chen and associates

CONSULTING GEOTECHNICAL ENGINEERS

chen and associates
CONSULTING GEOTECHNICAL ENGINEERS
96 SOUTH ZUNI STREET • DENVER, COLORADO 80223 • 303/744-7105

ENGINEERING GEOLOGY INVESTIGATION
LITTLE GRANITE CREEK ROAD CORRIDOR
TETON NATIONAL FOREST
TETON COUNTY, WYOMING

OPEN-FILE REPORT 81-853

PUBLISHED BY: U.S. Geological Survey

Prepared for:

LAND MANAGEMENT SERVICES
P.O. BOX 2116
JACKSON HOLE, WYOMING 83001

Job No. 6363W-B

November 15, 1980

TABLE OF CONTENTS

SCOPE AND METHOD OF INVESTIGATION

This report summarizes the results of an engineering geology investigation for the proposed Little Granite Creek Road Corridor access to the Getty drill site. The purpose of the investigation was to provide geologic data so that the U.S. Forest Service and U.S. Geological Survey can jointly draft an Environmental Impact Statement. The location of the proposed road corridor is shown on Fig. 1. The general geologic conditions within the corridor are described and their anticipated impacts on the proposed road are discussed. The data and conclusions presented in this report are suitable for evaluating general impacts; however, additional detailed studies will be required for final design purposes.

The geologic conditions in the proposed road corridor were evaluated by reviewing published regional geologic maps, a field reconnaissance, and interpretation of aerial photographs. The largest scale geologic map available for the area is the 1:24,000, Geologic Map of the Bull Creek Quadrangle, Schroeder (1976). In early October, 1980, a field reconnaissance was made by Doug Stack and Ralph Mock of Chen and Associates, Inc. along the proposed road alignment. In addition, colored aerial photography at a scale of 1:15840 was available for our investigation.

PROPOSED ROAD CONSTRUCTION

In order to provide access to the proposed Getty drill site located on a divide between Little Granite Creek and Horse Creek, it will be necessary to construct 5.9 miles of road. Construction will

Scale: 1: 250,000

LOCATION MAP LITTLE GRANITE ROAD CORRIDOR		
chen and associates, inc. CONSULTING ENGINEERS 96 S. ZUNI · DENVER, CO. 80223		
Job Number 6363W-B	Date: Dec. 1980	Fig. 1

start in the Little Granite Creek valley about 1.7 miles upstream from the confluence of Little Granite Creek and Granite Creek, as shown on Fig. 1. The road will go up the valley of Little Granite Creek and then cross along the western valley side to the drill site on the divide. The proposed road alignment is shown on Fig. 2. The road starts at the end of an unimproved dirt road and crosses through virgin land all the way to the proposed drill site. The width of the road will be kept relatively narrow, about 14 feet, and it is not anticipated that cut slope heights on the majority of the road will be in excess of about 10 feet. Deeper cuts will be necessary where the road switchbacks up steep hillsides.

GEOLOGIC SETTING

The proposed Little Granite Creek Road Corridor is located on the southwestern side of the Gros Ventre mountain range, about 16 miles southeast of Jackson, Wyoming, as shown on Fig. 1. The topography in the area is rugged, consisting of narrow, steep sided valleys which lie from 800 to 1,200 feet below the surrounding mountain ridges. The geology of the Gros Ventre Range is very complex. Structurally, the range is a northwest-trending asymmetric anticline with gentle dips on the northeast side and steep dips on the southwest. Precambrian age metamorphic rocks are present in the core of the anticline, and Paleozoic through Mesozoic sedimentary rocks form the anticline flanks. The anticlinal structure has been modified by thrust faults and normal faults which trend to the northwest. The thrust faults originated in the Paleocene. Overthrusting has occurred


Boundary Of Study Area
Cliff Creek Thrust Fault
Getty Site
SCALE IN FEET
1000 0 1000 2000 3000
REFERENCE:
1.) Schroder (1976)
EXPLANATION
SURFICAL DEPOSITS
Qs SWAMP and BOG DEPOSITS
Qdf DEBRIS FANS
Qal STREAM VALLEY and TERRACE ALLUVIUM
Qls LANDSLIDE DEPOSITS
Qg GLACIAL DEPOSITS
NOTE: Bedrock units are generally overlain by a thin veneer up to several feet of colluvium.
BEDROCK UNITS
Tr RED BEDS
Thu HOBACK FORMATION UPPER MEMBER
Th1 HOBACK FORMATION LOWER MEMBER
Ks SANDSTONE, SHALE and COAL SEQUENCE
Jt TWIN CREEK LIMESTONE
T̶Rc CHUGWATER FORMATION
T̶Rd DINWOODY FORMATION
Pp PHOSPHORIA FORMATION
PP̶Mw WELLS FORMATION and ASSOCIATED ROCKS
Mm MADISON LIMESTONE
SYMBOLS
THRUST FAULT
Dashed where concealed or inferred
STRIKE SLIP FAULT
Dashed where concealed or inferred
35°
STRIKE AND DIP OF BEDS
60°
STRIKE AND DIP OF OVER TURNED BEDS
SPRING
GEOLOGY MAP ROAD CORRIDOR
LITTLE GRANITE CREEK
chen and associates, inc.
CONSULTING GEOTECHNICAL ENGINEERS
96 SOUTH ZUNI STREET • DENVER, COLORADO 80223
Drawn A.S. Check R.G.M. Date December 1980
Revised
Job Number 6363W-B
Fig. 2

both toward the southwest and northeast. The episode of thrust faulting continued through the Pliocene. During the Pleistocene, the northwest trending Hoback normal fault developed along the southwestern margin of the range. There is evidence of about 9,000 feet of Pleistocene movement on the Hoback Fault, and the fault is still considered to be active, Behrent and others (1968).

The Gros Ventre Range lies along the eastern edge of the Intermountain Seismic Belt which is a northeast-trending zone of seismic activity extending northward through Utah, Idaho and Wyoming, Smith (1978). Major earthquakes have occurred in the Intermountain Seismic Belt during historic times. The largest event was the August 17, 1959 Hebgen Lake earthquake which had a magnitude of 7.1. The epicenter was located in the Yellowstone Park area about 100 miles northwest of the Gros Ventre Range. Major earthquakes have not occurred in the vicinity of the Gros Ventre Range during historic times; however, numerous small diffuse earthquakes have occurred in this area, Smith (1978). The magnitudes of these earthquakes have been less than 5.0.

GEOLOGY--LITTLE GRANITE CREEK CORRIDOR

The general geologic conditions along the corridor are shown on Fig. 2. Detailed descriptions of the geologic units mapped in the corridor are shown on Table I. Sedimentary rocks ranging from Paleozoic to Cenozoic age are present within the corridor. Intense post-depositional folding and faulting has affected all of the rocks in the corridor. The structural grain of the sedimentary rocks is

TABLE I

GEOLOGIC MAP UNITS
LITTLE GRANITE CREEK CORRIDOR

Map Symbol	Formation and Age	Thickness	Lithologic Character
Qs	Swamp and Bog Deposits (Holocene)	1 to 3 feet	Dark brown, soft, organic, fine, sandy silt.
Qdf	Debris Fans (Holocene)	Unknown	Cobbly and gravelly silts and clays.
Qal	Stream Valley and Terrace Alluvium (Holocene)	Unknown	Silty to clayey sand and gravel. A fine-grained, silty clay layer is generally present at the surface.
Qls	Landslide Deposits (Holocene or Pleistocene)	Unknown	Chaotic mixture of boulders, fine rock debris and soil emplaced by mass movement.
Qg	Glacial Deposits (Pleistocene)	Unknown	Till and outwash deposits. Ranges from non-stratified bouldery clays and silts to well stratified silty to clayey sand and gravels.
Tr	Red Beds (Eocene?)	500 + feet	Red conglomeritic silt-stone and sandstone.
Thu	Hoback Formation Upper Member (Paleocene)	9,000 + feet	Interbedded buff, fine-grained sandstone and greenish-gray siltstone and shale with some limestone lenses.
Thl	Hoback Formation Lower Member (Paleocene)	850 to 900 feet	Brownish-gray, hard, conglomerate with a fine-grained sandy matrix.
Ks	Sandstone, Shale and Coal Sequence (Upper Cretaceous)	5,000 + feet	Gray and tan lenticular fine-grained sandstone, gray plastic shale, carbonaceous shale and some coal beds.

TABLE I

GEOLOGIC MAP UNITS
LITTLE GRANITE CREEK CORRIDOR

Map Symbol	Formation and Age	Thickness	Lithologic Character
Jt	Twin Creek Limestone (Upper and Middle Jurassic)	750 to 800 feet	Gray, fine-grained limestone and shaley limestone with a yellow soft siltstone and claystone in lower part
℞c	Chugwater Formation (Upper and Lower Triassic)	1,000 to 1,200 feet	Interbedded red shale, siltstone and sandstone, with some limestone beds.
℞d	Denwoody Formation (Lower Triassic)	350 to 400 feet	Brownish-gray siltstone, sandstone and shale with interbedded gray limestone.
Pp	Phosphoria Formation (Permian)	235 feet	Interbedded dolomite sandstone, chert, phosphorite and black shale.
PPMw	Wells Formation and Associated Rocks (Permian, Pennsylvanian and Mississippian)	800 to 1,000 feet	Upper Part: Light gray, hard sandstone, fine-grained sandstone with some limestone and dolomite beds. Lower Part: Red gypsiferous shale and gray limestone. Sandstone at base which is in part correlative to the Amsden Formation.
Mm	Madison Limestone (Lower Mississippian)	1,300 to 1,600 feet	Gray, fine to coarse-grained massive to thin bedded limestone.

towards the northwest and parallels the trend of the thrust faulting in the area. Bedding planes in the sedimentary rocks generally strike toward the northwest with moderate to steep dips either to the northeast or southwest. In the vicinity of the Cliff Creek thrust fault, bedding has been overturned.

The bedrock in the proposed road corridor is usually covered by surficial deposits. Most of the tributary valley floors are underlain by shallow stream valley alluvium, Map Symbol Qal on Fig. 2, and many of the steep gradient tributaries to Little Granite Creek have debris fans at their mouths, Map Symbol Qdf. A landslide deposit is present along the lower reaches of Little Granite Creek between Stations 223+00 and 238+00. Active stream erosion is presently occurring at the toe of the slide. A second smaller landslide is present between Stations 26+00 and 28+00 in an area also underlain by Cretaceous age sedimentary rock. The latter landslide deposit appears to be shallow and apparently related to high ground water conditions and solifluction. In addition, geologic conditions similar to those present in the slide area are also present along much of the north facing hillside between Stations 28+00 and 70+00. The landslide deposits are shown by Map Symbol Qls. The lower, larger landslide deposit appears to be stable at the present time; however, the upper slide deposit appears to be active. Glacial deposits, shown by Map Symbol Qg, are present along much of the proposed alignment in the upper reaches of Little Granite Creek. The deposits are nonstratified, bouldery clays and silts. Some of the boulders are several tens of feet in diameter. Swampy and boggy deposits, Map Symbol Qs, are present at several locations in the areas underlain by glacial deposits. The bedrock in the corridor is generally covered by colluvium which varies from a thin veneer up to several tens of feet thick. Colluvial deposits in the corridor have not been shown by a map symbol on Fig. 2. The colluvium is a poorly stratified, sandy silt and clay with numerous angular rock fragments ranging from gravel to boulder size.

The proposed road alignment lies along the central portion of the study corridor as shown on Fig. 2. Geologic materials present along the proposed alignment and the length of road in each geologic material is shown on Table II.

TABLE II

GEOLOGIC MATERIALS PRESENT ALONG THE PROPOSED ROAD ALIGNMENT

Geologic Units	Miles of Road	% Total Road Length
Stream Valley Alluvium (Qal)	1.3	22
Debris Fans (Qdf)	0.3	6
Swamp and Bog Deposits (Qs)	0.2	2
Landslide Deposits (Qls)	0.3	6
Glacial Deposits (Qg)	1.8	30
Colluvium Over Bedrock	2.0	34
	5.9	100

In the sections of the road which cross stream valley alluvium, debris fans, swamp and bog deposits, landslide deposits and glacial deposits, we do not anticipate that the necessary grading will extend to depths exceeding the depths of these deposits. In areas where the road alignment crosses colluvium overlying bedrock, which accounts for 2.0 miles of the 5.9-mile alignment, we anticipate that grading for the road may be deep enough to encounter the underlying bedrock in many places. Bedrock types which may be encountered and the length of road section in each bedrock type are shown on Table III.

TABLE III

AREAS OF ANTICIPATED SHALLOW BEDROCK

Rock Underlying Colluvium	Miles of Road	% Total Road Length
Red Beds (Tr)	0.2	3
Lower Hoback Formation (Thl)	0.8	13
Sandstone, Shale and Coal Sequence (Ks)	1.0	18
	2.0	34

POTENTIAL IMPACTS OF CORRIDOR GEOLOGY ON ROAD

This section discusses the potential impact to the proposed road and its users related to the geologic processes and conditions present along the road corridor. Because most of the impacts are related to geologic processes which have varying rates of activity, it is necessary to establish a design life for the road in order to rank the potential impacts. A road service life of 25 years was considered. The potential geologic impacts on the road were ranked as high, moderate and low, using the following definitions:

High - Geologic processes or conditions which are likey to impact the road and its users one or more times during the road's service life.

Moderate - Geologic processes or conditions which are not likely to impact the road and its users during the road's service life, but are likely to impact the road during a time period which is severe to several tens times longer than the road's service life.

Low - Geologic processes or conditions which are not very likely to impact the road and its users during the road's service life. These types of events occur relatively infrequently and are likely to have recurrence intervals greater than several tens to several thousands times the road's service life.

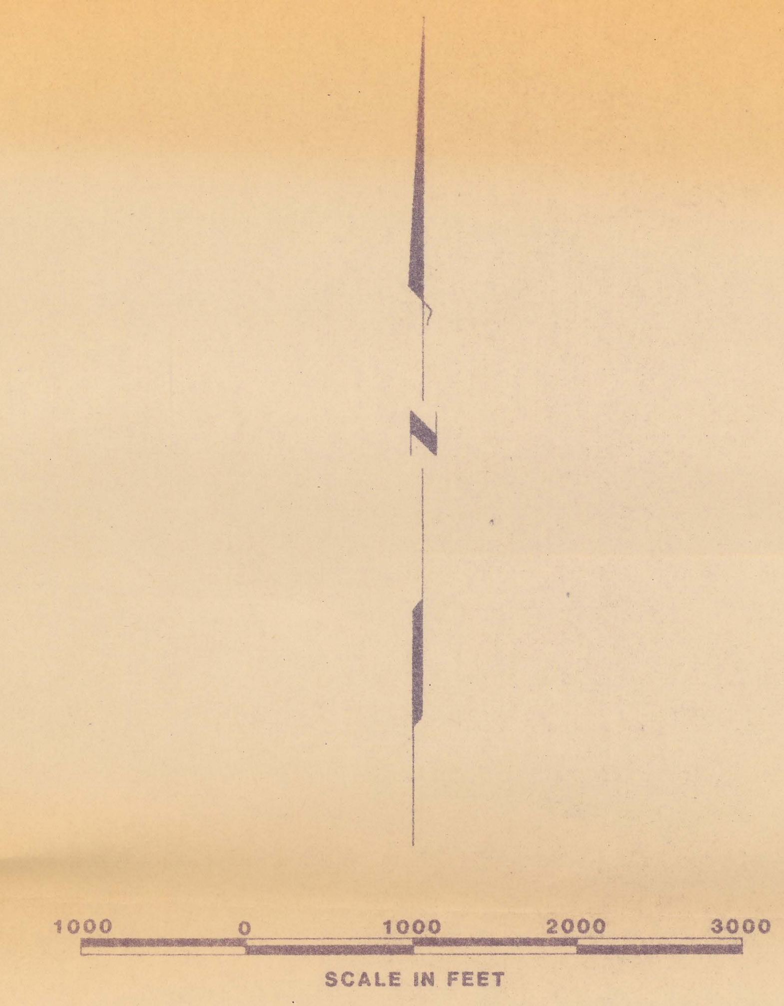
The potential impacts considered and their ranking are given on Table IV and discussed in the following sections.

TABLE IV

POTENTIAL GEOLOGIC IMPACTS

Geologic Impacts	Potential for Impact
Avalanche	High
Flooding	High
Landslide Movements	High to Moderate
Rockfall	Moderate
Debris Flows	Moderate
Earthquake Effects:	
Moderate Ground Shaking	High
Strong Ground Shaking	Low
Surface Fault Rupture	Low

Avalanches: Snow avalanches have occurred in the Jackson, Wyoming area in the past, Love (1973), and it is likely that avalanches will continue to occur in the future. The potential for an avalanche exists whenever the combination of steep slopes and adequate snowfall is present. These conditions occur at a few places along the proposed road alignment as shown on Fig. 3. In evaluating the avalanche potential in the road corridor, potential avalanche start zones were considered to be slopes without conifer forests in excess of 50% (27°) or forested slopes with well-defined avalanche tracks through the forests. The potential for avalanches impacting the road and its users is considered to be high, that is, it is anticipated that avalanches will impact some portions of the road during its service



EXPLANATION

Potential Avalanche Start Zone

Potential Rock Fall Source Areas

AVALANCHE AND ROCK FALL
LITTLE GRANITE CREEK
ROAD CORRIDOR

chen and associates, inc.
CONSULTING GEOTECHNICAL ENGINEERS
96 SOUTH ZUNI STREET • DENVER, COLORADO 80223

Drawn: A.S.	Check: R.G.M.	Date: Dec. 1980	Fig. 3
Revised:		Job Number: 6363W-B	

life; however, the areas susceptible to avalanche impact are relatively small. The adverse effects of avalanches on the road are expected to be small, and it is possible to close the road to travel while avalanche control operations, such as artificial avalanche release, take place as conditions warrant. Consequently, the potential danger to road users can be significantly reduced.

Flooding: Periodic flooding is expected to take place along the major drainages and their tributaries as a result of snowmelt runoff and storm runoff. The potential for flooding along the drainages is considered to be high, that is, flooding is expected to occur one or more times during the service life of the road. Flooding should not present a great danger to road users, and the potential adverse impacts to the road can be significantly reduced by engineering adequate surface drainage facilities where the road crosses drainage channels.

Landslide Movements: The landslide present along the lower portion of the road alignment between Stations 223+00 and 238+00 appears to be stable at the present time; however, Little Granite Creek is actively eroding at the toe of the slide. This condition provides a potential for renewed slide movement; however, the potential for renewed slide movement during the service life of the road is considered to be moderate. Construction of a road across the slide should not increase the potential for renewed slide movement; however, if sliding were to occur during the service life of the road, it is likely that considerable maintenance would be required to keep the road serviceable. Alternative locations of the road away from the slide area do not appear feasible.

The small landslide located along the upper portion of the road alignment between Stations 26+00 and 28+00 appears to be active at the present time. The sliding surface appears to be shallow and related to high ground water conditions. Construction of a road across the slide area would involve a relatively high potential for post-construction landslide movement; however, it should be possible to control or reduce slide movements by remedial construction such as subsurface drainage. The potential dangers to road users associated with the landslides are not considered to be great, since future movements are anticipated to be relatively slow.

Rockfalls: In the vicinity of Station 214+00, steep rock outcrops upslope from the road provide a potential source for rockfall. This area is shown on Fig. 3. A few boulders were observed in the vicinity of the proposed road alignment downslope from the source area, indicating that rockfalls have occasionally occurred here in the past. The potential for future rockfall in this area is considered to be moderate, that is, the likelihood of a rockfall occurring during the service life of the road is relatively remote; however, giving longer periods of exposure, the potential for rockfall is likely. The adverse effects of rockfall on the road are expected to be small, and the potential dangers to road users are also considered to be small because a vehicle traveling on the road will only be exposed to the potential for a short period of time.

Debris Flows: Evidence of past debris flows is evidenced by the debris fans present along portions of the proposed road alignment. The fan deposits have resulted from debris flows associated with relatively infrequent, intense storms. The potential for future debris flows is considered to be moderate, that is, debris flows are not likely to occur during the service life of the road; however, debris flows are likely to occur over longer time periods. The adverse effects of debris flows on the road are expected to be relatively minor. If a debris flow were to occur during the road's service life, it would be necessary to clean the debris off the roadway. The danger of debris flows to road users is considered to be small, since debris flows are expected to occur very infrequently and the exposure time of someone using the road in a debris flow area is very short.

Earthquake Effects: The Gros Ventre Range in the vicinity of the road corridor is in an area which has experienced moderate levels of historic seismic activity, and it is anticipated that moderate levels of seismicity will occur during the service life of the road. Judging from past seismic activity, peak ground accelerations of about 0.05g are likely to occur one or more times during the service life of the road. Ground shaking of this magnitude is not expected to be significant to the road or its users.

Considering the tectonic setting and recent geologic history of the area, there is also a potential for relatively infrequent, large earthquakes associated with the Hoback and Teton Fault Zones. Geologic evidence indicates that both of these fault zones have been active during the Quaternary. Average rates of displacement on the fault zones during the relatively recent geologic past indicate that the faults would be classified as moderately active, Slemmons (1977).

The recurrence interval for displacements along such faults and the generation of magnitude 7.0 or greater earthquakes is generally measured in thousands to tens of thousands of years for a given point on the fault, Slemmons (1977). Earthquakes of this size will produce strong ground shaking. Considering the proximity of these fault zones to the road corridor, it is anticipated that strong ground shaking in the corridor associated with a major earthquake would result in peak ground accelerations within the range of 0.3 to 0.7g; however, the recurrence interval for a major earthquake is considered to be greater than the service life of the road, and the potential for strong ground shaking is considered to be low during the road's service life.

POTENTIAL IMPACTS OF ROAD ON CORRIDOR GEOLOGY

This section discusses the potential impacts of road construction on the geologic conditions present in the proposed road corridor. Disturbance of the ground surface associated with road construction can be expected to have some impact on the corridor geology; however, if proper construction techniques are used, these impacts can be kept to a minimum. Potential impacts to the corridor geology are the potential for accelerated soil erosion and accompanying sedimentation and the potential for construction-induced slope instability.

The potential for accelerated soil erosion will occur in areas where road cuts remove the protective vegetative cover and where drainage collected along the upslope side of the road is discharged. Soil erosion on road cuts can be reduced by revegetation of the cut

depending on actual conditions enocuntered during construction. When deep cuts are necessary, free-draining rock buttresses may be necessary.

In order to minimize stability problems with fills, the fills should be compacted when placed. The ground surface below fills should be stripped of vegetation. Fills placed on steep side hills should be keyed into the hillside by benching the foundation. Compacted fills should be stable at angles of 1 1/2:1. Revegetation will minimize the potential for post-construction fill erosion. In areas where fill embankments are placed adjacent to flowing streams, the toe of the fill below flood level should be protected from erosion by riprap or other means.

GEOLOGIC CONSIDERATIONS FOR CONSTRUCTION

It should be possible to excavate the surficial deposits with heavy duty construction equipment. Some difficulty with excavation can be expected when large boulders are encountered in the glacial deposits. Shallow excavations into the bedrock can be done with rippers in most cases; however, some blasting may be required.

The swamp and bog deposits can be crossed on fills. In some cases, a granular fill base may be required to stabilize the foundation prior to completing the fill. Drainage should be provided through the fill to prevent damming of subsurface water flow.

If there are any questions concerning this report, please let us know.

RICHARD C. HEPWORTH REGISTERED 6538 PROFESSIONAL ENGINEER STATE OF COLORADO

CHEN AND ASSOCIATES, INC.

By Ralph G. Mock
Ralph G. Mock,
Engineering Geologist

Reviewed By Richard C. Hepworth
Richard C. Hepworth, P.E.

RGM/bn

REFERENCES

Behrendt, J.G. and others, 1968. A geophysical study in Grand Teton National Park and vicinity, Wyoming: U.S. Geol. Survey, Prof. Paper 516-E.

Love, J.D., 1973, Map showing the snowslide possibilities of the Jackson Quadrangle, Wyoming: U.S. Geol. Survey Map I-769-D.

Schroder, M.L., 1976, Geology Map of the Bull Creek Quadrangle, Wyoming: U.S. Geol. Survey Map GQ-1300.

Slemmons, D.B. 1977, State of the art for assessing earthquake hazards in the United States, Report 6, Faults and Earthquake Magnitude: U.S. Army Corps of Engineers Miscellaneous Paper S-73-1

Smith, R.B., 1978, Seismicity, crustal structure and interplate tectonics of the interior of the western Cordillera in Cenozoic Tectonics and Regional Geophysics of the Western Cordillera: Geol. Soc. Amer. Memoir 152.

REFERENCES

Behrendt, J.G. and others, 1968. A geophysical study in Grand Teton National Park and vicinity, Wyoming: U.S. Geol. Survey, Prof. Paper 516-E.

Love, J.D., 1973, Map showing the snowslide possibilities of the Jackson Quadrangle, Wyoming: U.S. Geol. Survey Map I-769-D.

Love, J.D. and Love, C.M., 1978, Geology Map of the Cache Creek Quadrangle, Wyoming: U.S. Geol. Survey Open File Report of 78-481.

Slemmons, D.B. 1977, State of the art for assessing earthquake hazards in the United States, Report 6, Faults and Earthquake Magnitude: U.S. Army Corps of Engineers Miscellaneous Paper S-73-1

Smith, R.B., 1978, Seismicity, crustal structure and interplate tectonics of the interior of the western Cordillera in Cenozoic Tectonics and Regional Geophysics of the Western Cordillera: Geol. Soc. Amer. Memoir 152.