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GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

PAPER 70-67

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QUATERNARY GEOLOGY ROAD LOGS - BANFF AREA, ALBERTA

(Report and 2 figures)

Nathaniel W. Rutter

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1971

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BANFF AREA, ALBERTA

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Illustrations

ABSTRACT

This paper contains six road logs dealing with aspects of the Quaternary geology in the area of Banff, Alberta.

QUATERNARY GEOLOGY ROAD LOGS
BANFF AREA, ALBERTA

INTRODUCTION

These road logs of the Quaternary geology of the Banff area are intended mainly for use by persons with some background in geology. However a glossary is included for those unfamiliar with geological terminology. The main purpose is to point out the variety of glacial features in the area, their mode of origin and, where helpful and possible, their lithology. The way in which the different features fit into the geological history is also discussed although it must be remembered that, as new information becomes available, some interpretations may have to be modified.

Situated in the eastern watershed of the Canadian Rocky Mountains section of the North American Cordillera physiographic province, the area discussed comprises the valley of the Bow River from the Lake Louise townsite to the Kananaskis River and includes side trips to Moraine Lake, Lake Louise, the valleys of Sundance Creek and Spray River, Lake Minnewanka and Mount Norquay. It extends from 51°00'N to 51°30'N and from 115°00'W to 116°15'W and covers parts of the following National Topographic Series' Maps: 82 O/3, 82O/4, 82 O/5, 82 O/6, 82 N/1 and 82 N/8.

Deposits, consisting mainly of till and glaciofluvial deposits, indicate four major late Pleistocene, probably Wisconsin, ice advances, all of which originated in the mountains to the west of the area. Individual sections display only limited parts of the total stratigraphic section; tills of the respective advances are not always lithologically distinctive, and interstadial or interglacial deposits are lacking. The stratigraphic succession on which the glacial chronology was based is constructed, therefore, from many incomplete sections, considerable reliance being placed on geomorphology and areal relationships.

The earliest recorded ice advance in the Banff area is inferred from outwash and till underlying younger glacial deposits. Widespread till deposits and breaks-in-slope at high elevations are the main evidence for the next advance – the Bow Valley Advance – during which ice extended eastward, well out into the Foothills. Ice-contact fluvial deposits, believed to have been originally kame moraines, indicate at least two intervals of glacier equilibrium during deglaciation. The next, the Canmore, apparently originated in the vicinity of Banff and probably extended eastward to the Foothills. This episode is recorded by breaks-in-slope and by discontinuous patches of till

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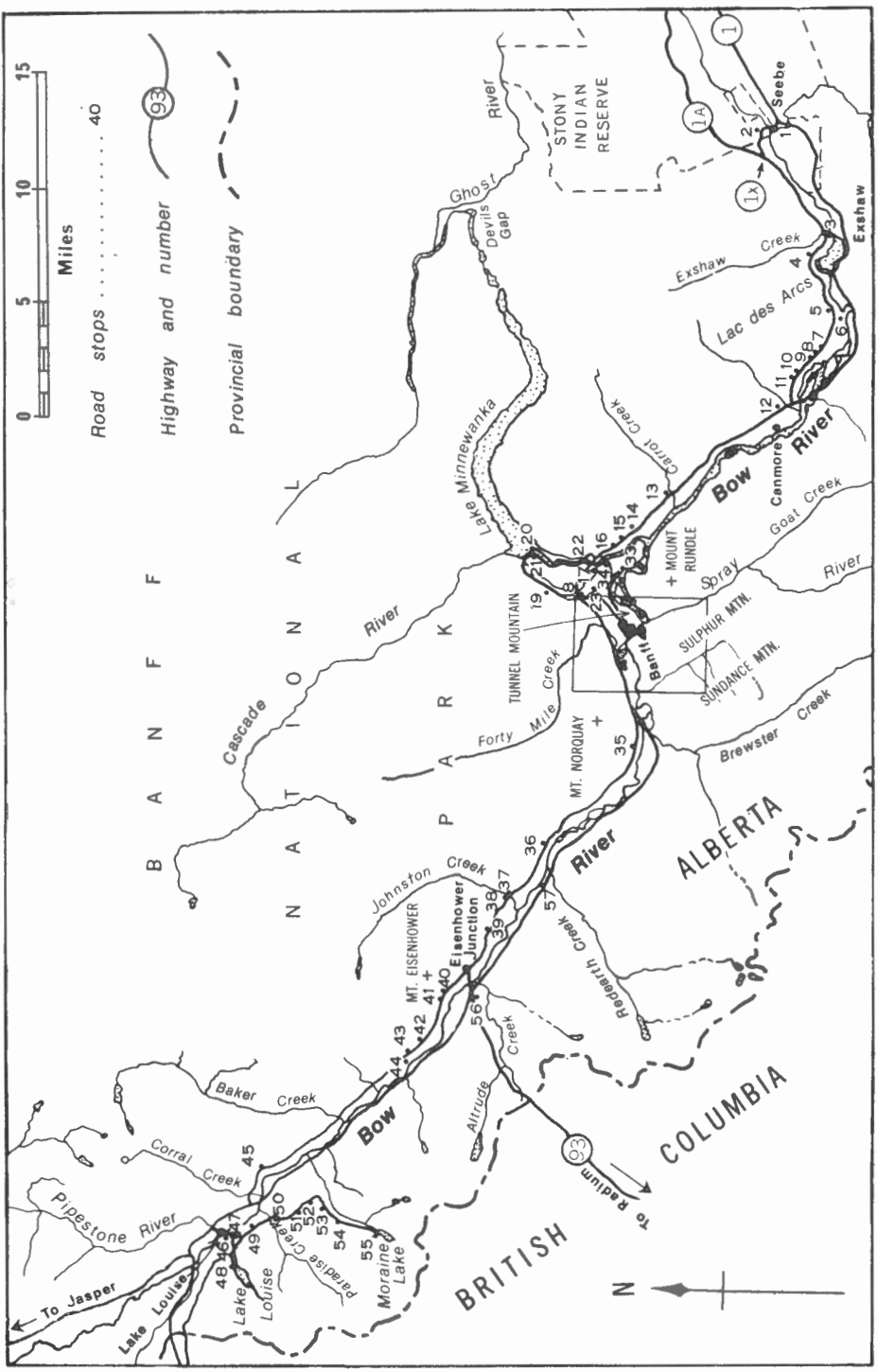

Figure 1. Route of Road Log itinerary.

over the outwash deposited during the Bow Valley retreat. The next advance, the Eisenhower Junction, extended southeastward about as far as Eisenhower Junction. Evidence for this advance includes well-preserved ground and lateral moraines, breaks-in-slope, fresh cirques, and an end moraine. That a minor re-advance may have followed is shown by the presence of till over the ice-contact fluvial deposits of the end moraine. A radiocarbon date of 9,330 ± 170 years B.P. (GSC-332) from a nearby area is correlated with the retreat of the ice of the Eisenhower Junction Advance.

A) KANANASKIS RIVER (SEEBE) TO BANFF

Road Log

Stops 1 to 24 are shown on Figure 1; Stops 23 and 24 also appear on Figure 2.

Distance
(miles)

0.0 Junction Highway 1 and Highway 1x, proceed northwest on Highway 1x

0.6 STOP 1: ESKER

1.3 Bow River bridge

1.4 STOP 2: KAME

2.5 Junction Highway 1x and 1A, turn left (west) onto Highway 1A
GENERAL DESCRIPTION

7.0 Exshw Creek bridge

7.4 STOP 3: SAND BLUFFS

8.4 STOP 4: VOLCANIC ASH

11.2 STOP 5: TILL

11.6 STOP 6: GLACIAL SCOURING

12.9 STOP 7: OUTWASH

13.1 STOP 8: OUTWASH

13.4 STOP 9: OUTWASH

14.2 STOP 10: PANORAMIC VIEW

14.4 STOP 11: OUTWASH

16.0 Route 1 overpass

17.1 Junction of Highway 1A and Canmore road

19.1 Junction of Highway 1 and Highway 1A, proceed northwest toward Banff on Highway 1

20.1 STOP 12: OUTWASH

Distance (Miles)	
21.7	Eastern gate of Banff National Park
23.1	STOP 13: OUTWASH
25.4	STOP 14: OUTWASH
26.4	STOP 15: OUTWASH-TILL
26.7	STOP 16: TILL
27.6	Junction of Highway 1 and the road to Lake Minnewanka
27.9	STOP 17: BANFF POWER HOUSE
29.2	STOP 18: DEGLACIATION SEQUENCE
29.3	Cascade River bridge
29.7	Banff circle; turn right (north) onto the road to Lake Minnewanka
31.6	STOP 19: LOESS
32.0	As indicated by test pits and steep sides, the road is constructed on an esker.
32.5	End of esker.
33.3	Road junction turn right (southeast)
34.3	STOP 20: PANORAMIC VIEW
34.4	STOP 21: TILL
36.8	STOP 22: PANORAMIC VIEW
37.9	Road cuts through thick deposits of till belonging to the same unit as that described at STOP 16
38.0	End of till section
38.1	Junction of Highway 1 and the road to Lake Minnewanka, turn right (northwest) on Highway 1
40.0	Banff circle, proceed around circle to Highway 1A (Banff townsite road)
40.2	Southeast side of Banff circle, proceed on Highway 1A (Banff townsite road)

Distance (Miles)	
40.4	Junction of Highway 1A and Banff dump road: turn left (east) onto Banff dump road
40.8	STOP 23: LAKE SEDIMENTS AND VOLCANIC ASH (Turn back to Highway 1A)
41.2	Junction of Highway 1A and Banff dump road, turn left (south) on Highway 1A.
42.4	STOP 24: OUTWASH
42.7	Banff townsite limits

End of Road Log A.

Site Descriptions

STOP 1: ESKER

Highway 1x traverses a region of stagnant ice features, including kames and eskers, that is bordered by non-ice-contact outwash gravels. These deposits extend eastward from the mountain front to just beyond the Kananaskis River. At Stop 1, a cross-section of a dissected esker can be seen a few hundred feet from the southwest side of the road. Its poorly sorted gravels consist mostly of limestone, dolomite and quartzitic sandstone derived from mountains to the west. The stagnant ice features were probably deposited during the retreat of the ice of the Canmore Advance, and may represent, in part, an end moraine.

STOP 2: KAME

Northeast of the road, earth removal has exposed steeply dipping, poorly sorted gravel beds, most likely part of a kame of the region of stagnant ice features described above. The upper surface has been truncated by subsequent erosion.

GENERAL DESCRIPTION

After the junction at 2.5 miles, stagnant ice features and non-ice-contact outwash are evident both north and south of Highway 1A for approximately two and one half miles. Up the Bow River valley from Exshaw Creek bridge, are typical postglacial alluvial fan deposits consisting mostly of poorly sorted gravels.

STOP 3: SAND BLUFFS

South of the road, sand bluffs can be seen bordering Lac des Arcs. They are composed of calcareous, well-sorted, laminated to thinly laminated silty sand, with occasional ripple marks, gastropods, wood fragments and clay-sized material. These sediments were originally deposited in Lac des Arcs when drift or ice-block damning, during deglaciation following the Canmore Advance, resulted in water levels higher than the present ones. Since that time, the water level has fallen, wind has reworked much of the material, and the Bow River has eroded most of the lacustrine sediments.

STOP 4: VOLCANIC ASH

Loess overlies bedrock northeast of the road. Within this loess is a bed of volcanic ash about three inches thick. This is Mazama ash, derived from an eruption at Crater Lake, Oregon about 6,600 years ago.

STOP 5: TILL

Northwest of the road, till can be seen on the lee side of a bedrock spur. It should not be confused with the stratified postglacial alluvium bordering the southeast side of the road. The till is unsorted and contains a high percentage of pebbles, mostly of limestone, dolomite and quartzitic sandstone. The high percentage of calcium carbonate in the matrix has resulted in a well-cemented and resistant deposit. It is typical of the tills deposited after the Bow Valley and Canmore Advances in which all constituents were derived from the vicinity of the Continental Divide or the areas to the east of it.

STOP 6: GLACIAL SCOURING

On the south side, just past a bend in the road, glacial scouring can be seen on the carbonate bedrock surface. Glacial striae and grooves are visible, most of them parallel or nearly parallel to the strike of the valley.

STOPS 7, 8, and 9: OUTWASH

Thick beds of glacial non-ice-contact outwash were deposited during the retreat that followed the Bow Valley Advance. The deposits seen at Stops 7, 8 and 9 were probably laid down when the retreating ice front was in the vicinity of Canmore, about four miles to the northwest. Down-valley, the material becomes better sorted and less coarse grained. The attitude and steepness of the beds also become less varied. Deposited as a valley train extending across the Bow Valley, this outwash has subsequently been partly eroded and now forms a terrace. At Stop 7, moderately sorted gravel overlies thick beds of well-sorted sand. The gravel consists mainly of sub-rounded pebbles of limestone, dolomite, quartzitic sandstone and chert. Crossbedding is common. The gross attitude of the beds is to the southeast (down-valley).

At Stop 8 outwash of the same unit as that at Stop 7 lies northwest of the road.

Northeast of the road at Stop 9, gravels, about as well-sorted as those at Stops 7 and 8 but somewhat coarser, occur. This indicates deposition closer to the ice-front. The thin layer of material that truncates the outwash at Stop 9 and forms the slope surface has resulted from postglacial slope washing and mass wasting.

STOP 10: PANORAMIC VIEW

Looking southwest from Stop 10, a ledge or break-in-slope is visible on the far side of the Bow Valley, about one-third of the way up the mountain at an elevation of about 4,800 feet. The break-in-slope is separated into two sections by the northeast-trending valley of Three Sisters Creek. It probably marks the upper limit of the Canmore Advance ice and would have been formed by lateral glacier stream activity above, and by glacier scouring below.

STOP 11: OUTWASH

At this point, about 100 feet of outwash gravel outcrops northeast of the road. It is part of the same unit as that exposed and described at Stops 7, 8 and 9.

STOP 12: OUTWASH

Toward the northeast, on the side of the bluff that rises from recent alluvium, there are steeply dipping, poorly sorted outwash gravels. The bluff, at this point, is a continuation of the outwash terrace observed at several of the earlier stops. The poor sorting and steep dips indicate that these are ice-contact deposits laid down following the Bow Valley Advance, at a time when the ice front was not far up-valley.

STOP 13: OUTWASH

Along the north side of Carrot Creek, non-ice-contact glaciofluvial outwash is exposed above creek level. It is, for the most part, poorly sorted and is interbedded with till. Not far up-valley, a lateral transition into ice-contact outwash and till suggests that deposition probably took place during an equilibrium phase in the retreat following the Bow Valley Advance.

STOP 14: OUTWASH

Above the old road on the northeast side of Route 1, an exposure of poorly sorted and thickly bedded gravels is part of the unit seen at Stop 13.

STOP 15: OUTWASH-TILL

On the northeast side of the road, till can be seen to the north and ice-contact deposits to the south. From this it is inferred that this viewpoint overlooks a transition zone, representing an equilibrium phase during the retreat of the ice of the Bow Valley Advance. Patches of till overlying this outwash unit down-valley, together with subsurface information and the break-in-slope seen at Stop 10, further suggest that this equilibrium phase may have marked the beginning of the Canmore Advance.

STOP 16: TILL

Here, beyond the picnic area on the northeast side of the road, are vertical cliffs of till typical of that found in the Bow Valley. This till contains between 15 and 20 per cent gravel-sized material, mostly subangular pebbles, some of which are striated and oriented in the direction of glacier movement. The gravel consists mostly of limestone, dolomite, quartzitic sandstone, quartzite and chert. The extremely firm matrix is composed of sandy clay loam with a high percentage of calcium carbonate cement.

The greater proportion of this till was probably laid down at the time of the Bow Valley Advance. However, as explained at Stop 15, the Canmore Advance probably originated from this area and the upper part of the till should, therefore, be equated to the Canmore Advance.

STOP 17: BANFF POWER HOUSE

Bluffs are visible south of the road and rising from the Cascade River. Their upper part is composed of Bow Valley till and perhaps, in places, of Canmore till, much like the unit observed at Stop 16. Underlying the till are glacial outwash gravels, composed primarily of subrounded limestone, dolomite, quartzitic sandstone, quartzite and chert pebbles. They are poorly to moderately sorted. Their date of deposition is in question but they are probably associated with a deglaciation that occurred prior to the Bow Valley Advance.

STOP 18: DEGLACIATION SEQUENCE

Above the railroad tracks southwest of the road, Bow Valley till lies in contact with bedrock. Overlying the till are glacial outwash gravels capped with lake sediments. This is a typical deglaciation sequence formed following the Canmore Advance.

STOP 19: LOESS

Off the west side of the road, thin patches of loess can be observed overlying fluvial gravels.

STOP 20: PANORAMIC VIEW

Lake Minnewanka occupies an artificially-dammed, glaciated valley. Before it was dammed the lake was much more restricted and occupied glacially scoured basins. The valley of Lake Minnewanka has had at least one reversal of drainage, for it can be demonstrated that during deglaciation of the area, water escaped through Devil's Gap at the far end of the valley, out of sight from Stop 20.

STOP 21: TILL

Off the northwest side of the road, thin patches of till can be seen "plastered" to the bedrock.

STOP 22: PANORAMIC VIEW

Looking southwest beyond the penstock, bluffs of Bow Valley till overlying outwash gravels are visible. These deposits are similar to those seen at Stop 17. The "smoothness" of the upper surface is noteworthy. Air photographs of the area show broad, glacially scoured swells and depressions striking parallel to the direction of glacier movement.

STOP 23: LAKE SEDIMENTS AND VOLCANIC ASH

Thick deposits of sand are exposed north of the road. The lower part of this unit consists mostly of calcareous, very thinly bedded to thinly laminated, well-sorted, medium-grained, lucastrine sand. Thin cross bedding and cross-laminations are present. These deposits were laid down during the deglaciation that followed the Canmore Advance. Wind-blown sand truncates the lake deposits and contains diffuse multicoloured buried soil horizons and a three-inch bed of white Mazama volcanic ash just above the lake deposits.

STOP 24: OUTWASH

Off the east side of the road is an exposure of glacial outwash underlying till similar to the section seen at Stop 17. This outwash may be associated with deglaciation prior to the Bow Valley Advance.

B) MOUNT NORQUAY DRIVE

Road Log

(see Figure 2)

Distance (miles)	
0. 0	From overpass at Mt. Norquay Drive and Highway 1, proceed up Mt. Norquay Drive.
3. 0	STOP 25: PANORAMIC VIEW
	End of Road Log B

Site Description

STOP 25: PANORAMIC VIEW

Looking southward from this vantage point, the valley of the Spray River provides an outstanding example of a U-shaped, glaciated valley. Till covers much of the valley floor. Flanking the west side is Sulphur Mountain, the northern end of which reaches an elevation of about 7, 600 feet. The mountains in this area have been glaciated and, on the higher ones, the upper limit of glacial erratics is about 8,000 feet. The present course of the Spray

River lies through the gap visible in the background beyond the southern end of Sulphur Mountain. This gap was probably formed originally by a lateral glacial stream that was diverted over the mountain when ice in the next valley lay close to the summit area. Erosion then kept pace with deglaciation.

To the southeast, Tunnel Mountain, once part of Mount Rundle, has also been glaciated. The gap between the two was probably formed originally by side glacial stream activity. The Bow River, which flows through the gap, was probably diverted to its present course by glacial or alluvial damming.

The valley of Sundance Creek, west of Sulphur Mountain, is an example of a hanging valley typical of many of the tributary valleys of the Bow.

Cirques can be seen on the east side of Sundance Mountain, above Sundance Creek.

C) CAVE AVENUE

Road Log

(see Figure 2)

Distance (miles)	
0.0	On the south side of the Bow River Bridge at the south end of Banff Avenue, at the junction with Spray and Cave Avenues; turn right (west) onto Cave Avenue.
1.5	STOP 26: POSTGLACIAL ALLUVIUM
3.1	STOP 27: SUNDANCE CANYON
	End of Road Log C.

Site Descriptions

STOP 26: POSTGLACIAL ALLUVIUM

Gravel pit operations have exposed a cross-section of a post glacial alluvial fan south of the road. The deposit consists mainly of poorly sorted gravel composed of boulders and pebbles of local bedrock.

STOP 27: SUNDANCE CANYON

Sundance Canyon, formed since the deglaciation of the area, extends from the lip of the hanging Sundance Creek valley to about the level of the present Bow River floodplain. Because of the steep slope separating the two levels, the creek has had to cut deeply into the bedrock. This is typical of the origin of many of the canyons in the Banff area.

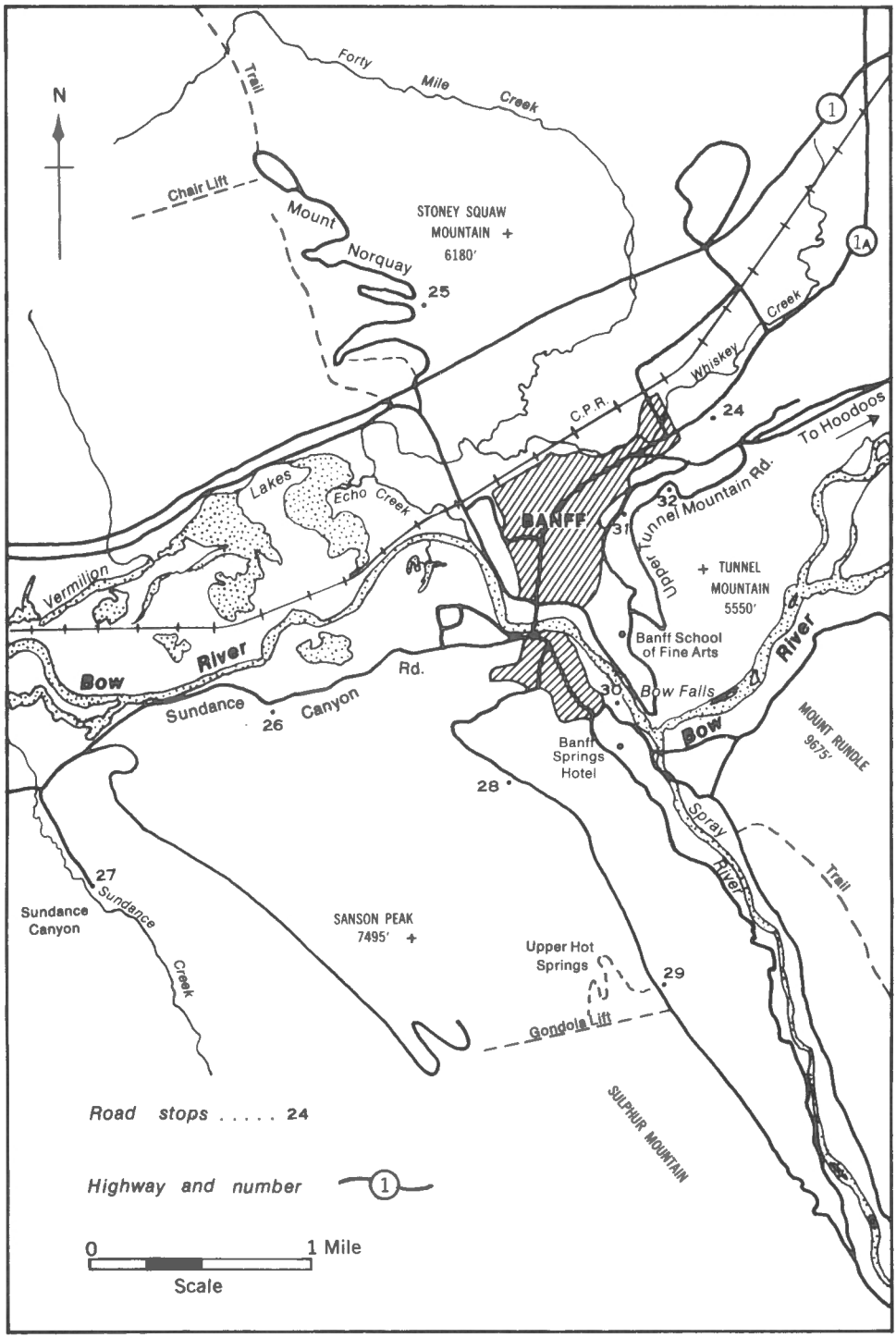

Figure 2. Route of road log itinerary - Banff townsite and vicinity.

D) SULPHUR MOUNTAIN AND BOW FALLS ROADS

Road Log

(see Figure 2)

Distance (miles)	
0.0	On the south side of the Bow River bridge, at the south end of Banff Avenue, at the junction with Spray and Cave Avenues; turn left (east) and follow signs to Upper Hot Springs and Sulphur Mountain (Spray and Mountain Avenues).
1.4	STOP 28: TILL
2.2	STOP 29: PANORAMIC VIEW Turn around.
4.1	Junction of Mountain and Spray Avenues; turn right (southeast) onto Spray Avenue.
4.4	Junction of Spray Avenue and Bow Falls road; turn left (northeast) onto Bow Falls road.
5.0	STOP 30: BOW FALLS End of Road Log D.

Site Descriptions

STOP 28: TILL

Till deposits southwest of the road extend for about one-half mile. Because of the steepness of the slope the material has been modified, mainly through reduction of the fine-grained particles, downslope movement and the incorporation of debris from above. There has also been some masking of the original material by colluvium.

STOP 29: PANORAMIC VIEW

Toward the northeast can be seen the gap between Mount Rundle and Tunnel Mountain. As explained at Stop 25, this gap was probably originally eroded by a side glacier stream. The width and polishing of the gap suggests that readvancing ice may have flowed through it. Later, it was occupied by the present Bow River.

STOP 30: BOW FALLS

The area around Bow Falls is one of the few places in Banff National Park where a stretch of the Bow River channel is cut into bedrock. This resulted from the diversion of the river from its earlier, well-developed

floodplain by glacial or alluvial damming during recession of the ice of the Canmore Advance. As explained at Stops 25 and 29, the gap to the east, between Mount Rundle and Tunnel Mountain, probably existed before the diversion.

E) TUNNEL MOUNTAIN ROADS

Road Log

(see Figures 1 and 2)

Distance (miles)	
0.0	Junction of Banff Avenue and Buffalo Avenue; proceed east on Buffalo Avenue toward the Banff School of Fine Arts.
1.3	Junction of Upper and Lower Tunnel Mountain roads; turn right (east) onto Upper Tunnel Mountain road.
1.8	STOP 31: PANORAMIC VIEW
2.1	STOP 32: TILL
2.7	Junction of Upper Tunnel Mountain road and the road to the Hoodoos; turn right (east) on Hoodoos road.
3.9	Junction of Hoodoos road and Hoodoos Viewpoint road; turn right (southeast) on Hoodoos Viewpoint road.
4.2	STOP 33: HOODOOS
	Turn around.
4.5	Junction of Hoodoos Viewpoint road and Hoodoos road; turn right (east) on Hoodoos road.
5.5	STOP 34: TILL-OUTWASH
5.8	End of till-outwash sequence
	End of Road Log E.

Site Descriptions

STOP 31: PANORAMIC VIEW

Toward the west is an excellent view of the glacial morphology of Bow Valley and its broad floodplain. The prominent notch visible on the southern flank of Sulphur Mountain was most likely formed by erosion of the bedrock by a lateral glacial stream when ice stood at about the same height as the notch. Cirques can be seen below the summits of the mountains in the background.

STOP 32: TILL

Till, typical of Bow Valley, can be seen south of the road. It lies on bedrock and the stratification indicates that it has, in part, been slightly modified.

STOP 33: HOODOOS

On looking down the steep slope toward the Bow River, prominent hoodoos or resistant pillars can be seen. The upper part of these pillars is composed of Bow Valley till whereas the lower part consists of outwash gravels. This is part of the same sequence that was seen at Stop 17 (see Road Log A), about one mile to the north . Differential weathering and erosion, controlled mainly by reprecipitated calcium carbonate cement, account for the pillars.

In the area of Hoodoos Viewpointroad and the traffic circle, post-glacial loess and wind-blown sand are present at the surface. At the edge of the traffic circle, a bed of Mazama ash is exposed in a road cut.

STOP 34: TILL-OUTWASH

The road cuts through till and outwash gravel, revealing the same sequence observed at Stops 17 and 33.

F) MOUNT NORQUAY OVERPASS TO MOUNT EISENHOWER LOOKOUT VIA LAKE LOUISE, MORAINE LAKE AND EISENHOWER JUNCTION

Road Log

(see Figure 1)

Distance (miles)	
0. 0	Mount Norquay Drive overpass and Highway 1; proceed southwest on Highway 1.
3. 4	Junction of Highways 1 and 1A; bear right and proceed northwest on Highway 1A.
5. 5	STOP 35: TILL
11. 3	STOP 36: LANDSLIDE
13. 3	End of landslide deposits
14. 3	STOP 37: JOHNSTON CANYON
14. 6	STOP 38: TILL

Distance (miles)	
16.2	STOP 39: TILL
18.2	Junction of Highway 1A and Eisenhower Junction cut-off road to Highway 1; continue on Highway 1A.
19.2	STOP 40: TILL
19.8	STOP 41: TILL
22.0	STOP 42: TILL
22.8	STOP 43: TILL
23.0	STOP 44: PANORAMIC VIEW
26.9	Baker Creek bridge
31.0	STOP 45: TILL
32.3	Corral Creek bridge
33.1	Junction of Highways 1 and 1A; turn right (northwest) onto Highway 1.
34.4	Junction of Highway 1 and road to Lake Louise; turn left (southwest) onto Lake Louise road.
35.0	Road junction; turn left toward Lake Louise.
35.2	Railroad crossing; follow signs to Lake Louise.
35.5	Bow River bridge on Lake Louise road.
35.7	STOP 46: TILL
36.0	STOP 47: TILL
36.6	Junction of Lake Louise road and Moraine Lake road; proceed toward Lake Louise.
37.3	Junction of road to Field, B.C. and Lake Louise road; proceed toward Lake Louise.
37.8	STOP 48: LAKE LOUISE
	Turn around, and proceed toward Moraine Lake.
38.3	Junction of Lake Louise road and road to Field, B.C.; proceed on Lake Louise road.

Distance (miles)	
39.0	Junction of Moraine Lake and Lake Louise roads; turn right (south) toward Moraine Lake.
39.8	STOP 49: PANORAMIC VIEW
40.8	Paradise Creek bridge
40.8	STOP 50: TILL
41.7	STOP 51: TILL
42.6	STOP 52: TILL
43.7	STOP 53: TILL
44.8	STOP 54: PANORAMIC VIEW
46.7	STOP 55: MORAINE LAKE
	Turn around
54.3	Junction of Moraine Lake and Lake Louise roads; turn right (southeast) onto Lake Louise road.
55.9	Road junction; turn right toward Highway 1.
56.5	Junction of Highway 1 and Lake Louise road; turn right (southeast) onto Highway 1.
71.4	Junction of Highways 1 and 93; turn right (southeast) onto Highway 93.
72.0	STOP 56: END MORAINE
	Turn around
72.6	Junction of Highways 1 and 93; turn right (southeast) onto Highway 1.
77.9	STOP 57: MOUNT EISENHOWER LOOKOUT
	End of Road Log F.

Site Descriptions

STOP 35: TILL

Northeast of the road, good exposures of till can be seen. This till is believed to have been deposited during the Bow Valley Advance and/or the Canmore Advance, and its characteristics are similar to those of the till described at Stop 16 (see Road Log A).

STOP 36: LANDSLIDE

From this stop onward for about two miles, the road passes through postglacial landslide deposits resulting in part from slumping and, possibly, fluvial erosion. Rubble and slump blocks cover an area of about two and one-half square miles, forming irregular mounds and depressions similar to knob-and-kettle topography typical of glaciated regions. The slumped rock consists mostly of Mesozoic sandstone and shale.

STOP 37: JOHNSTON CANYON

Johnston Canyon was eroded by a postglacial stream, Johnston Creek, which has cut deep into bedrock from the lip of the hanging valley to about the present level of the Bow River floodplain.

STOPS 38 and 39: TILL

Till, exposed northeast of the road, was probably laid down at the time of the Bow Valley Advance and/or the Canmore Advance. Its lithology is similar to that described at Stop 16 (see Road Log A).

STOPS 40, 41, 42, and 43: TILL

Till, most likely deposited at the time of the Eisenhower Junction Advance, outcrops just northeast of the road. As evidenced by end and lateral moraines, the last major ice advance in this area reached the vicinity of Eisenhower Junction. The lithology of its till is similar to that of the Bow Valley and Canmore Advances (see site description for Stop 16), but shows a relative increase of quartzitic sandstone indicative of the bedrock of the area over which the ice advanced.

The lack of any complete stratigraphic section and the similarity of all Rocky Mountain tills in the Banff area, make it impossible at this time to state definitely whether or not the till at this site was deposited during the Eisenhower Junction Advance.

STOP 44: PANORAMIC VIEW

Toward the southwest, a prominent ridge indicates the upper limit of the Eisenhower Junction Advance. It strikes parallel to the valley, truncating the spurs just below the treeline. Below the ridge, linear erosional structures in drift lie parallel to the direction of glacier flow.

Well-developed alpine glacial morphology can be clearly seen in the background.

STOP 45: TILL

High bluffs of till rise northeast of the road. All or most of the till was deposited during the Eisenhower Junction Advance. There are indications of some reworked material, with stratification near the upper surface.

STOP 46: TILL

The road runs through thick till outcrops. Some of the till has been modified as evidenced by stratification. Some poorly sorted fluvial gravels are present.

STOP 47: TILL

On the southwest side of the road more till is exposed, some of which has been modified and shows stratification.

STOP 48: LAKE LOUISE

Lake Louise has probably resulted from damming by a terminal moraine that extends from the mountain on the north side of the lake and continues, behind Chateau Lake Louise, to the mountain on the south side. Well-developed scree slopes have formed at the base of the enclosing mountains. Victoria Glacier can be seen to the southwest beyond the lake. The vegetation-free, fresh-looking material is, in part, an ice-cored moraine deposited during a late Neoglacial advance. Suspended clay and silt-size particles, derived from glacial meltwater, are responsible for the milky appearance of the lake.

STOP 49: PANORAMIC VIEW

To the northeast are linear structures parallel to the strike of the valley. These "drumlinoid" features result from scouring and moulding of glacial drift. Across the Bow River, on the southeast side of the prominent tributary valley occupied by Corral Creek, breaks-in-slope, caused by glacial erosion below and lateral glacial stream activity above, can be seen below the treeline.

STOPS 50, 51, 52 and 53: TILL

Till is seen on the west side of the road. Stratification indicates some reworking and modification of the material.

STOP 54: PANORAMIC VIEW

To the southwest, above the road, a prominent lateral moraine rises to about the upper limit of thick forest vegetation. This moraine was formed during the Eisenhower Junction Advance, at which time the ice reached a maximum elevation of approximately 7,500 feet. Although the upper limit of this moraine is obscured, the corresponding moraine on the southeast side of the valley extends for about two-thirds the distance up the mountain side. To the south, the remnant of a medial moraine extends from the flat-topped, bedrock pillar known as the Tower of Babel. During the Eisenhower Junction Advance, this medial moraine separated the ice streams that flowed from the valley of Babel Creek, east of the Tower of Babel, from the main ice streams that flowed from the Valley of the Ten Peaks.

STOP 55: MORAINE LAKE

Moraine Lake is dammed by landslide deposits derived from the mountain to the southeast. However, because the composite conical shapes are not typical of landslide deposits, there is the possibility that the material was deposited on a glacier and, with the melting of the ice, developed the present morphology. If such were the case, the deposits would technically be moraines.

Good examples of scree slopes and alpine glacial morphology can be seen from this stop. The Wenkchemna Glacier, bordered by ice-cored moraines formed during a late Neoglacial advance, lies only a short walk beyond the south end of Moraine Lake.

STOP 56: END MORAINE

In the gravel pit located south of the road there are good exposures of the Eisenhower Junction end moraine. The deposit consists of interbedded sand and poorly sorted gravel, dipping in various amounts and various directions but generally steeply to the southeast. The till, which overlies the moraine deposit in places, may indicate a minor re-advance.

STOP 57: MOUNT EISENHOWER LOOKOUT

To the northeast are the postglacial landslide deposits seen at Stop 36.

To the northwest, Mount Eisenhower rises to an elevation of over 9,000 feet. Cirques are well developed on its northeast side. Although not clearly indicated, it is believed that the maximum thickness of ice extended up the mountain no higher than about 8,000 feet.

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GLOSSARY*

advance (ice adv.): The forward movement of a glacier front.

alluvium: Stream deposits of comparatively recent time.

altithermal: Period of high temperature, particularly the postglacial thermal optimum.

attitude (gross att.): A general term to describe the relation of some directional feature in a rock to a horizontal plane.

break-in-slope: Any more or less sudden change in a slope, as in a hillside or valley.

calcium carbonate: A solid, $CaCO_3$, occurring in nature as calcite, etc. Reprecipitated calcium cement is dissolved $CaCO_3$ reverting to a solid form.

chert: An impure form of silica (silicon dioxide).

chronology: The arrangement of events, dates, etc. in the order of occurrence.

cirque: A deep, steep-walled recess or hollow in the side of a mountain, caused by glacial erosion.

colluvium: A general term applied to loose material of varied origin, usually found at the foot of a slope or cliff, brought there chiefly by gravity.

crossbedding A system of minor stratification or bedding oblique to the attitude of stratification that predominated locally.

damming: Alluvial - ... formed by the deposition of alluvium.
Glacial - ... formed by the obstruction of ice.

deglaciation: The withdrawal of an ice sheet from an area.

dolomite: A mineral [$Ca\,Mg\,(CO_3)_2$] but the term is frequently applied to those rocks that approximate dolomite in composition.

drift: Any detrital material deposited by a glacier.

drumlin: A streamlined hill or ridge of glacial drift whose long axis parallels the direction of flow of the former glacier.

drumlinoid: Rock structure superficially modified by ice movement and having the form of a drumlin.

equilibrium: In this case, where reference is to the phase of a glacier, equilibrium indicates that the front of the glacier is neither advancing nor retreating.

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* Certain definitions are restricted to the meaning appropriate for the paper.

erosion: Disintegration of land and rock by natural means (such as water, ice, wind, etc.) and its transportation.

erratic: A stone or boulder transported from a distance and therefore foreign to the local bedrock. The transporting agent may be glacier ice.

esker: Long ridge of gravel and/or sand laid down by a subglacial stream.

fan (alluvial): The alluvial or stony deposit of a stream where it issues from a gorge into a plain and spreads out in the shape of a fan or cone.

floodplain: An alluvial plain bordering a river and resulting from alluvium being deposited in times of flood.

fluvial: Pertaining to or produced by a channel of water, i.e.: a stream, creek, river, etc.

gastropoda: Snail

geomorphology: Earth science concerned with forms on the earth's surface and changes taking place as landforms develop.

glacial: Pertaining to, characteristic of, produced or deposited by, or derived from a glacier.
postglacial - after the retreat of the major Wisconsin glaciers.
preglacial - before the advance of the glaciers in the Pleistocene epoch.

glaciation: Alteration of the earth's surface through erosion and deposition by glacier ice.

glacier: A moving field or stream of ice formed by the compaction of snow under pressure. It moves slowly (as opposed to an avalanche) either down a slope, under the force of gravity, or spreading under its own weight. There are different kinds of glaciers such as continental, valley, island, etc.

glacier equilibrium: see: equilibrium

glaciofluvial: Pertaining to streams flowing from glaciers or to the deposits made by such streams.

gravel: An accumulation of rounded rock or mineral pieces larger than two mm in diameter.

outwash gravel: Gravel which has been washed out of and beyond the glacier.

horizon: A recognizable layer.

ice block damming: Damming created by a part of a glacier lying across a water channel.

ice contact fluvial deposits: see: deposits

ice front: The terminus of a glacier. The seaward-facing cliff of an ice-shelf.

interstadial: Ice free interval between glacial advances.

kame: A low, steep sided hill or stratified drift, formed in contact with glacier ice.

kettle (kettle hole): A hollow in a stretch of glacial material, apparently due to the former presence of great blocks of ice which melted.

knob-and-kettle topography: An irregular surface of glacial drift interrupted by many kettles or kettle holes.
see: kettle.

lacustrine: Of, by or pertaining to a lake.

lamina: Thin layer, usually considered less than one cm thick.

lateral glacial stream: Glacial stream flowing at the side of a glacier.

lithology: The description, study or composition of rocks.

loam: A soil composed of a mixture of clay, silt and sand, usually with some organic matter.

loess: Fine-grained, non-stratified, wind sorted and wind deposited material

mass wasting: A general term for a variety of processes by which masses of earth material are moved by gravity, either slowly or quickly, from one place to another.

matrix: In a rock in which certain grains are much larger than others, the grains of smaller size comprise the matrix.

Mesozoic: One of the divisions of geologic time, following the Paleozoic and preceding the Cenozoic. The term is also employed to define rock strata formed during that era.

moraine: Any accumulation of material deposited by a glacier. Moraines are a characteristic feature of a glacier. The term is applied both to the material and the feature produced.

end moraine - ... is deposited at the foot of a glacier.

ice-cored moraine - ... is one, the central part of which is formed of remnant glacier ice.

lateral moraine - ... is formed at the side of the glacier and is usually ridge-like in shape.

medial moraine - ... is formed down the centre of a glacier.

morphology: The study of the form and structure of landforms.

Neoglacial: That period of glacial expansion subsequent to maximum altithermal shrinkage.

outwash: Stratified glacial debris deposited by meltwater.

quartzite: A granular metamorphic rock consisting essentially of quartz.

Quaternary: Latest division of geologic time, divided into Pleistocene and Recent.

radiocarbon date: A date of age established by the radiocarbon method.

r. dating - ... is the determination of the age of prehistoric organic remains such as wood, bone, etc. by measuring the proportion of radioactive carbon (C^{14}) that it contains.

reduction: The process of removing oxygen from a chemical compound.

reworked (material): To rework is to remove sediment after preliminary deposition, commonly resulting in transportation and sorting.

ripple marks: A series of more or less parallel ridges, produced by wind or water on unconsolidated material.

rubble: Rough, irregular pieces of broken rock.

sand: Very small rock particles, usually considered between 1/16 and 2 mm in diameter.

calcareous sand - ... containing a certain amount of calcium carbonate.
laminated sand - ... sand lying in thin layers.
silty sand - ... sand containing a certain percentage of silt.
well-sorted sand - ... sand where all the particles are approximately the same size.

sandstone: A rock composed predominantly of sand-sized particles.

quartzitic sandstone - ... sandstone in which the particles are predominantly quartz.

scarp: An abrupt rise in surface elevation. A sharp boundary of a comparatively flat area such as plateau, terrace, mesa, etc.

scouring: Erosion, especially by moving water.

glacial scouring - erosion by ice.

scree (slope): A heap of coarse rock waste at the foot of a cliff or a sheet of waste covering a slope.

section: Either an artificial or a natural vertical rock cut or a diagram thereof.

silt-size: Small particles usually considered between 1/256 and 1/16 mm in diameter.

slope washing: The movement of soil and rock materials down a slope under the force of gravity and with the help of water, not concentrated in channels.

slump blocks: Blocks of material which have slumped. see: slumping

slumping: When the soil and earth material on a steep slope become charged with water, it is both heavier and more mobile and sometimes slides down a slope. On a small scale this is called slumping, on a larger one it becomes a landslide.

sorting: Process of differentiating sediments according to properties such as size, shape and weight of individual particles. A sample of sediment in which all grains are about the same size is well sorted. If various sizes or weights are mixed together, the sample is poorly sorted.

spur: A sharp projection from the side of a hill or mountain. A lateral branch of a larger landform.

stratigraphy: Branch of geology dealing with origin, composition, arrangement and sequence of stratified or layered rocks.

stratigraphic section - a section of layered rocks see: section

stratigraphic succession - The order in which sedimentary rocks have been deposited in any given area.

stratum: A layer, specifically of sedimentary rock. Pl. strata.

stria: Minute groove or channel formed by ice scraping over a stone surface. Pl. striae.

strike: The direction of a horizontal line on a plane.

subangular: A grade of roundness in which there are definite effects of wear but the fragments still bear their original form. This is less rounded (or more angular) than subrounded.

subrounded: A grade of roundness in which considerable wear is shown but where the original shape of the grain is still distinct.

suspended: Suspension is a state in which particles are sustained, e.g.: in water, for long periods of time. Muddy water is material in suspension.

till: Unsorted glacially deposited sediment.

truncate: To cut the end or top off.

valley:

hanging - a tributary valley the lower end of which is well above the bed of the main valley, commonly found where the main valley has been deepened by a glacier, which has since disappeared.

U-shaped - as implied, this is a valley which is U- rather than V-shaped, as a result of ice smoothing out the sides.

valley train: Material distributed by the meltwater from a glacier, usually extending across an entire valley.

watershed: Catchment area or river basin.

weathering: The process by which rocks are decomposed (chemical change) or disintegrated (mechanical fragmentation) because of exposure at or near the earth's surface.

Wisconsin: The last Pleistocene glaciation.