big Horn County and the Crow Indian Reservation, Montana: U.S. Geological Survey Bulletin 856, 200 p., plate 1, scale 1:190,080.

LANDSLIDE DEPOSITS IN THE LODGE GRASS 30′ X 60′ QUADRANGLE, MONTANA AND WYOMING

By

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