DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

MISCELLANEOUS INVESTIGATIONS SERIES
MAP I–1316

MAP OF SNOW AVALANCHE AREAS AND KNOWN ACCIDENT SITES IN THE TELLURIDE REGION, SAN MIGUEL COUNTY, COLORADO

By
Betsy R. Armstrong and Paul E. Carrara
1981

DESCRIPTION OF MAP UNITS

MINIMAL AVALANCHE HAZARD—Areas where avalanches are unlikely; may include areas of moderate avalanche hazard which are too small to identify at this scale

MODERATE AVALANCHE HAZARD—Consists of several different kinds of areas, including the following: (1) steep slopes that range from well-forested north-facing slopes to open south-facing slopes below timberline and (2) certain cirque floor areas. The slope areas may be susceptible to avalanche activity during extended periods of snowfall while the cirque floor areas may be in the runout zone of large, infrequent avalanches. Where avalanche path symbols are shown in this unit, avalanche hazard can be severe

SEVERE AVALANCHE HAZARD—These areas are predominantly steep open slopes above timberline but also includes avalanche tracks and runout zones below timberline. Avalanche activity has been frequently observed in many of these areas

Bobtail — PROMINENT AVALANCHE PATH—Many have well-defined forest trimline boundaries. Name denotes a well-known avalanche path frequently mentioned in the historical records. From the frequent descriptions many of these named avalanche paths appear to have run yearly

Uncle Sam — WIDE AVALANCHE PATH—Well-defined forest trimline boundaries. Name denotes a well-known avalanche path mentioned in the historical records

(25) DESTRUCTIVE AVALANCHE SITE—Number referred to in table

INTRODUCTION

The purpose of this map is twofold: first, to identify areas of avalanche hazard for the user; and second, to present the historical data upon which much of the delineation of the hazard areas has been based.

During the last century the San Juan Mountains of southwestern Colorado have had a history of avalanche disasters. From 1879 to 1979, a total of 247 deaths have been documented in the surviving historical record of Ouray, San Juan, and San Miguel Counties (Armstrong, 1980). In addition, avalanches have destroyed property, and obstructed business, mining, and travel in these mountains since the early mining days (Armstrong, 1976, 1977, 1980).

When the San Juan Mountains were opened to mining in 1873, prospectors, miners, packers, and others associated with mining invaded the region. Soon, permanent settlements, such as Telluride, the county seat of San Miguel County, were established. Originally founded as Columbia in 1878, the town was renamed Telluride in June 1887. In 1890, when the Denver and Rio Grande Railroad linked the Telluride mining district to the smelters at Durango and Alamosa, making the shipping of ore financially viable, development of the mountainous areas in the Telluride region began in earnest. By 1900, the population of San Miguel County was approximately 5,400 (U.S. Office of the Census, 1913). Many of these people lived near and worked in the mines of the high basins surrounding the town of Telluride. Many of these mines were above timberline and adjacent to steep slopes subject to avalanche releases as were many of the connecting roads, trails, aerial tramways, and railroads.

THE AVALANCHE HAZARD IN THE TELLURIDE REGION 1883–1979

The avalanche hazard is concentrated in the high basins and peaks surrounding the town of Telluride. The earliest mining activity in San Miguel County was in Marshall Basin, which is also the site of the earliest avalanche accidents. The Mendota, Sheridan, and Smuggler Mines were worked year round for the first time in 1882 and by 1883, the year San Miguel County was created, 100 men were working in Marshall Basin (Henderson, 1926). The first documented report of avalanche fatalities in this region was on February 3, 1883, when three men were killed in an avalanche near the Union Mine (site no. 11 on map) in Marshall Basin (La Plata Miner, Feb. 10, 1883).

With increasing development of the region's mineral resources came increasing numbers of people. Greater numbers of people living and traveling in this region meant increased numbers of avalanche encounters. It was during the peak mining period, from the early 1880's to about the end of World War I, when most of the mining activity, and hence, many avalanche encounters occurred. During this period the largest avalanche disaster in Colorado history took place. On February 28, 1902, three avalanches killed a total of 18 men at the Liberty Bell Mine north of Telluride. The first avalanche struck a boarding house and was followed by a second avalanche which struck a rescue party at the site of the first disaster. Later in the day a third avalanche released a short distance from the mine and struck a group of rescuers returning to Telluride. In addition to these casualties another man died about a week later from injuries received during the disaster. Although this accident is unsurpassed in terms of fatalities, the period of peak mining activity was one of many avalanche disasters including numerous fatalities.

As mining activity decreased after World War I, so did the number of avalanche encounters. In addition, the Idarado Mining Company, the major producer of precious metals in San Miguel County until its shutdown in 1978, worked the old holdings of the Ajax, Argentine, Black Bear, Montana, Pandora, Smuggler-Union, Tomboy, and other mines between Telluride and Red Mountain, about 10 km east of Telluride. However, in contrast to the early mining period, when each mine operated independently, had separate portals, used surface and aerial tramways, or hauled ore by wagon exposing many people to the avalanche hazard, the Idarado Mining Company used and expanded an already extensive network of tunnels inside Telluride Peak. Hence, the company was able to have access to all the workings from either the Treasury Tunnel on Red Mountain Pass in Ouray County or the Mill Tunnel near the old town of Pandora reducing the exposure of people and property to avalanche hazards.

No avalanche fatalities had been recorded in the Telluride region from the 1920's until 1979. The recent avalanche fatality involved a cross-country skier in the Palmyra Mine area. As increased interest in winter recreation brings more people into the San Juan Mountains it is feared that a new era of avalanche accidents may begin. In addition, increasing metal prices will undoubtedly cause a resurgence in mineral exploration and development. All of these factors contribute to an increasing number of people in avalanche terrain and indicate the need for awareness of avalanche hazards and public warnings (Judson, 1976).

SNOW CLIMATE OF THE SAN JUAN MOUNTAINS

"Snowfall this year has been the heaviest ever known here since last winter." (Telluride Journal, February 2, 1911)

The winter snow cover of the San Juan Mountains is characterized by relatively light, low-density snowfalls; annual accumulations generally amount to depths of two to greater than three meters with a highly differentiated stratigraphy of very low mechanical strength. This latter condition is primarily the result of two factors. First, the extreme cooling by nocturnal radiation occurring on all exposures produces temperature gradients in the snowpack large enough to cause significant recrystallization or temperature-gradient metamorphism that forms a type of snow called "depth hoar" that has a low tensile strength. Second, there is a substantial amount of solar radiation on slopes with a southerly exposure; this daytime condition causes melt just below the surface and subsequent melt-freeze crusts. These two factors influence the snow cover throughout the winter and the resulting stratigraphy is highly complex (Armstrong and Ives, 1976). The snow climate was well described in 1912, when the local newspaper explained the occurrence of a large avalanche cycle:

> "Our first snow storms started last November and at that time the mountain ranges and high basins received a fall of about four feet, which was crusted by intense cold afterwards, and the little snows which followed until this storm started, in the main remained as they fell, with but a few little slides. That left the hillsides glazed over and when the heavy snow of this week came and piled up, snow slides were inevitable." (San Miguel Examiner, March 9, 1912).

The November snow cover, because of radiation cooling, had probably metamorphosed into depth hoar and once a significant load was imposed, the weak snowpack collapsed and avalanches resulted.

AVALANCHES

In general, an avalanche consists of a large mass of snow, ice, rock, earth, or mud moving rapidly down a slope or over a precipice. In the English language, the term avalanche is reserved almost exclusively for snow avalanche. The minimal requirement for the occurrence of an avalanche is snow on an inclined surface.

The snow structure determines which of two predominant types of avalanches will occur. The first type, the loose snow avalanche (fig. 1), initiates from a point where crystals with poor adherence to each other collect on a slope steeper than the angle of repose. Failure begins near the surface when a small amount of cohesionless snow slips out of place and starts moving downslope; this in turn, sets the downslope snow in motion. The resulting fan-shaped avalanche widens from the initial point as more snow becomes incorporated. This type of avalanche usually involves only surface snow, which limits the volume of snow and thus the magnitude of the event. The hazard is also limited by the fact that loose snow avalanches often come to rest once the slope angle becomes less than the angle of repose. However, loose snow avalanches can trigger slab avalanches, thereby increasing the hazard.

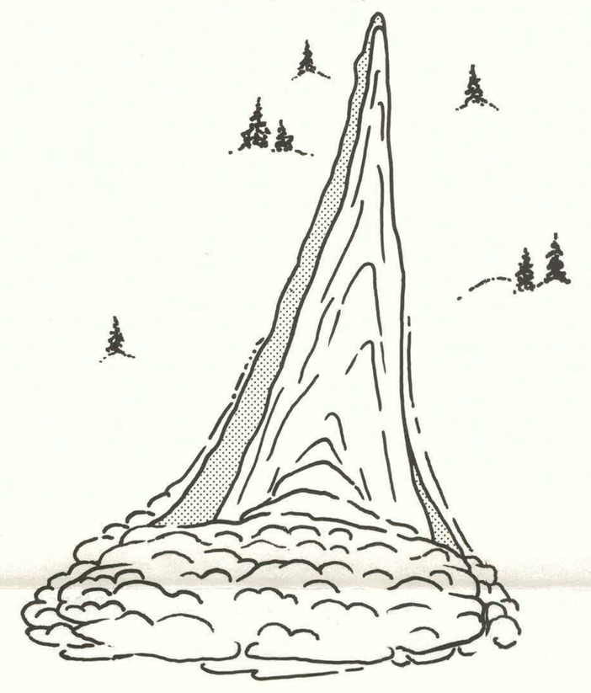

Figure 1.—*Loose snow avalanche widens from an initial point of failure to a fan-shaped feature*

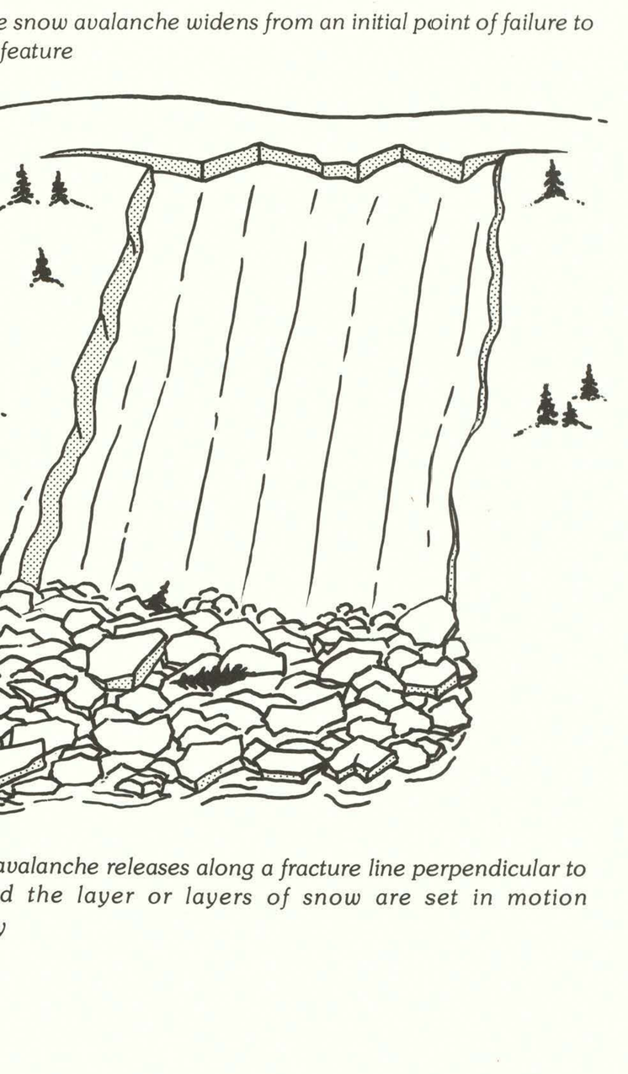

Figure 2.—*Slab avalanche releases along a fracture line perpendicular to the slope and the layer or layers of snow are set in motion simultaneously*

The second type, the slab avalanche (fig. 2), occurs whenever a cohesive layer of snow lies on a slope and is poorly bonded to the snow or ground below. Generally, slabs are formed by wind which deposits snow as a dense, hard layer. Cohesive layers of lesser density may form, even in the absence of wind action, as a result of the deposition of crystal types allowing mechanical interlocking or a close packing ratio. Poor adhesion between layers may be the result of an ice crust, buried surface hoar, or the presence of depth hoar formed by temperature-gradient recrystallization within the snowcover. Slab avalanches release along a fracture line; a sharp division between sliding snow and stable snow forms with the face of the fracture perpendicular to the slope. The entire layer of unstable snow is set in motion simultaneously and the fracture line may extend from tens of meters to more than a thousand meters across the slope. The slab itself may vary from only a few centimeters to over several meters in thickness, and sometimes incorporates the entire snow cover down to the ground surface. For these reasons, slab avalanches may move large volumes of snow at high speed and hence are quite dangerous. Slab avalanches, like loose snow releases, may involve dry midwinter snow or wet spring snow where the presence of free water, from melt or rain, provides the critical loss in snow strength. Whether dry or wet, slab avalanches may incorporate only new snow or may comprise one or more layers of older snow deposited and metamorphosed prior to the triggering precipitation event. The latter type of release composes 80 to 90 percent of the slab releases in the San Juan Mountains where slab avalanches are a direct result of the complex and highly variable stratigraphy of the local snow cover (Armstrong and others, 1975; Armstrong and Ives, 1976).

RECOGNITION OF AVALANCHE HAZARD AREAS IN THE TELLURIDE REGION

Areas of avalanche hazard have been defined on the basis of (1) the historical records of avalanche accidents, (2) vertical aerial photograph interpretation, (3) topographic map interpretation, and (4) field observations. The outlined areas are approximate boundaries of the avalanche hazard areas and do not indicate absolute limits. These limits could be improved by detailed ground study of the area in question and by the use of much larger scale maps.

A search through the archives of the Colorado Historical Society and the Denver Public Library has indicated that the pre-1897 newspaper record from San Miguel County no longer exists. Avalanche data for San Miguel County prior to 1897 comes primarily from the Ouray and Silverton newspapers whose accounts were sometimes conflicting. In several instances, Telluride newspapers reminded their readers of a large avalanche disaster in the very early mining days on the anniversary of the described event. The newspaper record from San Miguel County is nearly continuous from 1897 to 1943 and from 1962 to the present. Avalanche fatalities occurring in San Miguel County during the 1870's, 1880's and most of the 1890's may have been missed due to lack of record.

As part of this study, microfilms of San Miguel County newspapers were examined for the months November through May, which is the major avalanche season. Sites of avalanche disasters were mapped whenever possible. Some descriptions, however, were too general to accurately locate on the map. All recorded avalanches which involved people and which damaged property are listed in table 1 by geographic location. On the accompanying map, 61 avalanche fatalities and at least 119 survivors have been documented from the surviving newspaper record. Figure 3 indicates the majority of avalanche deaths occurred during the months of February and March (Armstrong, 1980); this is also true for the San Juan Mountains as a whole. It should be noted that the month of February on figure 3 is heavily weighted by the Feb. 28, 1902 series of avalanches which claimed 19 lives at the Liberty Bell Mine. Because of the incompleteness of the San Miguel County historical record the figures presented are minimum. Detailed histories of avalanche disasters in San Juan, Ouray and San Miguel Counties can be found in Armstrong (1976, 1977, 1980).

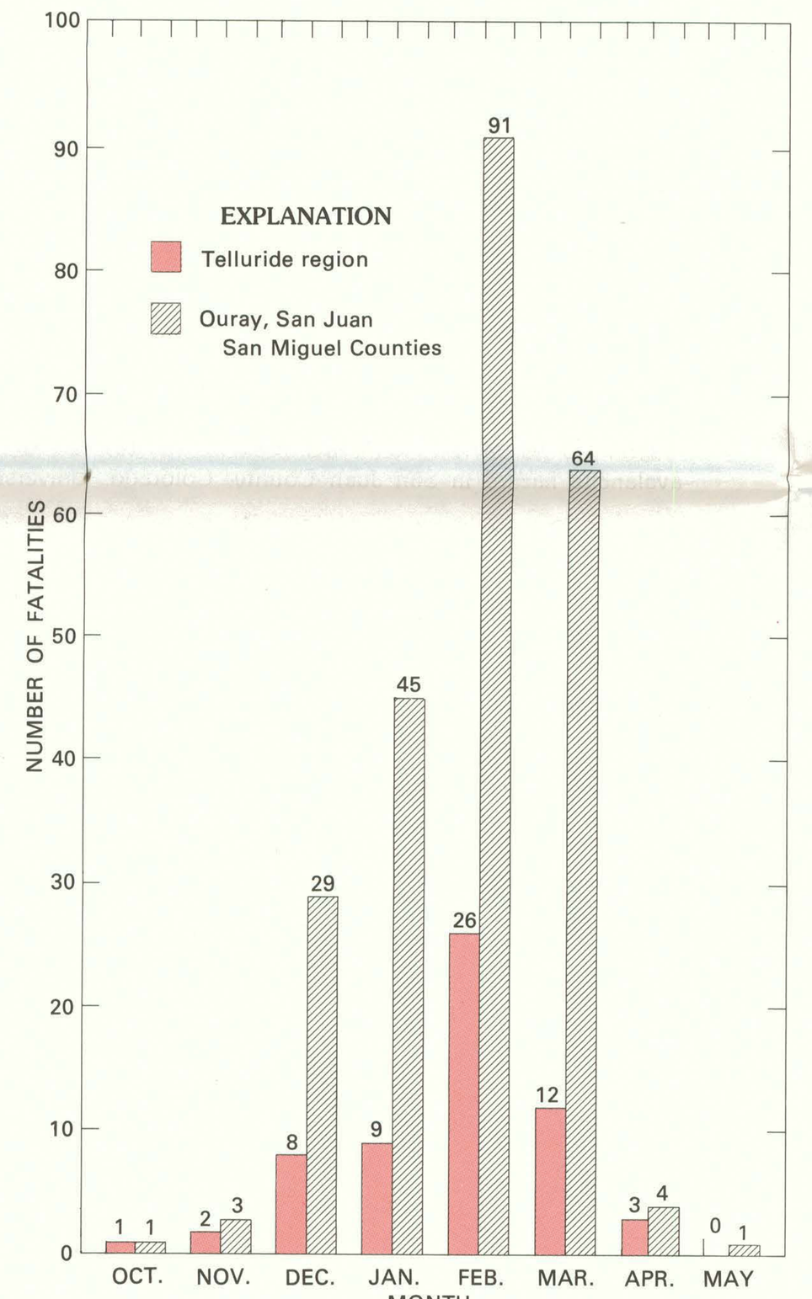

Figure 3.—*Graph showing avalanche fatalities by month in the Telluride region, (1883–1979) and in Ouray, San Juan, and San Miguel Counties, Colorado (1874–1979) (Armstrong, 1980). A total of 61 fatalities were reported in the Telluride region; 247 fatalities were reported in Ouray, San Juan, and San Miguel Counties, but a specific month could not be determined for 9 of these*

The interpretation of air-photos and topographic maps in conjunction with field observations have allowed us to make the following generalizations in regard to the recognition of avalanche areas in the Telluride region. Many avalanche areas have been readily identified by their associated morphological characteristics. Large avalanches in the Telluride region start in cirquelike basins high above the valleys into which they run out. These basins are the avalanche starting zones, the area where the initial rupture of the snow cover occurs and where the avalanche begins its downward course; the large basins may be greater than 1 km² in area and the smaller ones less than 100 m². These areas commonly have slope angles of between 30° and 45°, although avalanches may release on both steeper or gentler slopes (fig. 4). Once initial failure and acceleration have occurred within the starting zone, the avalanche travels down into the avalanche track where it attains its maximum velocity. The track is the path the avalanche follows as it descends to the valley floor; it may be confined in a gully or consist of a broad open slope and in general, has a gradient ranging from 20° to 30° The boundary between the starting zone and the track may be well defined by the slope angle or topography, as in the case of a broad, open basin feeding into a narrow gully, but often, and especially in the case of open slopes with little variation in slope angle, the distinction is difficult to make. Large avalanche tracks may be 1 km in length and more than 100 m wide. Small tracks, such as those immediately south of Telluride, are only 100 m or so long and several meters wide. The runout zone, usually a valley floor, is that portion of the avalanche path where the avalanche stops; the gradients of runout zones are usually less than 20°. Near the lower reaches of the avalanche, a well-defined avalanche track (gully) commonly grades into a fanlike feature which represents the runout zone or at least part of the runout zone. These fanlike features are probably built up by normal alluvial processes and debris flows emanating from the gully but are commonly associated with large well-developed avalanche systems. Runout zones present a very real hazard because their gentle slopes or flat valley floors often provide the optimum and most desirable construction sites within a mountain environment (Carrara, 1979; Ives and others, 1976).

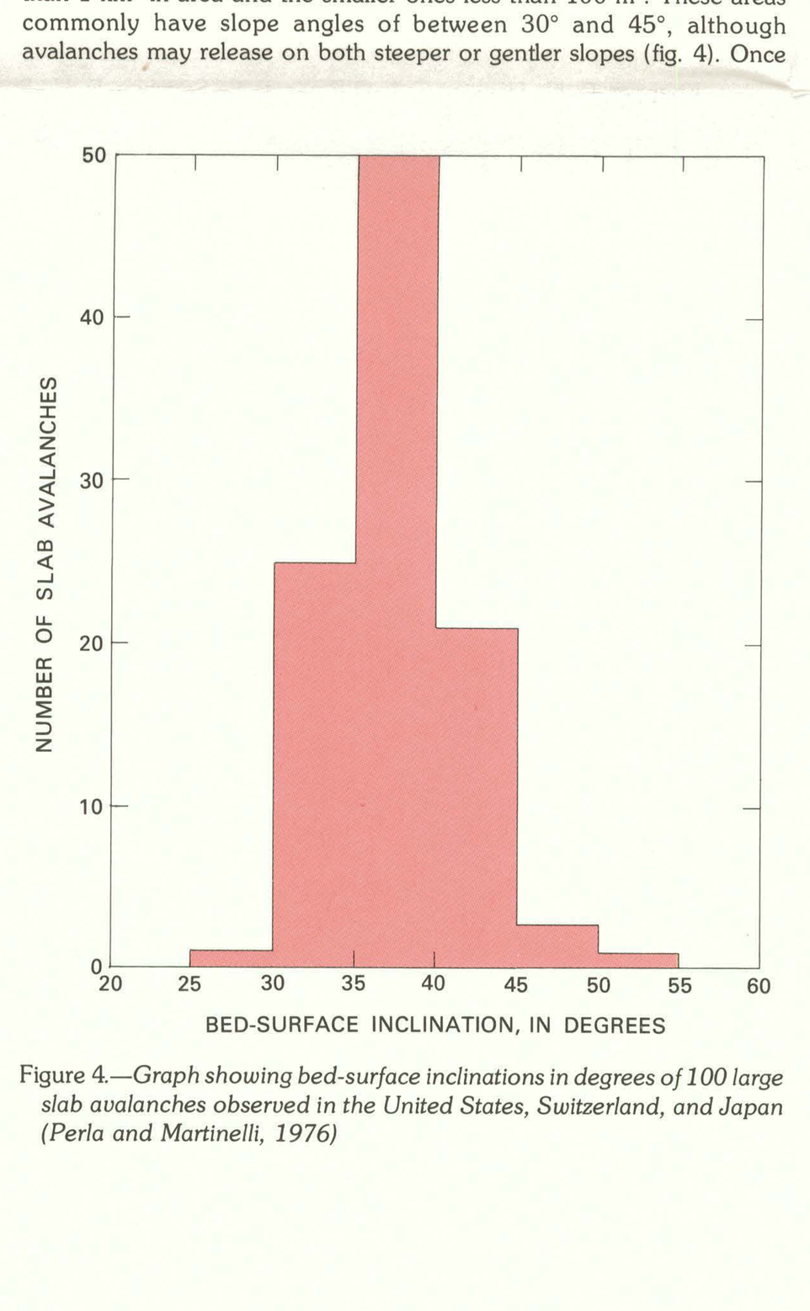

Figure 4.—*Graph showing bed-surface inclinations in degrees of 100 large slab avalanches observed in the United States, Switzerland, and Japan (Perla and Martinelli, 1976)*

In addition to morphological characteristics which smaller avalanche areas may not possess, certain easily recognized vegetative patterns indictative of avalanche activity are common to both large and small avalanche paths. These are primarily the absence of mature forest and (or) the downslope alinement of open areas through the forest on hillsides below treeline. Large areas of the catchment basin (release zone) may be free of forest because of frequent avalanche activity, although many catchment basins are above treeline and free of forest anyway. Avalanche tracks leading from the catchment basin to the valley floor are usually free of forest cover. Lateral boundaries of the avalanche tracks commonly coincide with forest trimlines. These trimlines separate mature undisturbed forest on one side from an area of no forest or immature forest cover on the other side. In some areas, trimlines exist on the valley wall opposite the avalanche tracks indicating some avalanches have crossed the valley floor and ascended part way up the other side of the valley.

ADDITIONAL COMMENTS

The areas of avalanche hazard have been outlined on the basis of current understanding and experience with snow avalanche behavior in the San Juan Mountains. The authors cannot assume responsibility for the future behavior of snow avalanches when affected by extraordinary winter storms, changes in climate, destruction of forest cover, or other unforseen events.

Back-country travelers should note that a majority of avalanche fatalities occur in small avalanches which run 30 vertical meters or less. Such areas as small, steep gullies and localized steep slopes should be avoided when avalanche conditions are present. Due to the small scale of this map, these areas may not have been identified.

It should also be noted that avalanche occurrences are highly dependent on weather and snow conditions. Even in areas mapped as severe, many times during the winter season the snowpack may be stable and hence free of avalanche danger. During times such as these, these areas may be traversed in relative safety. Mountain travelers should become familiar with the various literature on avalanches so that they may judge for themselves the relative safety or hazard existing on a given day.

This map is one of a growing number of avalanche-hazard maps produced by state and federal agencies for public use in determining areas of avalanche hazard. County-wide mapping of natural hazards, including avalanches, using remote-sensing techniques, was done for Ouray, San Juan, San Miguel, and Hinsdale Counties in southwestern Colorado by the Institute of Arctic and Alpine Research of the University of Colorado (Bovis and others, 1976a, b, c; Knepper and others, 1977). Fifteen specific areas of avalanche hazard in Colorado have been mapped by the Colorado Geological Survey (Mears, 1979). In addition, the U.S. Geological Survey has produced avalanche hazard maps of the Jackson Quadrangle, Teton County, Wyoming (Love, 1973); Henrys Lake Quadrangle, Idaho and Montana (Witkind and others, 1972); and the Aspen Quadrangle, Pitkin County, Colorado (Bryant, 1972).

ACKNOWLEDGMENTS

The authors wish to thank the staffs of the Colorado Historical Society and the Denver Public Library for their help and cooperation. In addition, Donald O'Rourke, longtime resident of Telluride and past president of the San Miguel Historical Society provided valuable information as to the location of various mines and avalanche paths in the region. The authors also wish to thank Art Judson and Pete Martinelli, Jr. of the U.S. Forest Service and B. H. Bryant and R. W. Fleming of the U.S. Geological Survey for their comments on earlier drafts of this manuscript.

REFERENCES

Armstrong, B. R., 1976, Century of struggle against snow—a history of avalanche hazard in San Juan County, Colorado: University of Colorado, Institute of Arctic and Alpine Research, Occasional Paper no. 18, 97 p.
______1977, Avalanche hazard in Ouray County, Colorado 1877–1976: University of Colorado, Institute of Arctic and Alpine Research, Occasional Paper no. 24, 126 p.
______1980, Century of avalanche hazard in the San Juan Mountains, Colorado: University of Colorado, unpublished M. A. thesis; 180 p.
Armstrong, R. L., and Ives, J. D., editors, 1976, Avalanche release and snow characteristics, San Juan Mountains, Colorado: University of Colorado, Institute of Arctic and Alpine Research, Occasional Paper no. 19, 256 p.
Armstrong, R. L., La Chapelle, E. R., Bovis, M. J., and Ives, J. D., 1975, Development of methodology for evaluation and prediction of avalanche hazard in the San Juan Mountains of Southwestern Colorado: University of Colorado, Institute of Arctic and Alpine Research, Occasional Paper no. 13, 141 p.
Bovis, M. J., Summer, R. M., Sauchyn, D. H., Squier, M. J., Trench, N. R., Waterman, J. L., Knepper, D. H., and Ives, J. D., 1976a, Natural hazards of Ouray County, Colorado: University of Colorado, Institute of Arctic and Alpine Research, Report to the Ouray County Planning Commission, NASA-PY Grant No. NGL-06-003-200, 48 p.
Bovis, M. J., Summer, R. M., Knepper, D. M., and Ives, J. D., 1976b, Natural hazards of San Juan County, Colorado: University of Colorado, Institute of Arctic and Alpine Research, Report to the San Juan County Planning Commission, NASA-PY Grant No. NGL-06-003-200, 50 p.
Bovis, M. J., O'Boyle, P. S., Summer, R. M., Squier, M. J., Knepper, D. H., and Ives, J. D., 1976c, Natural hazards of San Miguel County, Colorado: University of Colorado, Institute of Arctic and Alpine Research, Report to the San Miguel County Planning Commission, NASA-PY Grant No. NGL-06-003-200, 51 p.
Bryant, Bruce, 1972, Map showing avalanche areas in the Aspen quadrangle, Pitkin County, Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–785–G, scale 1:24,000.
Carrara, P. E., 1979, The determination of snow avalanche frequency through tree-ring analysis and historical records at Ophir, Colorado: Geological Society of America Bulletin, Part I, v. 90, no. 8, p. 773–780.
Cross, Whitman and Purington, C. W., 1899, Description of the Telluride Quadrangle [Colorado]: U.S. Geological Survey Geologic Atlas, Folio 57.
Gallagher, Dale., editor 1967, The snowy torrents—avalanche accidents in the United States 1910–1966: U.S. Forest Service Alta Avalanche Study Center, Wasatch National Forest, 144 p.
Henderson, C. W., 1926, Mining in Colorado, a history of discovery, development, and production: U.S. Geological Survey Professional Paper 138, 263 p.
Ives, J. D., Mears, A. I., Carrara, P. E., and Bovis, M. J., 1976, Natural hazards in mountain Colorado: Association of American Geographers, Annals, v. 66, no. 1, p. 129–144.
Judson, Arthur, 1976, Colorado's avalanche warning program: Weather Wise, v. 26, no. 6, p. 268–277.
Knepper, D. H., Hansen, K. J., O'Boyle, P. S., Sauchyn, D. H., Summer, R. M., Trench, N. R., and Waterman, J. L., 1977, Natural hazards of northern Hinsdale County, Colorado: University of Colorado, Institute of Arctic and Alpine Research, Report to the Hinsdale County Planning Commission, NASA-PY Grant No. NGL-06-003-200, 67 p.
LaChapelle, E. R., 1961, The ABC of avalanche safety: Denver, Colorado, Colorado Outdoors Sport Corporation, 47 p.
Love, J. D., 1973 [1974], map showing snowslide possibilities of the Jackson quadrangle, Teton County, Wyoming: U.S. Geological Survey Miscellaneous Investigations, Series I–769–D, scale 1:24,000.
Martinelli, Mario, Jr., 1974, Snow avalanche sites, their sites, their identification and evaluation: U.S. Forest Service, Argriculture Information Bulletin 360, 27 p.
Mears, A. I., 1979, Colorado snow-avalanche area studies and guidelines for avalanche-hazard planning: Colorado Geological Survey, Special Publication 7, 123 p.
Mellor, Malcolm., 1968, Avalanches; Cold regions science and engineering, *in* section A3, Snow Technology, *of* Part 3, Engineering: Hanover, New Hampshire, U.S. Army Cold Regions Research and Engineering Laboratory, 215 p.
Perla, R. I., and Martinelli, Mario, Jr., 1976, Avalanche Handbook, U.S. Department of Agriculture, Agriculture Handbook 489, 238 p.
Purington, C. W., 1898, Preliminary report on the mining industries of the Telluride quadrangle, Colorado: U.S. Geological Survey 18th Annual Report, Part 3, p. 745–851.
U.S. Office of the Census, 1913, Abstract of the Census with supplement for Colorado, *in* Thirteenth Census of the United States, Washington, D. C., U.S. Government Printing Office, 697 p.
Williams, Knox, 1975, The snowy torrents—avalanche accidents in the United States, 1967–1971: U.S. Forest Service Technical Report RM–8, 190 p.
______1975, Avalanche fatalities in the United States, 1950–1975: U.S. Forest Service Research Note RM–300, 4 p.
Witkind, I. J., Hoskins, P. A., Lindsey, V. L., and Mitchell, E. L., 1972 [1974], Map showing snow avalanche probabilities in the Henrys Lake quadrangle, Idaho and Montana: U.S. Geological Survey Miscellaneous Investigations Series I–781–I, scale 1:62,500.

Table 1.—*List of recorded destructive avalanches in the Telluride region by geographic location, 1883–1979*

[Leaders (—) indicate not applicable]

Map No.[1]	Location of accident	Description of incident and date	Fatalities[2]	Survivors[2]	Source of data[3]
1	Boomerang Road—	The snow pack on Boomerang Hill slid over the wagon road. March 6, 1912.	—	—	SME, Mar. 9, 1912.
2	Boomerang Road area.	Traffic on the Denver and Rio Grande Railroad was prevented from leaving Telluride by an avalanche which released on Boomerang Hill just east of the wagon road bridge. The avalanche covered the railroad tracks for 150 ft (46 m) with 10 ft (3 m) of snow. March 7, 1912.	—	—	SME, Mar. 9, 1912.
3	Liberty Bell Mine—	Three avalanches occurred at this site on the same day. The first avalanche destroyed the boarding house, bunk houses, tramway station, and ore-loading house. The second avalance struck a rescue party at the site of the first avalanche. The third avalanche caught another rescue party returning to Telluride. In all, 19 men were killed and 9 men injured. February 28, 1902.	19	9+	SME, Mar. 1, 1902; TJ, Mar. 6, 1902.
	—do—	An avalanche struck the bulwarks above the boarding house and then destroyed a tramway tower. March 24, 1906.	—	—	TJ, Mar. 29, 1906.
	—do—	Three men were caught in an avalanche a short distance from the mine; all survived. February 1908.	—	3	TJ, Feb. 6, 1908.
4	Stillwell Tunnel of the Liberty Bell Mine.	Six horses caught in avalanche; one horse was killed. February 1908.	—	—	TJ, Feb. 6, 1908.
	—do—	Three avalanches in less than 24 hours damaged various properties of the Liberty Bell workings. Three horses were killed and one miner was caught by avalanches. January 1916.	—	1	SME, Jan. 29, 1916.
	—do—	Two men were killed when an avalanche struck the boarding house. March 12, 1919.	2	—	SS, Mar. 15, 1919.
5	West side of Royal Gulch on Tomboy Road	One wagon swept down the slope by an avalanche. March 18, 1912.	—	—	SME, Mar. 23, 1912.
6	Tomboy Road by Herron Spring.	Five men were caught and buried to the shoulders in an avalanche. A nearby road crew soon dug them out; all survived. February 1912.	—	5	SMCJ, Feb. 27, 1942.
7	Smuggler-Union Adit Tunnel.	Avalanche destroyed all surface buildings, sections of flume, tramway, and other equipment. March 1920.	—	—	OH, Mar. 18, 1920.
8	Mendota Mine—	Eight men were killed and another 8 were injured when an avalanche destroyed the shaft house. In addition, 3 horses were killed. December 26, 1883.	8	8	SJH, Jan. 3, 1884.
	—do—	One man was injured by an avalanche. January 14, 1887.	—	1	SD, Jan. 22, 1887.
9	Sheridan Mine—	Twenty-one men were buried by an avalanche which destroyed all the buildings on the premises; 4 men were killed. January 25, 1886.	4	17	TJ, Feb. 6, 1908.
	—do—	An avalanche struck the boarding house killing 1 man; 7 others survived. February 28, 1902.	1	7	SME, Mar. 1, 1902.
	—do—	Avalanche destroyed tramway tower. January 26, 1914.	—	—	SME, Jan. 31, 1914.
	—do—	Avalanche destroyed the transformer house and knocked over a tramway tower. February 4, 1915.	—	—	SME, Feb. 6, 1915.
10	Smuggler Mine—	Avalanche destroyed snowsheds. January 1887.	—	—	SJ, Feb. 10, 1887.
	—do—	Avalanche covered entrance of one or two tunnels. February 2, 1887.	—	—	SJ, Feb. 3, 1887.
11	Union Mine—	Three men killed by an avalanche a short distance from mine. February 3, 1883.	3	—	LPM, Feb. 10, 1883.
	—do—	Shaft house, powder magazine, and tunnel house destroyed by an avalanche. February 1883.	—	—	LPM, Feb. 17, 1883.
	—do—	Cook house and bunk house destroyed by an avalanche; 1 man killed. January 14, 1887.	1	—	SD, Jan. 22, 1887.
12	Valley View Avalanche.	Five men carried 1,000 ft downhill to Pennsylvania Tunnel by avalanche; all dug out uninjured. February 1908.	—	5	TJ, Feb. 6, 1908.
	—do—	One man carried over cliffs by avalanche; survived. December 1910.	—	1	TJ, Dec. 29, 1910.
	—do—	Several men caught in avalanche were dug out; 1 man was injured. February 1915.	—	several	SME, Feb. 6, 1915.
13	Pandora Avalanche—	Avalanche damaged buildings and covered the entrance of the French Tunnel trapping 2 men inside. Men were able to dig themselves out. March 1906.	—	2	TJ, Mar. 22, 1906.
	—do—	Avalanche destroyed the blacksmith shop. February 1908.	—	—	TJ, Feb. 6, 1908.
	—do—	Avalanche destroyed showsheds and carried away supply of lumber and mine timbers. December 17, 1908.	—	—	TJ, Dec. 24, 1908.
	—do—	Avalanche, which was artificially released by dynamite, destroyed snowsheds, blacksmith shop, and tramhouse; also destroyed 50 ft (15 m) of snowsheds of the Pennsylvania Tunnel, the blacksmith shop, water and air pipes of the Smuggler-Union Tunnel, and power lines belonging to the Telluride Power Co. February 1909.	—	—	TJ, Feb. 25, 1909.
	—do—	One man caught by an avalanche and carried downhill; dug out uninjured. February 25, 1910.	—	1	SME, Feb. 26, 1910.
	Pandora and Oriental Avalanches.	Both avalanches released together and destroyed 200 ft (61 m) of Pennsylvania Tunnel sheds and track. In addition, two tramway towers of the Tomboy Gold Mine Co. in Marshall Creek were destroyed. February 5, 1915.	—	—	SME, Feb. 13, 1915.
14	Oriental Avalanche—	Avalanche ran over Pennsylvania Tunnel buildings doing little damage. January 28, 1914.	—	—	SME, Jan. 31, 1914.
15	Bullion Tunnel—	Avalanche caught a mule team; 4 mules killed. February 9, 1909.	—	—	TJ, Feb. 11, 1909.
16	Blacksmith Shop Avalanche.	Avalanche thought to have been released by concussion of Oriental and Pandora Avalanches. Avalanche covered the Smuggler Mine blacksmith shop. February 5, 1915.	—	—	SME, Feb. 13, 1915.
17	Cimmaron Mine area.	One man was killed by an avalanche above the mine. February 20, 1884.	1	—	SM, Feb. 29, 1884.
18	Lower end of Marshall Basin.	The Seventy-Six Avalanche released and severely damaged one house. March 11, 1911.	—	—	SME, Mar. 18, 1911.
	—do—	The Seventy-Six and Cimmaron Avalanches released together and destroyed 3 houses. Ten occupants inside the houses survived; 1 man in a yard outside was killed. March 7, 1912.	1	10	SME, Mar. 9, 1912.
19	Little Elephant Avalanche.	Avalanche destroyed telephone and power lines. January 12, 1906.	—	—	TJ, Jan. 18, 1906.
	—do—	Buildings at the entrance of the Japan Tunnel were destroyed by an avalanche. January 19, 1910.	—	—	TJ, Jan. 20, 1910.
20	Big Elephant Avalanche.	Avalanche buried a surface tram and destroyed 2 spans of track sheds about 170 ft (52 m) in length. In addition 5,500 ft (1,675 m) of telephone line and 5 telephone poles were swept away. March 5, 1912.	—	—	SME, Mar. 9, 1912.
	—do—	Two avalanches covered the Tomboy tramway sheds and reached the wagon road. January 1914.	—	—	SME, Jan. 24, 1914.
21	Upper workings of the Tomboy Mine.	One man was killed by an avalanche near the blacksmith shop. January 10, 1901.	1	—	SME, Jan. 12, 1901.
	—do—	Avalanche destroyed the transformer house. April 1, 1926.	—	—	TDJ, Apr. 1, 1926.
22	Bobtail Avalanche—	One horse caught by an avalanche; recovered uninjured. March 11, 1901.	—	—	SME, Mar. 16, 1901.
	—do—	Five men were caught by an avalanche; all survived. However, soon after a rescue party reached the scene another avalanche released, killing 1 man. March 2, 1902.	1	5+	TJ, Mar. 6, 1902.
	—do—	Cable belonging to power company damaged by avalanche ("almost a yearly event for the power company"). January 1906.	—	—	TJ, Jan. 25, 1906.
	—do—	The Bobtail and Hanging Rock Avalanches released together and destroyed 3 of the main towers of the Smuggler tramway. In addition, the avalanche air blast pushed all the ore buckets from the Pennsylvania Tunnel tramway. March 10, 1912.	—	—	SME, Mar. 16, 1912.
23	Area of the old town of Pandora.	House "shattered to kindling" by avalanche concussion. 1901.	—	—	TJ, Mar. 22, 1906.
	—do—	The Ajax Avalanche released twice in same day. The larger, second avalanche destroyed a tram tower and house 100 ft (30 m) south of the mill. March 2, 1902.	—	—	SME, Mar. 8, 1902.
	—do—	Windows at Smuggler Mill and a residence broken by an avalanche. March, 1906.	—	—	TJ, Mar. 22, 1906.
	—do—	The Ajax Avalanche, which was artificially released by dynamite, destroyed 3 towers of the Black Bear Mine's lower tram and unroofed the terminal building in Pandora Park. Part of the roof was thrown about 100 yd (91 m) from the building. March 10, 1912.	—	—	SME, Mar. 16, 1912.
	—do—	The Bobtail Avalanche released and ran past the Smuggler-Union Mill and into the San Miguel River. Several houses at Pandora were slightly damaged. December 5, 1913.	—	—	SME, Dec. 6, 1913.
	—do—	Concussion from the Ajax Avalanche broke windows of 2 houses in Pandora. January 27, 1916.	—	—	SME, Jan. 29, 1916.
	—do—	Ajax Avalanche destroyed 2 homes with 3 people inside. Two people were killed and 1 of the houses was carried 200 yd (183 m). March 16, 1928.	2	1	TDJ, Mar. 16, 1928.
	—do—	In the early 1950's the Ajax Avalanche destroyed several sheds and damaged the mill.	—	—	Donald O'Rourke, written commun, 1980.
	—do—	The Ajax Avalanche caused $40,000 to $50,000 damage to snow sheds and other buildings of the Idarado Mining Co. 1968.	—	—	TE, Jan 7 1976.
24	Between Meldrum Tunnel and Ingram Falls.	One man carried by avalanche several hundred feet; survived. March 1901.	—	1	SME, Mar. 23, 1901.
25	Between Bridal Veil Falls and the Black Bear Mill.	One man caught by an avalanche; survived. March 6, 1912.	—	1	SME, Mar. 9, 1912.
26	Ingram Falls area on the upper zigzag.	Four men and a pack train were struck by the Finnlander Avalanche; 1 man was killed. November 19, 1902.	1	3	TJ, Nov. 20, 1902.
27	Ingram Falls area—	Avalanche destroyed tramway and damaged part of a building. April 2, 1926.	—	—	TDJ, Apr. 2, 1926.
28	Uncle Sam Avalanche.	Tramway tower of the Black Bear Mine destroyed by avalanche. February 1, 1915.	—	—	SME, Feb. 6, 1915.
	—do—	Avalanche damaged Black Bear Mine tramway. March 1924.	—	—	TDJ, Mar. 21, 1924.
	—do—	Two men caught in an avalanche; dug themselves out. March 20, 1924.	—	2	TDJ, Mar. 22, 1924.
29	Black Bear Mine—	Highest tram tower destroyed by an avalanche. February 1908.	—	—	TJ, Feb. 13, 1908.
	—do—	Avalanche near Black Bear Tunnel moved compressor building about 20 ft (6 m). December 1909.	—	—	SME, Dec. 18, 1909.
	—do—	Bunkhouse, containing 14 men, was struck by an avalanche. Three men were killed and 3 others were injured. March 13, 1912.	3	11	SME, Mar. 16, 1912.
	—do—	Part of the upper tramway terminal was destroyed by an avalanche. March 1924.	—	—	TDJ, Mar. 25, 1924.
	—do—	All the buildings destroyed by an avalanche. Two persons were killed; 5 other persons survived. April 2, 1926.	2	5	TDJ, Apr. 2, 1926.
30	Top of Bridal Veil Falls.	Water pipe of the Smuggler Company destroyed by an avalanche. February 1911.	—	—	SME, Feb. 25, 1911.
31*	Bridal Veil Basin—	Smuggler-Union water pipe and power lines damaged by an avalanche. March 1924.	—	—	SS, Mar. 29, 1924.
32*	Near Pulaski Mill—	Power line of the Smuggler Company destroyed by an avalanche. Bridal Veil Creek was dammed. March 6, 1912.	—	—	SME, Mar. 9, 1912.
33*	Montezuma Avalanche.	Smuggler Company power and telephone lines destroyed by an avalanche. February 1911.	—	—	SME, Feb. 18, 1911.
34*	Blue Lake area—	Smuggler-Union regular and emergency power and telephone lines destroyed by avalanche. March 20, 1924.	—	—	TDJ, Mar. 21, 1924.
35	Lewis Mine—	Avalanche crushed in the shaft house killing 2 men. February 5, 1908.	2	—	TJ, Feb. 6, 1908.
36*	Trail to La Junta Basin.	Two men caught by an avalanche and carried about 1,500 ft (457 m); 1 man was killed. October 18, 1888.	1	1	CT, Oct. 26, 1888.
37	Contention Mine—	Avalanche caused major damage to several buildings. April 8, 1903.	—	—	TJ, Apr. 9, 1903.
38	La Junta Mill boarding house.	La Junta Tramway damaged by avalanche, in addition the avalanche's concussion broke some windows of the boarding house. January 28, 1914.	—	—	SME, Jan. 31, 1914.
39*	Bear Creek—	Power line of the Thomas Mill damaged by avalanche. March 16, 1906.	—	—	TJ, Mar. 22, 1906.
40*	Bear Creek—	One man caught by an avalanche; survived. January 1915.	—	1	SME, Jan. 30, 1915.
41*	Bear Creek—	One man caught in avalanche and carried for 500 ft (152 m); dug himself out. January 7, 1901.	—	1	SME, Jan. 12, 1901.
42	Silver Chief Mill—	Mill destroyed by avalanche. March 1902.	—	—	TJ. Mar. 13, 1902.
43	Fairview Mine area—	Three men caught by avalanche while crossing avalanche path; all survived. March 4, 1912.	—	3	SME, Mar. 9, 1912.
44	Thomas Mine area—	Three men caught by avalanche; 1 man was killed. March 8, 1901.	1	2	SME, Mar. 9, 1901.
	—do—	Two men in a cabin were killed when an avalanche destroyed the cabin. March 4, 1902.	2	—	SME, Mar. 8, 1902.
45	Nellie Mine area—	Three persons were killed and 2 others were badly injured when an avalanche destroyed the Mammoth boarding house near the Nellie Mine. Two other people were able to dig themselves out. January 23, 1909.	3	4	TJ, Jan. 28, 1909.
	—do—	Tramway and upper part of the Nellie Mill were damaged by an avalanche. March 14, 1912.	—	—	SME, Mar. 16, 1912.
46	Gold King Basin—	Avalanche took out 400 ft (122 m) of the Gold King tram. February 1897.	—	—	OM, Feb. 21, 1897.
	—do—	Blacksmith shop of the Alta Mine covered by avalanche. December 16, 1899.	—	—	SME, Dec. 23, 1899.
	—do—	Avalanche struck the boarding house of the Alta Mine, killing 1 man. Another man was able to dig himself out. April 19, 1901.	1	1	SME, Apr. 20, 1901.
	—do—	Several hundred feet of shed covering the Gold King surface tram was taken out by the Alta Avalanche. February 28, 1902.	—	—	TJ, Mar. 6, 1902.
	—do—	The boarding house of the Alta Mine was struck by an avalanche. Three men were buried but were dug out uninjured. February 5, 1908.	—	3	TJ, Feb. 6, 1908.
	—do—	Four men, 2 horses and a mail wagon were caught by an avalanche; all uninjured. March 1912.	—	4	SME, Mar. 9, 1912.
47	Palmyra Mine area—	Cross-country skier killed by avalanche. November 24, 1979.	1	—	DP, Nov. 25, 1979.

[1]Asterisk (*) denotes that the exact location is unknown.

[2]A total of 61 avalanche fatalities and at least 119 survivors have been documented in the surviving historical record. Because of the incompleteness of this record these figures are minimal totals. Avalanche encounters occurring in the 1870's, 1880's, and most of the 1890's may have been missed due to lack of surviving historical records.

[3]CT, Colorado Topics; published weekly in Hyde, Colorado; 1886–1889
DP, Denver Post; published daily in Denver, Colorado; 1894–present
LPM, La Plata Miner; published weekly in Silverton, Colorado; 1875–1886
OH, Ouray Herald; published weekly in Ouray, Colorado; 1894–1939
OM, Ophir Mail; published weekly in Ophir, Colorado; 1894–1904
SD, Silverton Democrat, published weekly in Silverton, Colorado; 1885–1887
SJ, San Juan, published weekly in Silverton, Colorado; 1886–1887
SJH, San Juan Herald, published weekly in Silverton, Colorado; 1881–1885
SM, Solid Muldoon, published weekly in Ouray, Colorado; 1879–1892
SMCJ, San Miguel County Journal, published weekly in Telluride, Colorado; 1938–1945
SME, San Miguel Examiner, published weekly in Telluride, Colorado; 1897–1929
SS, Silverton Standard, published weekly in Silverton, Colorado; 1889-present
TDJ, Telluride Daily Journal, published daily in Telluride, Colorado; 1894–1929
TE, Telluride Examiner, published weekly in Telluride, Colorado; 1975–1976
TJ, Telluride Journal, published weekly in Telluride, Colorado, 1889–1927

For sale by Branch of Distribution, U.S. Geological Survey, Box 25286, Federal Center, Denver, CO 80225