DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

MISCELLANEOUS INVESTIGATIONS SERIES
MAP I–1033–H

DESCRIPTION OF MAP UNITS

AREA OF RECENT LANDSLIDING—Mainly areas affected by slumps, slides, and falls of rock and debris within the last few thousand years. Recent landslides have fresh, sharp forms and are not extensively weathered. The risk of future landsliding in the areas may be relatively high because the rock, slope, and moisture conditions that originally caused landsliding still exist

AREA OF OLDER LANDSLIDING—Areas affected by slumps, slides, and falls of rock and debris more than a few thousand years old. The deposits have lost much of their original form due to weathering and stream erosion. Some recent landslides with indistinct forms are included. The risk of future landslides in these areas is variable. In some places slopes are stabilized; in other places the conditions that originally caused slope movement persist

AREA BURIED BY DEBRIS-FLOW COLLUVIUM AND ALLUVIUM—Areas where coarse colluvium and alluvium, washed from debris slides, are deposited below the toes of the slides. There is a moderate risk that recurring movement at the heads of debris slides may cause future episodes of rapid deposition. Such activity has occurred repeatedly in the past under conditions similar to those existing at the present time. Thickness less than 2 m over wide areas, but as much as 80 m in one canyon

AREA OF ROCK FALL POTENTIAL—Cliffs and very steep slopes where falling rocks and rock slumping pose a potential hazard

AREA OF LITTLE OR NO LANDSLIDE POTENTIAL—Slopes too gentle to promote landsliding and some steeper areas where there is no evidence of landsliding. Very localized areas of steep slopes subject to landsliding may be included because they are too small to map at this scale

INTRODUCTION

This map is one of a series showing geologic factors potentially affecting development of natural resources in the Kaiparowits coal-basin area of southern Utah. The rocks of this part of the Colorado Plateaus province include a variety of sedimentary lithologies ranging from marine shale to eolian sandstone, and from quartzite conglomerate to lacustrine limestone. The sedimentary rock sequence is capped by volcanic tuffs and flows of latitic to basaltic composition. Generally the beds are gently inclined, except along four narrow monoclines, where they may by tilted as much as 70° (Hackman and Wyant, 1973).

The landscape has been eroded into a succession of plateaus, cliffs, benches, and canyons (Sargent and Hansen, 1980); altitudes in this map area range from 3,276 m (10,748 ft) on the Aquarius Plateau near the northern map boundary to about 1,125 m (3,690 ft) at the surface of Lake Powell on the southern map boundary. The Kaiparowits Plateau occupies the central part of the map and covers about 30 percent of the area. The area is underlain by extensive coal deposits.

Several kinds of landslides and areas of potential landslides are common in this rugged terrain. The variety of landslide deposits is the result of variations in rock type, topography, soil moisture, and hence, geomorphic process. On the southern and eastern sides of the Kaiparowits Plateau, rock falls, rock slumps, debris slides, and debris flows (Varnes, 1978) occur where relatively resistant sandstone and interbedded shale of the Upper Cretaceous Straight Cliffs Formation overlie the soft, incompetent Upper Cretaceous Tropic Shale. In the northern part of the map area, around the Aquarius Plateau, similar landslide processes are active where resistant volcanic rocks uncomformably overlie less resistant rocks. Areas at higher altitudes, because of greater precipitation and cooler temperatures, seem to be generally more susceptible to landsliding than geologically similar areas at lower altitudes; Shroder (1978) has shown the rate of movement of one high-altitude slide to correlate directly with the amount of precipitation. In more arid areas, at lower altitudes, where alternating layers of hard and soft sedimentary rocks have been eroded to steep cliffs separated by benches, rock fall is the dominant type of slope mo- ement.

DISCUSSION

On the flanks of the Aquarius Plateau, slide colluvium originates where large blocks of volcanic rock, overlying a variety of less resistant rocks, break away from the cliff and slump downward, the top of the block rotating back toward the plateau (rock slump). Commonly the blocks separate from the cliff along crescentic fractures, although locally they separate along straight fractures parallel to faults. Rotation of the blocks produces depressions, some of which contain lakes; water collected in these lakes, combined with water from the large springs near the base of the volcanic cap rock, tends to saturate the blanket of colluvium below the cliff, facilitating movement. As large blocks move slowly downslope, they break up and continue to rotate backward, causing the blocky form to become subdued.

As colluvium, sliding downslope from wide areas, is gradually funnelled into narrow valleys, it thickens, and one of two similar processes becomes predominant. Either episodic debris slides carry thick colluvium far down the valley, or masses of angular boulders topple and roll down steep slopes and valleys to form relatively thin and short block streams (Varnes, 1978, fig. 2.1).

Debris slides and block streams grade into one another, depending on the steepness of the slope and the amount of fine sediment in the colluvium. In debris-slide colluvium, generally from 20 to 80 percent of the particles are finer than 2 mm (Shroder, 1971, p. 2) and, consequently, debris slides can move down more gentle slopes than can the coarser block streams. Block streams, therefore, are restricted to the relatively few places where very steep slopes occur near the base of a volcanic cliff and where the volcanic rock is strongly jointed and layered, as is typical of the Miocene Osiris Tuff (Hackman and Wyant, 1973). The greatest concentration of block streams occurs where the Osiris Tuff crops out along the western margin of the Aquarius Plateau. Interstitial ice can form in the block streams, which then take on characteristics of rock glaciers (Shroder, 1978, p. 170).

Characteristics of debris slides near but outside the mapped area have been well described by Flint and Denny (1958, p. 137). Very complex forms occur east of the Aquarius Plateau and north of the map area in valleys on the flanks of Boulder Mountain where landsliding and glaciation have both occurred. Glaciation, however, is not believed to have extended into the map area.

On the flanks of the Kaiparowits Plateau landslide processes are generally similar to those around the Aquarius Plateau, but differ in rock types and in the origin of the colluvium. Rather than being the result of rock slumps, most of the colluvium on the flanks of the Kaiparowits Plateau originates where tall columns of sandstone and shale from the high cliffs of the Straight Cliffs Formation (Upper Cretaceous) lose support and topple onto the bench of Tropic Shale (Upper Cretaceous) below. The layer of debris overloads the weak shale, causing it to fail and slide downslope in a thin blanket. This process is accelerated as the permeable rockfall debris transmits moisture to the shale and inhibits drying. The blanket of colluvium commonly thickens as it is funnelled into valleys cut into the plateau's lower cliffs, which comprise the Cretaceous Dakota Formation and the Jurassic Morrison Formation and Entrada Sandstone. Eventually the colluvium spills and slides over the lower cliff to form debris slides. Where the lower cliff is absent, debris is not channelled into distinct slides, but may develop complex forms in which slumping and rock-block sliding are common. The more complex landslide forms generally are found on the southern flank of the Kaiparowits Plateau, where the dipping of beds or the burning of coal in the Straight Cliffs Formation has accelerated slope failure.

In many localities in the mapped area, during periods of rapid movement, debris slides and, to a lesser extent, block streams have moved coarse sediment into valleys at rates far exceeding the rates at which the sediment could be removed by the local streams. Consequently, the downstream valley floors have been buried under as much as 80 m of accumulated landslide-derived alluvium, which thins rapidly downstream and away from the stream axis, but may extend as far as 20 km below the slide toe. In areas where canyon walls below the slide are low, as along the Straight Cliffs, slide alluvium has entirely filled deep canyons and formed wide fans, shallowly burying many square kilometers of land far from the original stream course. The risk of partial burial of man-made structures far below slide toes should be recognized as a significant landslide hazard in parts of this map area.

All types of landsliding were probably more active during the wetter climate of the Pleistocene Epoch, which ended about 10,000 years ago. However, landsliding continues to be an active process, as indicated by the fresh, unreroded forms of some of the deposits. Trees on a slide from the Table Cliffs Plateau have been repeatedly disturbed by movement recurring intermittently over the last 200 years (Shroder, 1978), and wood and charcoal less than 2,000 years old (1,680± 70, W-4334; 1,370±110, W-4336) (Meyer Ruben, written commun.) is deeply buried beneath alluvium derived from a large debris flow from the Straight Cliffs of the Kaiparowits Plateau.

The presence of a landslide hazard, however, does not necessarily preclude man's use of the land. Many landslide areas are now relatively stable. Some active slides may move little over tens of years, allowing use for roads, campgrounds, reservoirs, and lumbering. For each use, benefits must be balanced against risk, including the risk of reactivating relatively stable slides. The magnitude of risk can only be evaluated through detailed engineering analysis. This map is not based on such analyses and provides only a general indication of potential hazard.

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Base from U.S. Geological Survey, Escalante, 1956–70, 1:250,000

SCALE 1:125 000

2 0 2 4 6 8 10 MILES

2 0 2 4 6 8 10 KILOMETERS

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100-FOOT INTERVALS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

APPROXIMATE MEAN DECLINATION, 1981

UTAH
QUADRANGLE LOCATION

Photointerpretation by H. Kit Fuller and Roger B. Colton, 1976
Compilation by H. Kit Fuller, 1976–77, assisted by Jeffrey A. Holligan
Field checked by Van S. Williams, 1978–79, assisted by Joan Heller

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MAP SHOWING AREAS OF LANDSLIDING IN THE KAIPAROWITS COAL-BASIN AREA, UTAH

By

H. Kit Fuller, Van S. Williams, and Roger B. Colton

1981

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