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Late Cenozoic geomorphic history of Lee Canyon, Spring Mountains, Nevada

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Late Cenozoic Geomorphic History of Lee Canyon, Spring Mountains, Nevada

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by

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TABLE OF CONTENTS

	Page
Acknowledgments	ii
List of Tables	v
List of Figures	vi
List of Plates	viii
FRONTISPIECE	1
Stereoscopic View of the Lee Canyon Area	1
INTRODUCTION	2
General Statement of Problem	2
Origin of Study	2
Purpose and Scope of Study	5
Description of the Study Area	5
Physiography	5
Climate	6
Previous Related Studies	9
SUMMARY OF REGIONAL GEOLOGY	10
Stratigraphy	10
Precambrian Era	10
Paleozoic Era	10
Mesozoic Era	10
Cenozoic Era	12
Cemented Gravels of Local Origin	12
Las Vegas Formation	12
Structure	12
Structural History of Southern Nevada	13
Structure of the Study Area	14
UNCONSOLIDATED DEPOSITS OF THE LEE CANYON AREA	15
Lee Canyon Primary Fill	15
Alluvial Facies	16
Colluvial Facies	19
Thickness of Fill	19
Modern Alluvium	25
Modern Colluvium	25
Alluvium and Bedrock Undifferentiated	28
Colluvium and Bedrock Undifferentiated	28
DESCRIPTION OF SURFACES	30
Level I	30
Level II	34
Level III (Present Valley Floor)	39

TABLE OF CONTENTS CONT'D

	Page
GEOMORPHOLOGY OF LEE CANYON	41
Bedrock Barrier	41
Geomorphic History	48
SUMMARY AND CONCLUSIONS	55
BIBLIOGRAPHY	58

LIST OF TABLES

Table		Page
1	Stream Gauge and Precipitation Data for the Lee Canyon Drainage Basin	8
2	Joint Data from the Bedrock Barrier	46

LIST OF FIGURES

Figure		Page
1	Westward View Toward the Spring Mountain Range	3
2	Index Map of the Study Area	4
3	Topography of Lee Canyon and Its Environs	7
4	Diagrammatic Representation of the Paleozoic and Mesozoic Stratigraphy of the Spring Mountain Area (modified from Longwell, et al., 1965)	11
5	Composite Photograph of a Measured Section of the Alluvial Facies of the Lee Canyon Primary Fill	17
6	Schematic Representation of a Measured Section of the Alluvial Facies of the Lee Canyon Primary Fill (Plate 1)	18
7	Erosional Remnant of the Colluvial Facies of the Lee Canyon Primary Fill	20
8	Colluvial Facies of the Lee Canyon Primary Fill . . .	21
9	Estimation of the Thickness of the Lee Canyon Primary Fill	23
10	Late-Stage Case-Hardening Developed on a Colluvial Remnant	24
11	Measured Section of Modern Alluvium	26
12	Schematic Representation of Measured Section of Modern Alluvium	27
13	Fan-Shaped Deposit of Modern Colluvium	29
14	Bedrock Barrier	31
15	Surfaces of Lee Canyon	32
16	Vertical Cliff of the Level I Riser	35
17	Ledgy Cementation of the Level II Riser	38

LIST OF FIGURES CONT'D

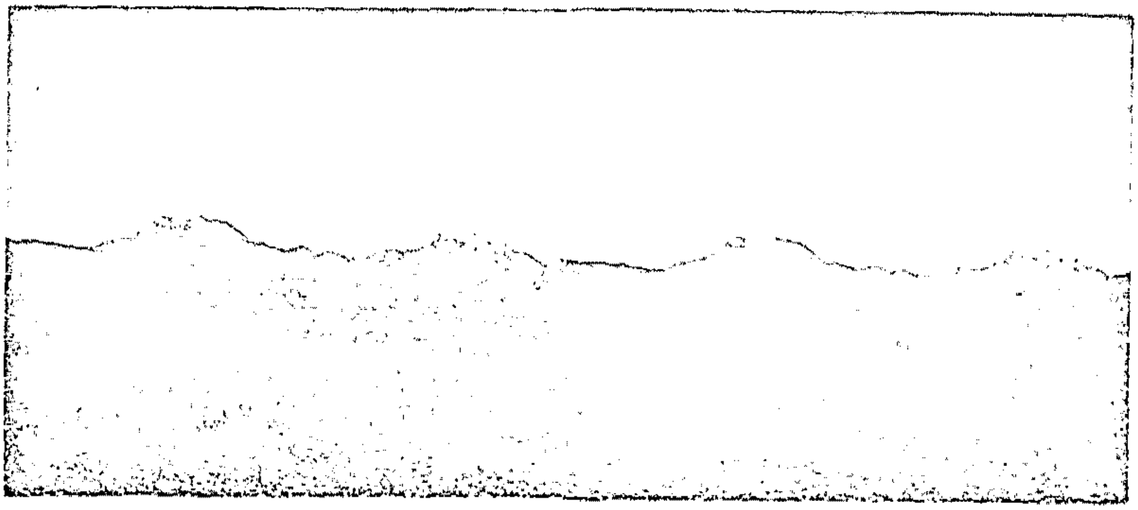
Figure		Page
18	Topographic Profile of the Bedrock Barrier Showing the Location of Stream Channels	42
19	Lesser Jointed Area of the Bedrock Barrier	43
20	Highly Jointed Area of the Bedrock Barrier	45
21	Soil Profile Developed on Level II	52

LIST OF PLATES

Plate

1 Geomorphic Map of the Lee Canyon Area, Spring Mountains, Nevada

2 Cross Sections and Longitudinal Profile of Lee Canyon, Spring Mountains, Nevada



Frontispiece. Stereoscopic View of the Lee Canyon Area

INTRODUCTION

General Statement of the Problem

Located in the west central portion of Clark County, Nevada, the Spring Mountain Range (Figure 1) borders the western edge of the Las Vegas Valley (Figure 2). Within the mountain range, a fault block, there are several canyons whose geomorphic history is closely related to the geomorphic history of the major alluvial fans which flank the mountains. Lee Canyon, which is the study area (Figure 2), is one of these canyons. In Lee Canyon is preserved a complex canyon fill which has been subjected to several periods of down-cutting and valley-widening. The details of the canyon's geomorphic history recorded by filling and fill removal have not previously been studied.

Origin of Study

This study was originated by Dr. Laurence H. Lattman who is presently interested, in part, in the depositional history of the alluvial fans or bahadas which flank the Spring Mountain Range. It was felt that the depositional history of the fans would be recorded in more erosional and depositional detail in the canyons because the canyons are closer to the source areas of the sediments which compose the fans. Whereas the fans might receive almost continuous deposition, changes resulting in deposition or erosion would be recorded in the canyon filling and cutting. This study was begun in the spring of 1968 and the field work was done during the summer of 1968.

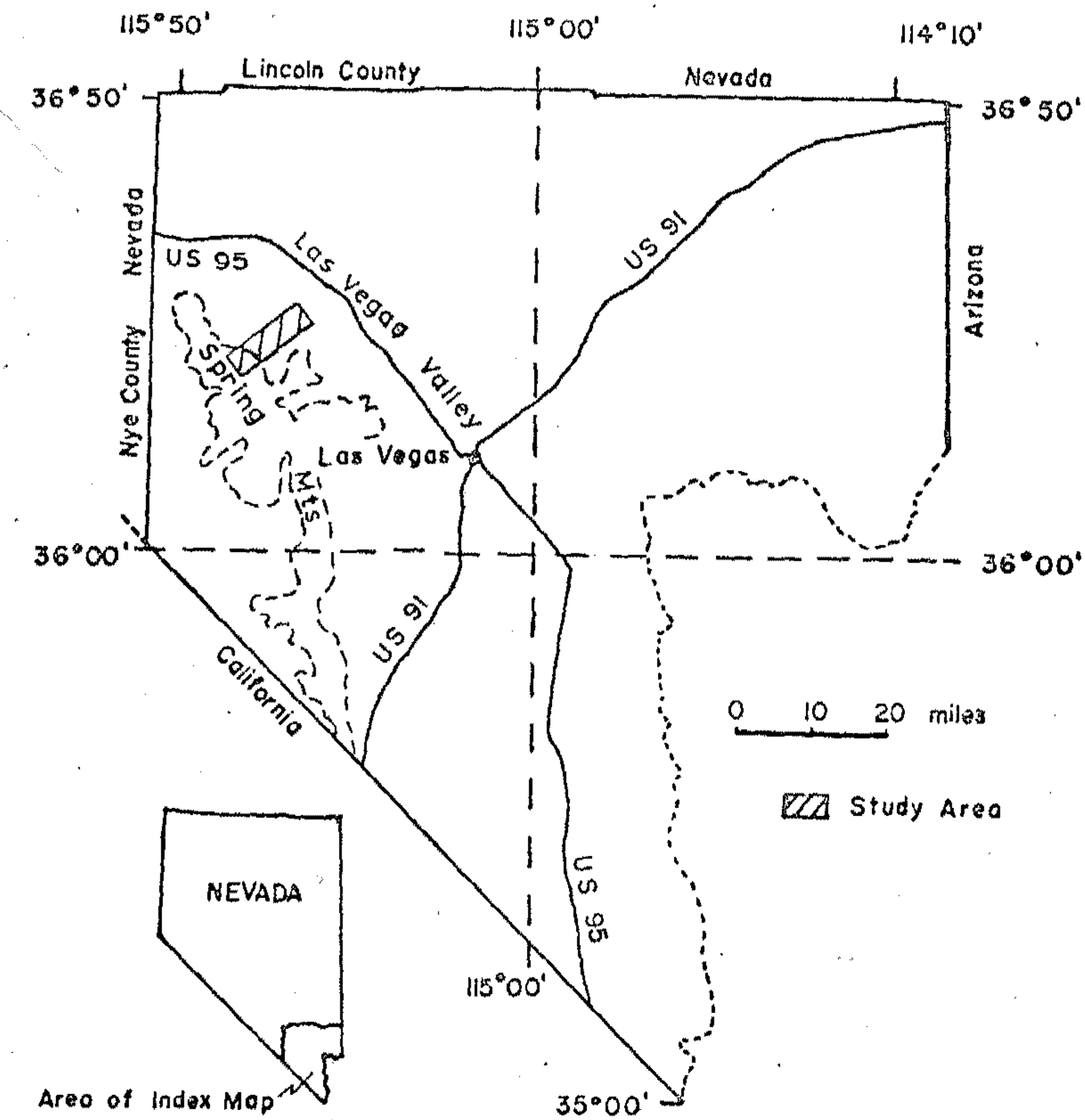


Figure 2. Index Map of the Study Area.

Purpose and Scope of Study

The purpose of the study was to determine the erosional and depositional history of the Lee Canyon primary fill (see later section). This study is one of several which are ultimately directed toward a better understanding of the evolution of the alluvial fans which flank the Spring Mountain Range. By recognizing and identifying the various stages of the erosional and depositional history of Lee Canyon, a generalized model of the depositional history of the alluvial fans may be constructed.

This study involved identifying and mapping the different lithologic units which comprise the Lee Canyon primary fill, identifying and describing the various terrace levels which are indicators of the erosional history of this fill, and determining the evolution of the main Lee Canyon drainage.

The study area extends from near McWilliams Campground (Plate 1) located in the headward regions of Lee Canyon to a group of bedrock foothills approximately 14 miles downstream and northeast of the campground. The study area does not extend into the present-day bahada.

Description of the Study Area

Physiography

The north to northwest trending Spring Mountain Range is located in the west central portion of Clark County, Nevada (Figure 2). It is the highest mountain range in the county and is one of many which make up the Basin and Range physiographic province. As is true of all mountain ranges in arid southern Nevada, the Spring Mountain Range is flanked by coarse alluvial sediments which form a bahada.

Lee Canyon drains the eastern flank of the Spring Mountains and trends northeastward toward the Las Vegas Valley. Figure 3 displays the topography of Lee Canyon and its environs. The present Lee Canyon drainage is one of anastomosing intermittent stream channels which are joined by several large intermittent tributaries. Table 1 presents the only stream gauge and precipitation data which are available for the Lee Canyon drainage basin. The main Lee Canyon drainage has a downstream gradient of 375 feet per mile. The Lee Canyon drainage basin, with respect to the Bedrock Barrier (see later section) located on Plate 1, is 16 square miles in area.

Climate

Clark County has been classified as arid to semiarid (Maxey and Johnson, 1948) with an average annual precipitation of less than ten inches. Generally, at elevations below 2000 feet above sea level, the rainfall is less than five inches per year and at higher elevations it may be as much as twenty inches per year. Most precipitation occurs during the months from December to March. Summer months are characterized by intense, short-lived, local thunderstorms. In any particular area the precipitation rates may vary considerably from year to year because local storms are responsible for most of the rainfall or snow. The only precipitation records which exist for the

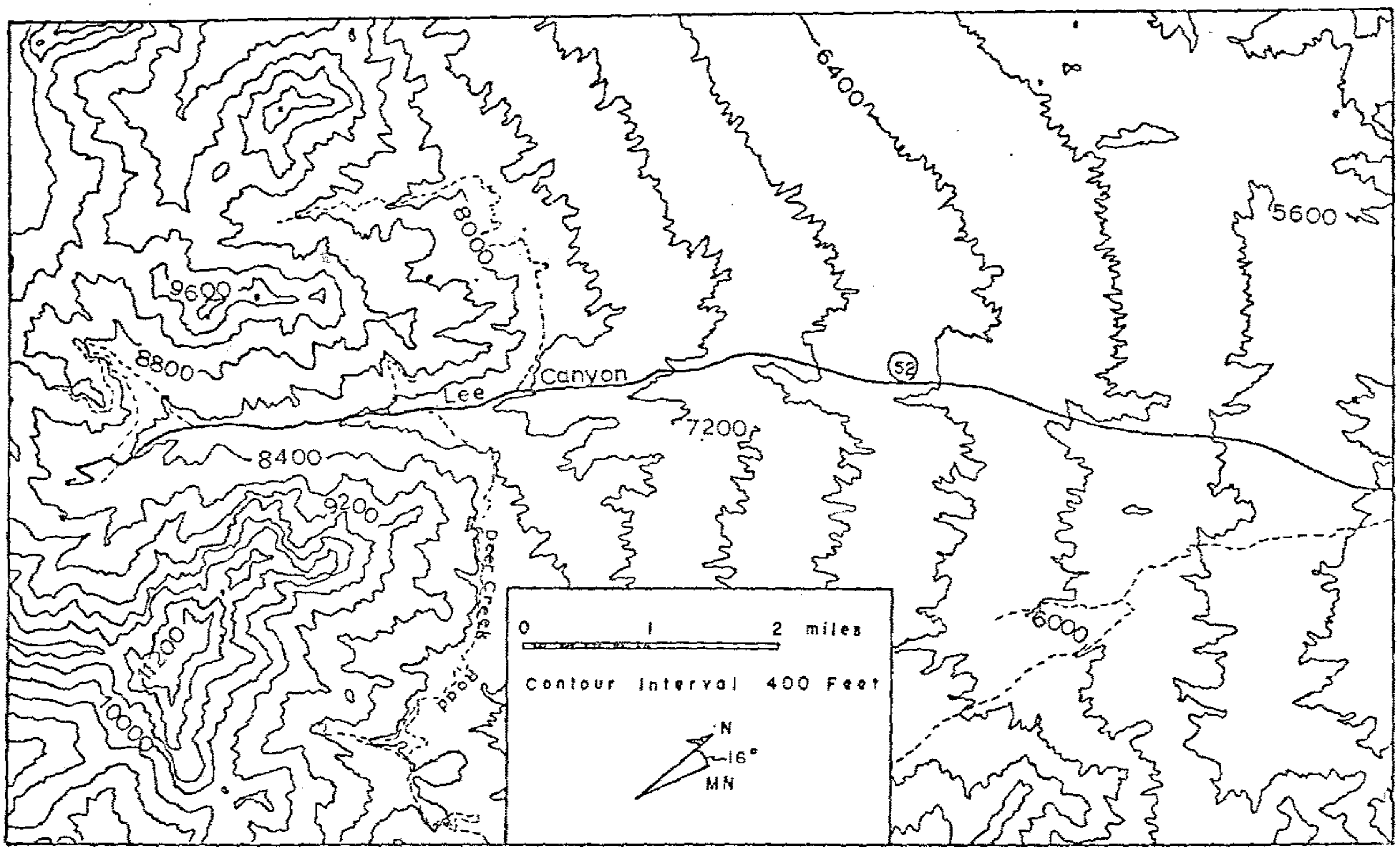


Figure 3. Topography of Lee Canyon and Its Environs.

Table 1

Stream Gauge and Precipitation Data for the Lee Canyon Drainage Basin

Stream Gauge Data

Year	Maximum Discharge		Observed Flow
1961	119 cfs	Aug.	No
1964	29 cfs	Aug. 5	No
1965	602 cfs	Aug. 17	?
1966	200 cfs	Aug. 19	?
1967	1170 cfs	Sept. 25	No

Precipitation Data

1967 13 inches of rain (11 inches between July 1 and Sept. 30). Failure to record snowfall.

Lee Canyon Gauging Station Located: Lat. 36°20'25"N, Long. 115°39'00"W, NE1/4 Sec. 35, T.18 S, R.56 E, on the right bank 50 feet above bridge on Deer Creek Road, south of junction with State Highway 52 and 5 1/2 miles north of Charleston Peak.

Drainage Area: 9.20 square miles

Lee Canyon drainage basin (Table 1) were made available by the Water Resources Division of the United States Geological Survey. These records indicate 13 inches of rain for the year 1967 with 11 inches falling between the months of July and September. The precipitation record is incomplete, however, as the gauge was faulty and failed to record any snowfall.

Temperatures range from 120°F. in the lower valleys during the summer months to below 20°F. in the higher mountains in the winter. Strong winds are common, but some days have no breeze.

Previous Related Studies

Dolliver (1968) studied the late Tertiary and Quaternary geomorphic history of Kyle Canyon, which is located approximately 10 miles south of Lee Canyon. Simonberg (1969) has studied the origin and development of case-hardening in the northeastern portion of the Spring Mountains.

SUMMARY OF REGIONAL GEOLOGY

Stratigraphy

Precambrian Era

In Clark County the Precambrian Era is represented by scattered outcrops of a complex of schists, gneisses and coarse-grained igneous rocks. No Precambrian rocks crop out in the immediate vicinity of the study area.

Paleozoic Era

The Paleozoic Era is represented by a thick sequence of marine sedimentary rocks. They have a maximum thickness of 26,000 feet in the ranges north of the Las Vegas Valley and in the northern portion of the Spring Mountains. They thin to about 7000 or 8000 feet eastward and southward.

Mesozoic Era

The Mesozoic Era is represented by basal marine sediments which appear "to represent the last invasion of the sea over any part of southern Nevada" (Longwell, 1965, p. 39) and which are overlain by a thick sequence of continental clastic sediments. No rocks of Mesozoic age crop out in the study area. Figure 4 is a schematic representation of the Paleozoic and Mesozoic stratigraphy of the Spring Mountains as modified from Longwell, *et al.*, (1965).

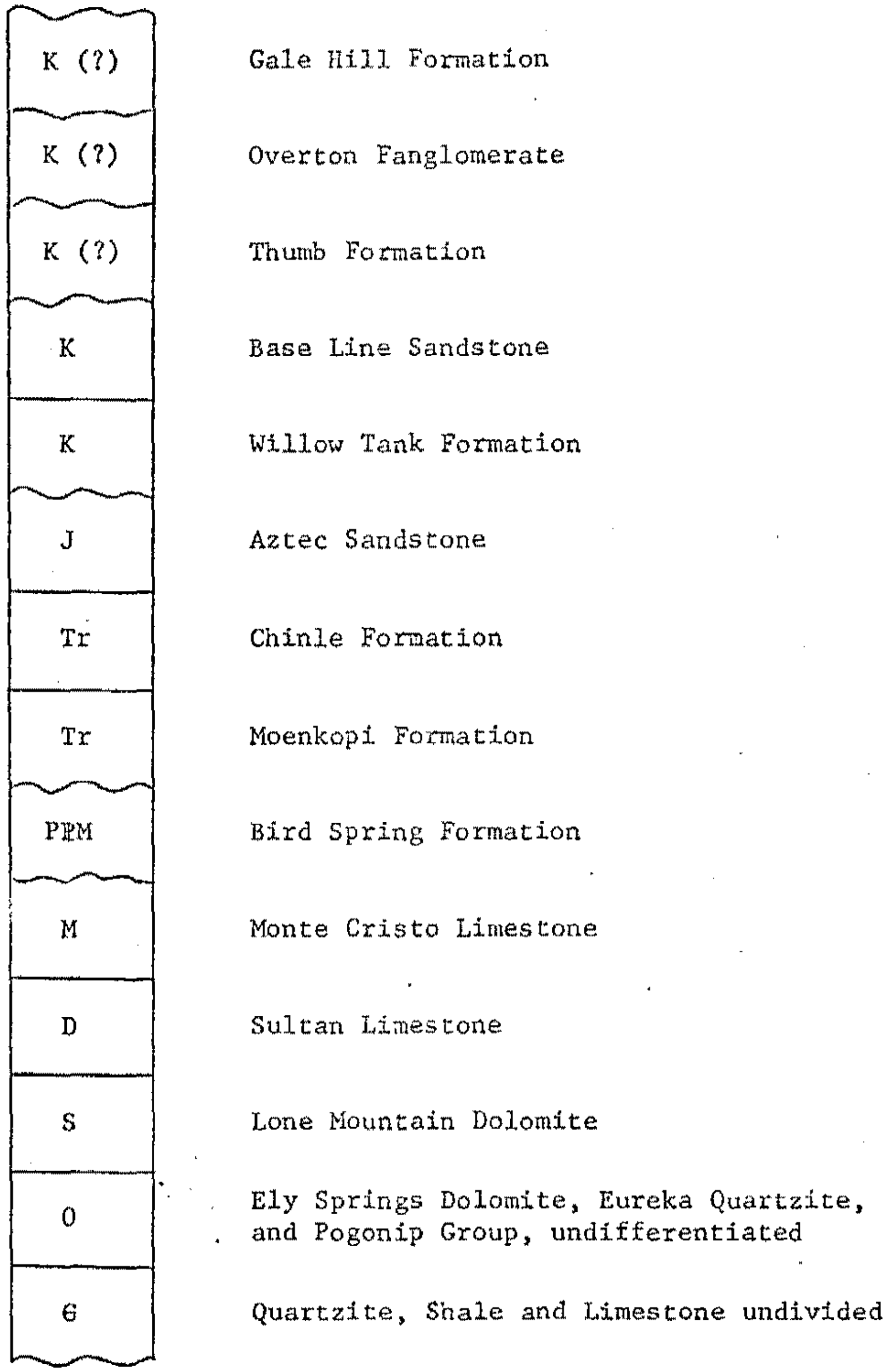


Figure 4. Diagrammatic Representation of the Paleozoic and Mesozoic Stratigraphy of the Spring Mountain Area (modified from Longwell, et al., 1965).

Cenozoic Era

The only rocks of Cenozoic age which are found in the study area have been tentatively assigned to the Quaternary system (Longwell, et al., 1965).

Cemented Gravels of Local Origin: The gravels consist primarily of limestone and dolomite fragments which have been derived from the Paleozoic bedrock. They have been firmly cemented with calcium carbonate. These gravels are part of a large sedimentary apron which mantles the lower portions of the Spring Mountains. The thickness of this gravel varies as it was deposited over a highly irregular topography. In Lee Canyon there is evidence that, in places, this gravel was at least 800 feet thick (see later section).

Las Vegas Formation: These deposits are found in portions of the Las Vegas Valley and consist of light-colored silts and clays which are believed to have been deposited in a series of shallow lakes. Fossil evidence indicates a Pleistocene age for the Las Vegas Formation (Longwell, 1946, p. 828).

Structure

The following descriptions of the structural history of southern Nevada and of the structure of the study area are modified from Longwell, et al., (1965).

Structural History of Southern Nevada

The structural history of the Precambrian rocks is believed to have been extremely complex and involved at least one major period of deformation, metamorphism, and intrusion followed by a period of extensive erosion. Because little time has been spent in the study of the Precambrian rocks, little is known of their history.

The sedimentary record of the Paleozoic suggests a long time interval of carbonate sediment accumulation in a north trending trough (Cordilleran geosyncline). Westward migrating depositional environments are recorded in the stratigraphic record. One minor period of uplift during late Mississippian time is recorded by the slight unconformity at the base of the Bird Spring Formation, and the close of the Paleozoic is marked by widespread unconformity.

Major orogenic activity in southern Nevada began in the Cretaceous Period and continued into the Tertiary Period. The orogenic activity consisted of intense folding with large scale thrust faults accompanied by some normal, high angle reverse, and strike slip faults. There was also some intrusion of plutonic rocks and initiation of volcanic activity. This period was also marked by alteration of limestone and repeated sedimentation within structural basins.

The existence of relatively undeformed Pliocene sediments in wide areas indicates that there was no major regional deformation in southern Nevada since the Pliocene Epoch.

Structure of the Study Area

The northern portion of the Spring Mountains trends in a northwesterly direction, but near latitude 36°10'N the crestline trends north-south, and this trend continues southward to the state line (Figure 2). Some secondary ridges trend at right angles to the main axis of the range and extend eastward toward the Las Vegas Valley.

The geologic structure of the Lee Canyon area is complex, consisting of large thrust faults, large folds associated with the thrusts, and several normal faults which generally strike northwest. The Lee Canyon thrust (Longwell, 1965) has a northeasterly strike and is evidenced in the head of Lee Canyon by Cambrian beds overlying Ordovician through Permian beds. In the eastern foothills of the Spring Mountains, in the lower reaches of Lee Canyon, close folds and a thrust fault with a northeasterly strike probably represent a continuation of the Lee Canyon thrust (Longwell, et al., 1965), but a thick cover of cemented gravel prevents a definite projection of this thrust. This cemented gravel, which forms high scarps along present washes, does not give any evidence of local deformation since its deposition.

UNCONSOLIDATED DEPOSITS OF THE LEE CANYON AREA

The unconsolidated deposits of the Lee Canyon area are here differentiated into several units. These units are: 1) the Lee Canyon primary fill, 2) modern alluvium, 3) modern colluvium, 4) alluvium and bedrock undifferentiated, and 5) colluvium and bedrock undifferentiated. The Lee Canyon primary fill is further subdivided into alluvial and colluvial facies.

Lee Canyon Primary Fill

Longwell, et al., (1965) state that the cemented gravel in Lee Canyon and other deep valleys suggests that after the valleys were cut into bedrock they were filled with coarse debris which was later partly removed by erosion. The term Lee Canyon primary fill is here adopted to apply to the coarse debris which was deposited essentially continuously in Lee Canyon before the terrace cutting stages began. This term is not intended as a formational name which meets the requirements of the Code of Stratigraphic Nomenclature as established by the American Commission on Stratigraphic Nomenclature, but rather as an aid in this discussion. As defined for field use, the Lee Canyon primary fill consists of those sediments which comprise a large fan-shaped deposit whose head is in the upper reaches of Lee Canyon and whose distal end is several miles beyond the mountain. No major unconformity or disconformity is to be seen in this fill and

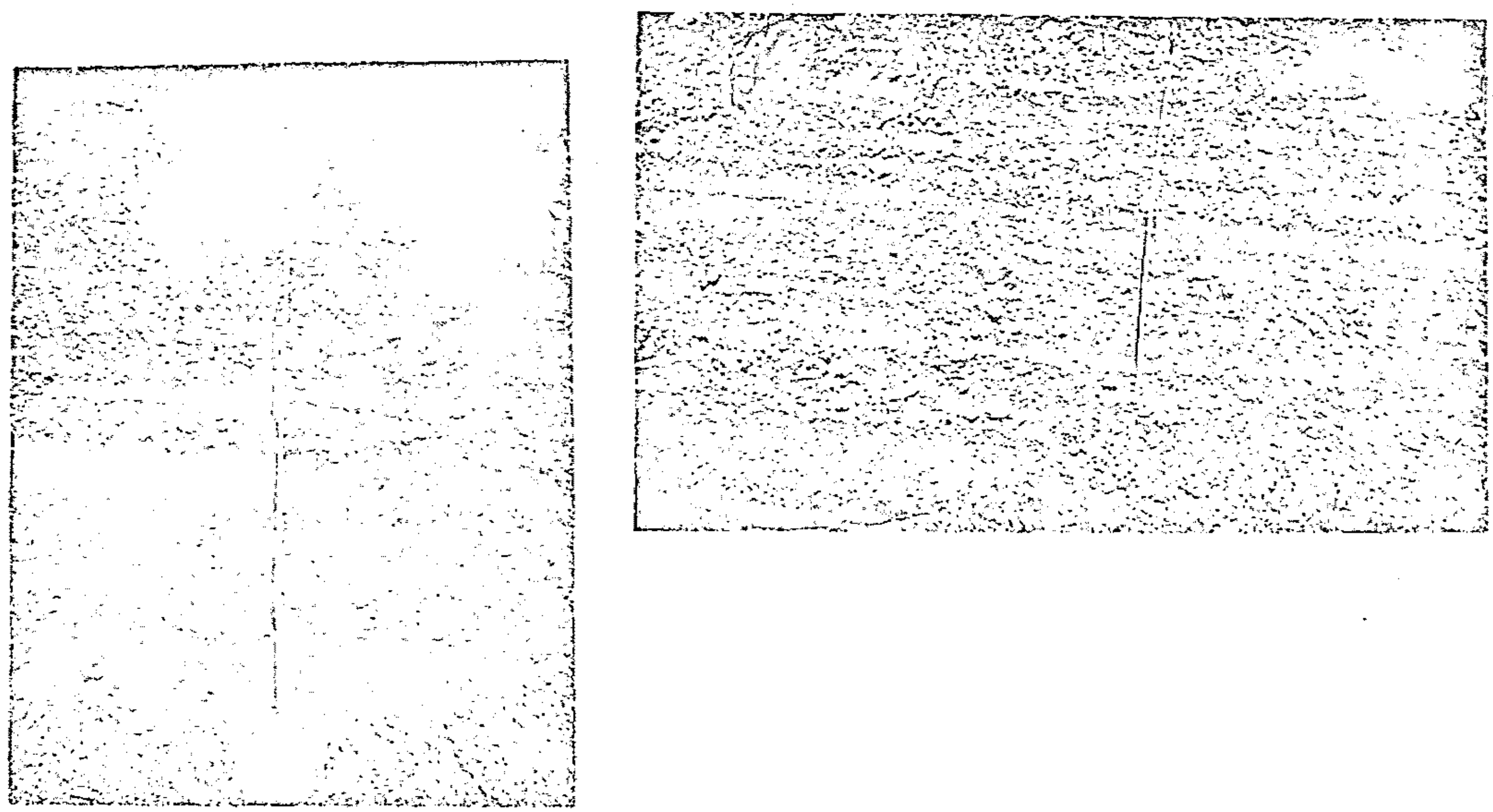


Figure 5. Composite Photograph of a Measured Section of the Alluvial Facies of the Lee Canyon Primary Fill. Folding six-foot rule for scale (Plate 1).

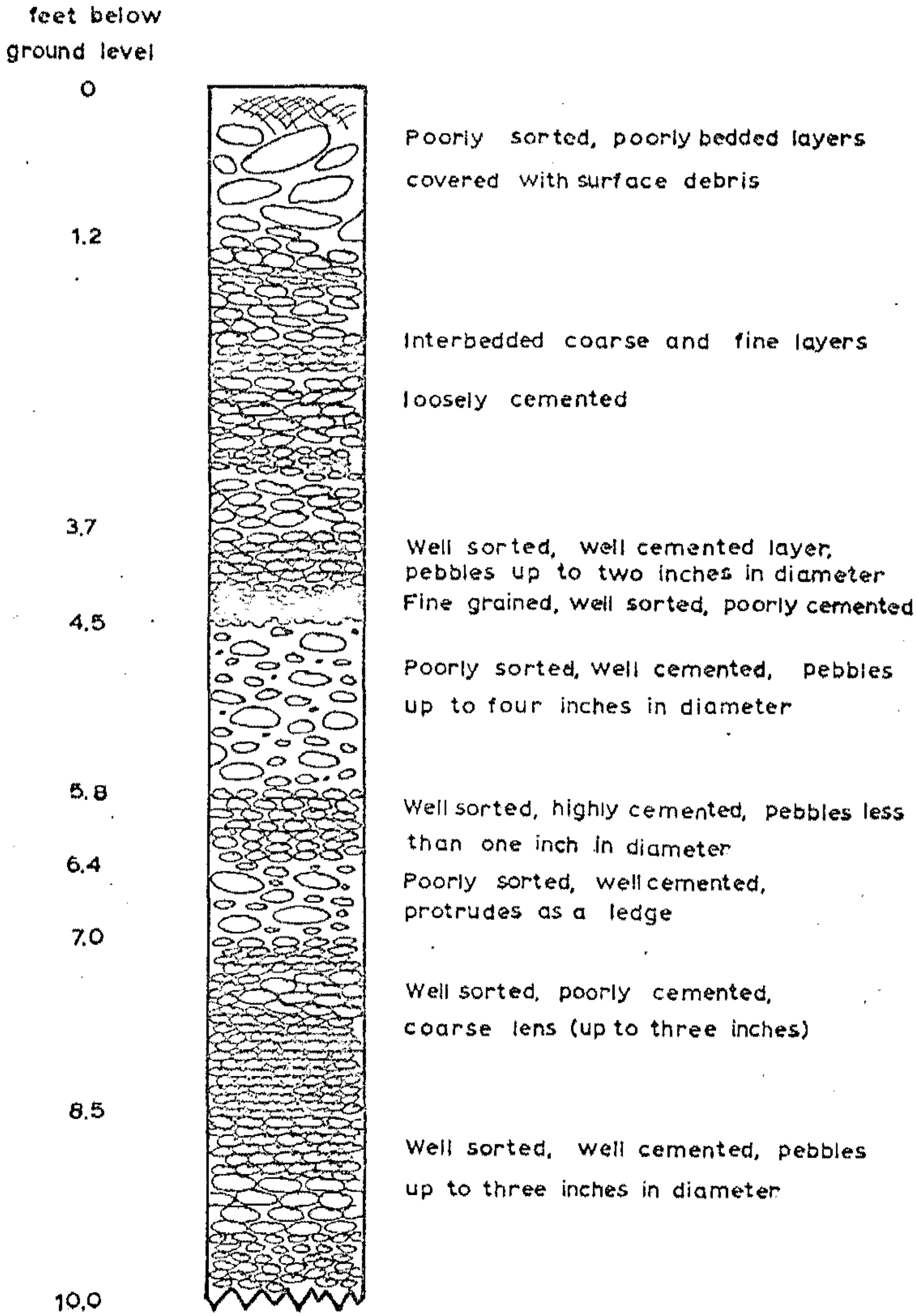


Figure 6. Schematic Representation of a Measured Section of the Alluvial Facies of the Lee Canyon Primary Fill (Plate 1).

alluvial facies of the Lee Canyon primary fill crops out exclusively beyond the mountain front (Plate 1) and is preserved in the form of terraces and other erosional remnants.

Colluvial Facies

These sediments were deposited as talus and other mass-movement accumulations, as well as unconcentrated surface runoff deposits. They generally were poorly sorted, exhibited only crudely developed bedding, consisted of angular fragments, and contained a large amount of matrix material, resulting in few grain to grain contacts among the clasts. These deposits were found almost entirely within the mountain block (Plate 1) as scattered erosional remnants (Figure 7) located on the valley sides and generally dipped towards the center of the valley at an angle of 15-25 degrees. Figure 8 is a photograph of sediments which were mapped as the colluvial facies of this primary fill.

Thickness of Fill

The highest exposures of the alluvial facies are found near the mountain front at an elevation of 8000 feet. Remnants of the colluvial facies are found within the mountain block at elevations of 9000 feet, but they dip towards the center of the valley at an angle of 15-25 degrees and probably represent colluvial aprons which were graded to the surface of the fill in the center of the canyon.

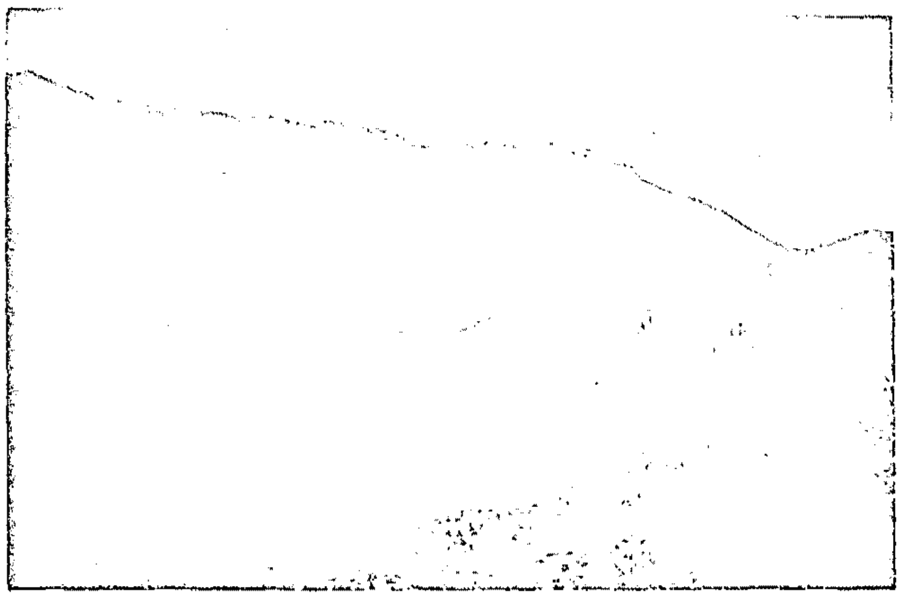


Figure 7. Erosional Remnant of the Colluvial Facies of the Lee Canyon Primary Fill. Broken line represents angle of dip of unusually well-developed bedding planes.

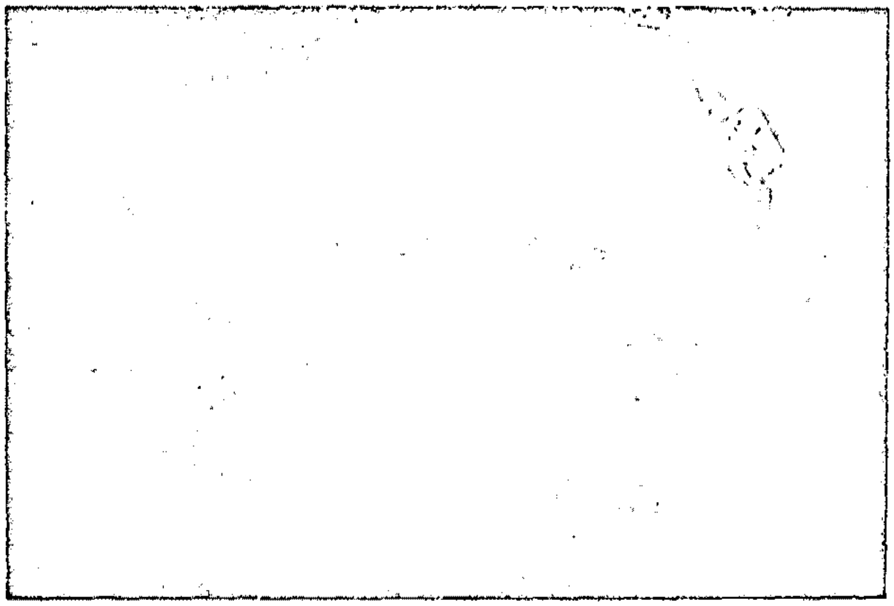


Figure 8. Colluvial Facies of the Lee Canyon Primary Fill.

Projecting the slopes of two of these colluvial remnants (Figure 9) results in an estimation of 8400 feet as the minimum elevation of the fill in the center of the canyon. The present elevation of the valley floor at this location is 8050 feet. In the immediate vicinity of this area a water well was drilled on the present-day flood plain to a depth of 448 feet and it did not encounter bedrock. This would suggest a minimum thickness of 800 feet for the Lee Canyon primary fill at this particular location. The thickness of this fill at other locations, however, is varied because the topography upon which it was deposited was highly irregular. Figure 9 also indicates that the pre-fill Lee Canyon was narrow, deep, and steep-walled.

The Lee Canyon primary fill was probably deposited within the mountain block as colluvial debris which was partially removed by stream activity and deposited beyond the mountain front as part of a large alluvial fan.

All observed exposures of the Lee Canyon primary fill were case-hardened (Simonberg, 1969) to some degree. Figure 10 shows a late-stage case-hardening that is developed on a colluvial remnant. This type of cementation was determined to be a surface phenomenon which is, in part, a function of the length of time of exposure (Simonberg, 1969). The degree of cementation of the Lee Canyon primary fill ranges from only slight development along the more recent road cuts to complete cementation of some of the older natural exposures of both alluvium and colluvium.

The Lee Canyon primary fill is one of several units which Longwell, et al., (1965) has termed Cemented Gravels of Local Origin

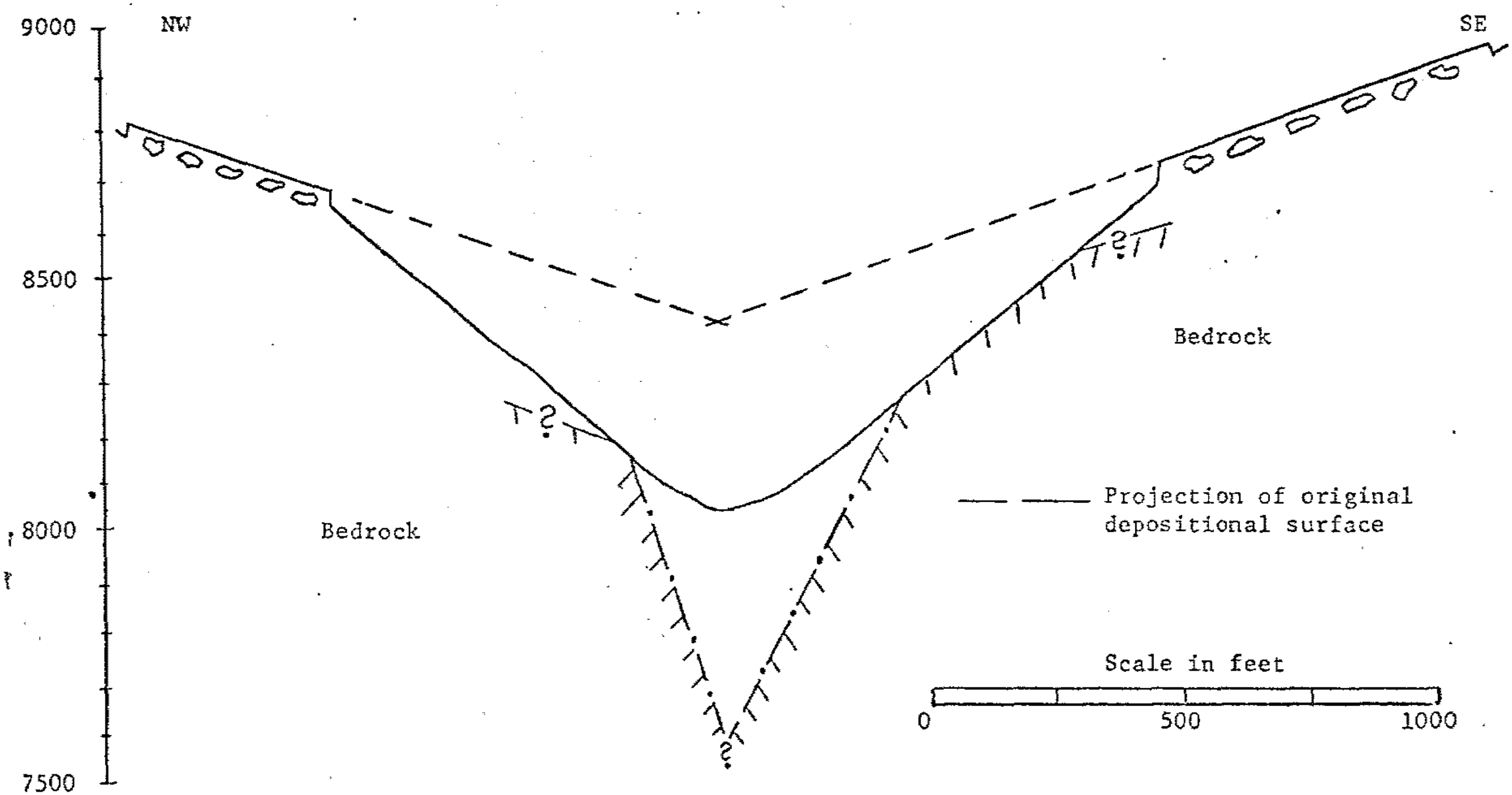


Figure 9. Estimation of the Thickness of the Lee Canyon Primary Fill. Note the steepness of the pre-fill valley sides as estimated from well data. Profile located one-half mile upstream from junction of Deer Creek Road and Highway 52.

Figure 10. Late-Stage Case-Hardening Developed on a Colluvial Remnant.

and to which he has assigned a tentative age of Pleistocene. In this study no evidence was discovered which supports or disproves this estimation.

Modern Alluvium

A second mappable lithologic unit was termed modern alluvium. It is similar in texture to the alluvial facies of the Lee Canyon primary fill, but field relations indicate that it is younger. Figure 11 is a photograph of a measured section of the modern alluvium (Plate 1) and Figure 12 is a schematic diagram of this measured section. This unit consists primarily of reworked sediments of the Lee Canyon primary fill and of the modern colluvium (discussed below). Some of the exposures of this unit indicate that calcium carbonate cementation has begun, but the degree of cementation is not great. The majority of the exposures had little or no cement development.

This unit occupies the present valley floor of the main drainage, as well as the channel bottoms of the major tributaries (Plate 1) and extends from the head of Lee Canyon to beyond the bedrock foothills at the northeastern edge of the study area.

Modern Colluvium

The term modern colluvium is applied to those colluvial deposits which began forming shortly after incision of the Lee Canyon primary fill began. This deposit is made up of weathered remnants of

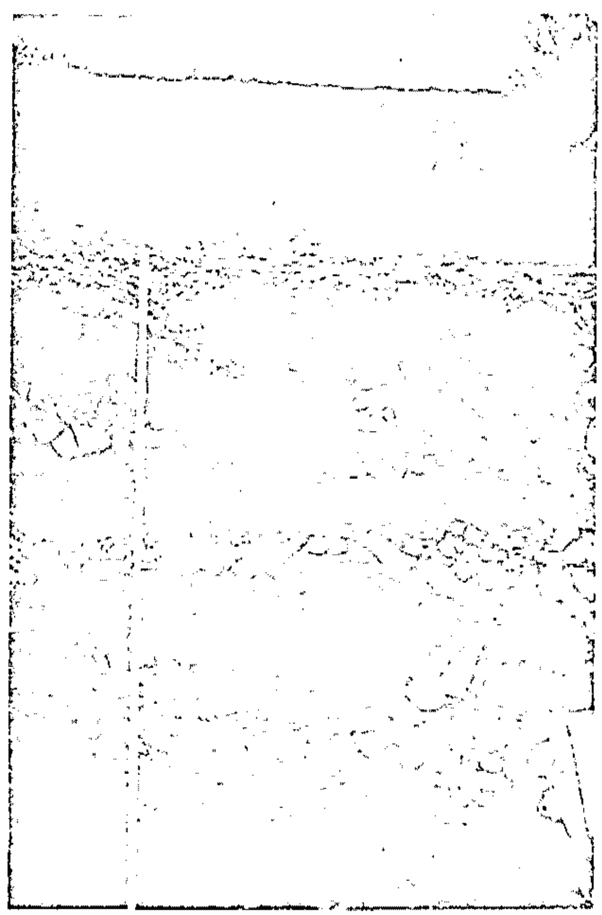


Figure 11. Measured Section of Modern Alluvium.

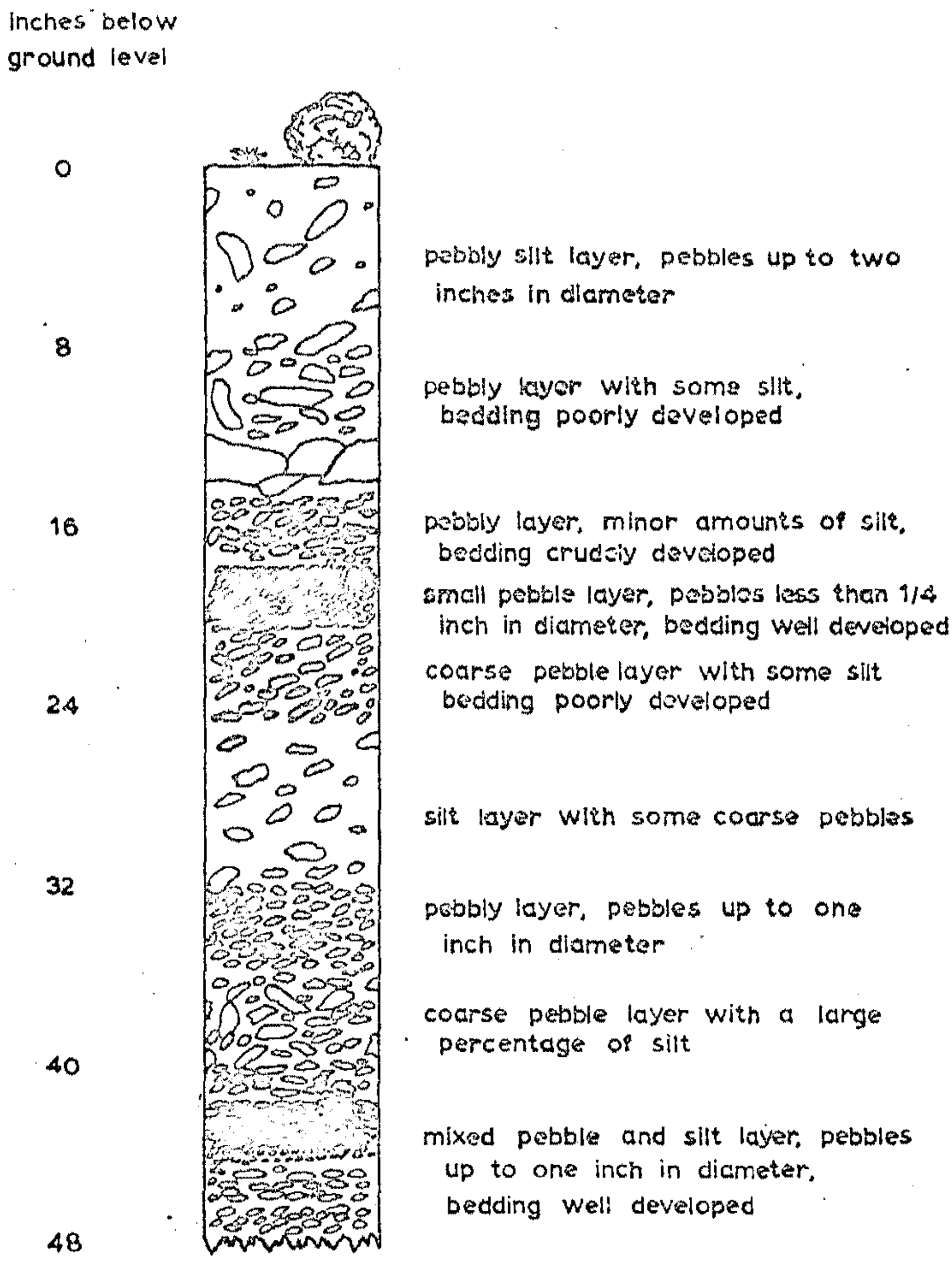


Figure 12. Schematic Representation of Measured Section of Modern Alluvium.

the Lee Canyon primary fill and recently weathered bedrock, and its deposition has continued up to the present time. Figure 13 is a photograph of a fan-shaped deposit of modern colluvium. The distal portion of this fan is composed of water worked sediments.

Alluvium and Bedrock Undifferentiated

To aid in mapping areas of numerous small bedrock outcrops and thin gravel cover a separate mapping unit is here defined. This unit is called Alluvium and Bedrock Undifferentiated on Plate 1 and consists of a gravel veneer overlying bedrock and within which are exposed numerous bedrock outcrops.

Colluvium and Bedrock Undifferentiated

In areas of extensive colluvial debris and numerous scattered bedrock outcrops a mapping unit here designated as Colluvium and Bedrock Undifferentiated (Plate 1) was used. This unit consists of isolated bedrock ridges whose slopes are mantled with colluvial debris.

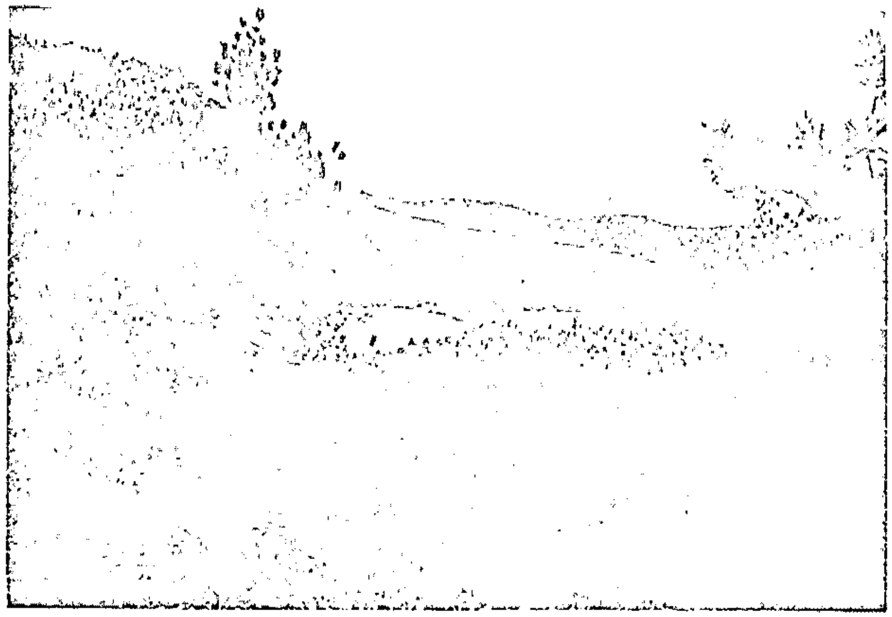


Figure 13. Fan-Shaped Deposit of Modern Colluvium. Sediments found in the distal portion of this fan have been reworked by streams. Dashed line outlines the deposit.

DESCRIPTION OF SURFACES

The Lee Canyon primary fill has been incised twice which results in the appearance today of three levels. The highest level, here designated Level I, is the upper surface of the fill. Level II consists of well-preserved terrace remnants within the fill; and Level III, resulting from a second period of incision (which may be continuing today), is the present valley floor.

Level II is strongly influenced by a bedrock barrier (Figure 14) which is the eastern limit of the study area. A series of drainage diversions occurred along the barrier and caused small, local terrace remnants which are here included in Level II.

Level I

Level I is the highest surface preserved in the study area (Plate 1 and Figure 15), and it is believed to represent approximately the original surface of the Lee Canyon primary fill. This surface is found to be parallel to bedding near the crests of some of the drainage divides which have been developed on Level I. The crests of these divides represent a minimum elevation for the depositional surface of the fill.

Remnants of this level are found as paired terraces and are mappable between the mountain front and the foothills of the eastern portion of the study area. Some colluvial remnants (Plate 1) found within the mountain block may also represent this level. This

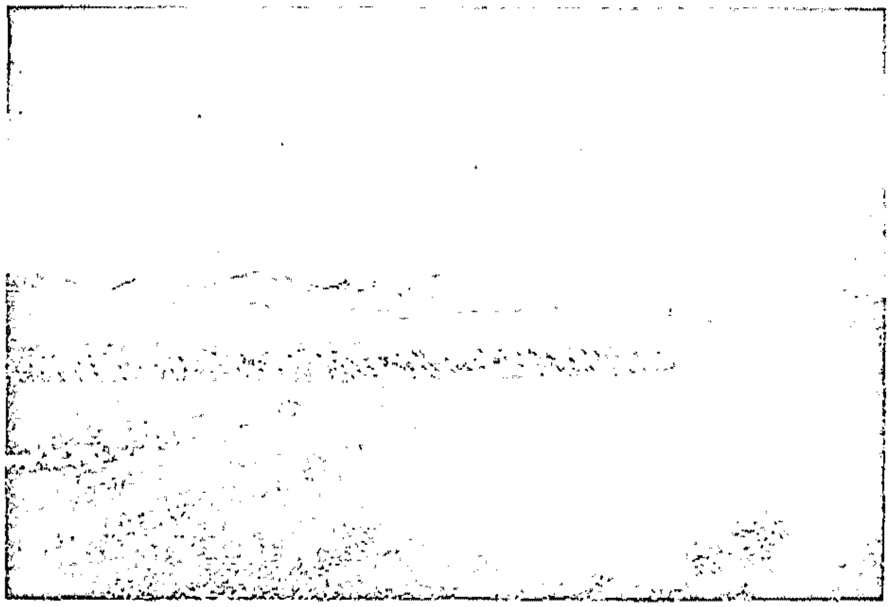


Figure 14. Bedrock Barrier. Dashed line represents the crest of the ridge.

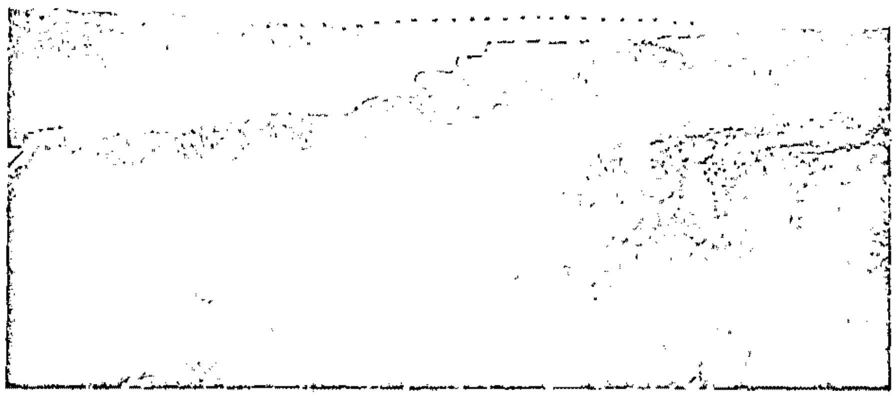


Figure 15. Surfaces of Lee Canyon. Dotted line represents Level I, and dashed line represents Level II. Note colluvial remnant.

surface has undergone extensive erosion which has resulted in a highly irregular, and discontinuous topographic expression (Plate 1).

A well-developed drainage pattern has been established on Level I. It consists of deep, steep-walled washes which are the sites of infrequent stream flow. The drainage established on remnants of Level I found on the northern side of Lee Canyon generally trends north, and the drainage established on the remnants on the southern side of Lee Canyon generally trends northeast. It is believed that these drainage remnants are part of a radial drainage pattern which was established on the original depositional surface of the Lee Canyon primary fill. Such patterns are developed today on alluvial fans.

Along the southern side of the modern Lee Canyon drainage, near the mountain front, Level I reaches an elevation of 8000 feet. Near the foothills in the lower portions of the study area it reaches an elevation of 5900 feet. Thus this level has a slope of approximately 430 feet per mile to the northeast.

The gravels exposed in the risers immediately below Level I (Level I risers) have been case-hardened. Near the crests of the modern drainage divides where this gravel is generally exposed in vertical faces, the cementation is similar to that which is described by Simonberg (1969) as being a late-stage development of case-hardening. There is very little micro-relief on the exposed surfaces and the individual gravel clasts are cemented to each other.

The Level I risers are usually covered with colluvium composed of fragments of cemented gravels as well as some individual gravel clasts. Along the southern side of the modern Lee Canyon drainage, near the mountain front, the Level I risers are characterized by 20-30 foot high vertical cliffs which rise above a colluvium covered slope (Figure 16).

The surface of Level I is characterized by a veneer of weathered, cemented gravel which overlie unweathered cemented gravel. In some areas the weathered debris consists of individual gravel clasts which have weathered out of the calcium carbonate cement, while in other areas the weathered debris consists of fragments of cemented gravels. These fragments consist of several clasts cemented together. The transition from one type of weathered debris to the other is relatively rapid and it appears that these weathering phenomena are locally controlled. The factors which control the type of weathering are not presently known.

Level II

The most extensively preserved, and second oldest, level observed in the study area is designated Level II (Plate 1). Remnants of this level are found within the mountain block as well as beyond the mountain front. The most extensive remnant is located on the northern side of the modern Lee Canyon drainage, and some small scattered remnants are found on the southern side (Plate 1). Those remnants which are found within the mountain block are developed on

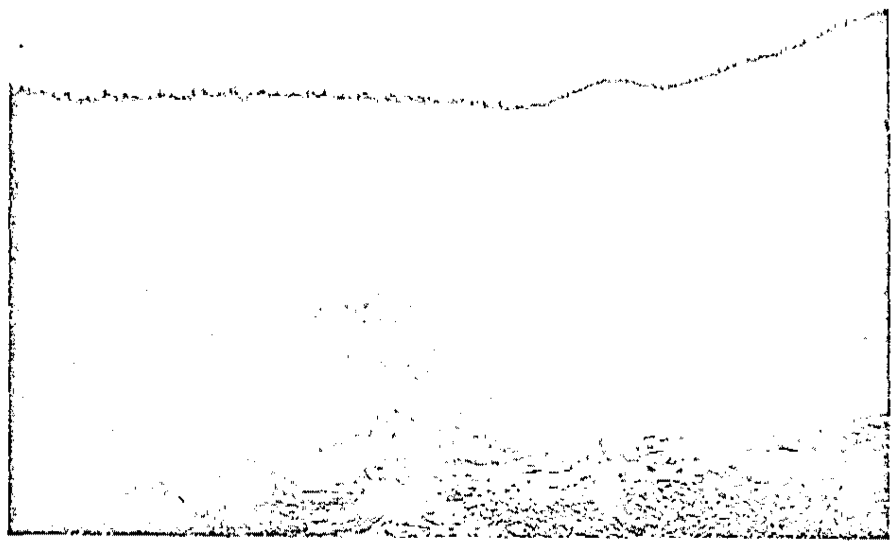


Figure 16. Vertical Cliff of the Level I Riser.

cemented colluvial debris, while those found beyond the mountain front are developed on cemented alluvium.

Within the mountain block, remnants of this level are found at elevations of at least 8500 feet, while at the edge of the mountain front and in the lower reaches of the modern drainage they are found at elevations of 7700 and 5360 feet respectively. A downvalley slope of 380 feet per mile is therefore calculated for this level.

Developed on Level II is a drainage pattern which trends in a northeasterly direction. This pattern consists of numerous, shallow (less than 20 feet deep), intermittent stream channels. A large stream channel which is tributary to the main Lee Canyon drainage is located along the northern edge of this terrace at the base of the Level I riser. The surface of Level II slopes toward this large drainage (Plate 2).

Scalloping of the Level I riser in the immediate vicinity of the mountain front suggests that when Level II was forming, the main Lee Canyon drainage followed a meandering pattern (Plate 1). Downstream from the mountain front there is a large arcuate remnant of Level II which indicates that the stream which cut Level II was deflected against the northern side of the canyon. This arcuate remnant is located directly across from a large southern tributary and it is believed that this tributary deflected the main stream. This tributary is now building a small alluvial fan on the present valley floor and is diverting the modern Lee Canyon drainage toward the north.

The cementation of Level II and the Level II risers is distinctively different from that of Level I and the Level I risers. The surface of Level II is covered with a veneer of gravel clasts which appear to have weathered from a calcium carbonate cemented gravel. The cement still is attached to some of the clasts. However, nowhere on this surface was found angular fragments of cemented gravel, such as were found on Level I. Close inspection of the animal burrows on Level II showed that to at least a depth of 15 inches the gravels were only loosely cemented together, whereas in most areas on Level I the gravels were well cemented within a few inches of the surface.

The cementation developed on vertical exposures of the Level II risers was also noticeably different. The Level II risers were characterized by ledgy cementation (Figure 17). These vertical exposures were well cemented and had a surface micro-relief of up to two feet. Simonberg (1969) states that ledgy cementation is one of the middle stages in the process of case-hardening. The Level II risers generally consist of a colluvium covered slope with a few scattered vertical exposures of cemented gravel.

For both the Level I and Level II risers almost all vertical exposures of cemented gravel are found on north-facing slopes. Those exposures which are found on south-facing slopes are considerably smaller than those found on north-facing slopes. The difference is attributed to the amount of colluvial debris which is on the slopes. South-facing slopes have considerably more colluvium than do north-facing slopes. This difference may be a function of the amount of

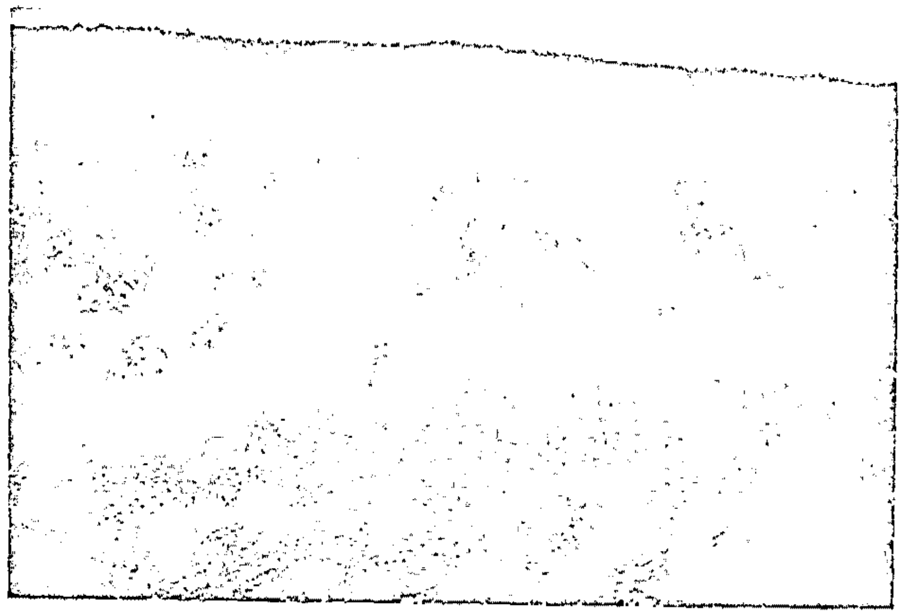


Figure 17. Ledgy Cementation of the Level II Riser.

exposure to sunlight. The majority of north-facing slopes are in the shade for all but a few hours of the day, whereas the south-facing slopes are exposed to sunlight up to 12 hours a day. In an area of predominantly physical weathering, such as Lee Canyon, the larger temperature differential which is experienced by the south-facing slopes may be sufficient to cause the more rapid weathering of the cemented gravels and the subsequent production of larger amounts of colluvial debris.

Level III (Present Valley Floor)

The present valley floor is classified as Level III because it is of large areal extent and represents the present time period. It differs from Level I and Level II, however, in that one cannot be certain as to the nature of the present stream regimen. That is, it is not known whether the stream is actively down-cutting or primarily widening its valley.

The present valley floor is occupied by the modern Lee Canyon drainage and is characterized by an anastomosing pattern of intermittent stream channels. The stream channels are predominantly underlain by gravel, which in one area is at least 450 feet thick. In the vicinity of the Bedrock Barrier (discussed below), however, the gravel thickness is considerably thinner as one of the major tributaries near this barrier exposes bedrock in the middle of the channel (Plate 1).

The surface of Level III is underlain by uncemented gravels ranging in size from less than one-quarter inch in diameter to at least 14 inches in diameter. Natural vertical exposures of this alluvium show that it contains a high percentage of silt-sized material (Figure 11). In none of the exposures was there complete cementation of the gravels. The only evidence of cementation found in exposures of the modern alluvium was a calcium carbonate coating on many of the individual clasts and an apparent enrichment of some horizons by calcium carbonate.

GEOMORPHOLOGY OF LEE CANYON

Bedrock Barrier

Located in the lower reaches of Lee Canyon are bedrock ridges (Plate 1) which give evidence of having influenced the evolution of the Lee Canyon drainage. It is believed that the two, large, northeastward trending ridges which flank the present Lee Canyon drainage below Deer Creek Road have restricted the lateral movement of drainage in the canyon since after the Lee Canyon primary fill was desposited. A northwestward trending ridge which lies between these two major ridges is referred to herein as the Bedrock Barrier (Figure 14). This transverse ridge has affected the evolution of the Lee Canyon drainage after incision of Level I began. Before the incision of the Lee Canyon primary fill the main Lee Canyon drainage was apparently positioned between the two major northeastward trending ridges. Incision of the fill caused the main Lee Canyon drainage to become confined between these ridges which thus restricted its lateral movement and caused it to be superposed across the northwestward trending Bedrock Barrier. The various positions of the superposed Lee Canyon drainage are recorded by abandoned channels developed across the Bedrock Barrier (Figure 18). The barrier is approximately 1800 feet long and reaches a maximum elevation of 5717 feet near its central portion. It exhibits a large variation in degree of jointing at various places along its length. Figure 19 is a photograph of one of

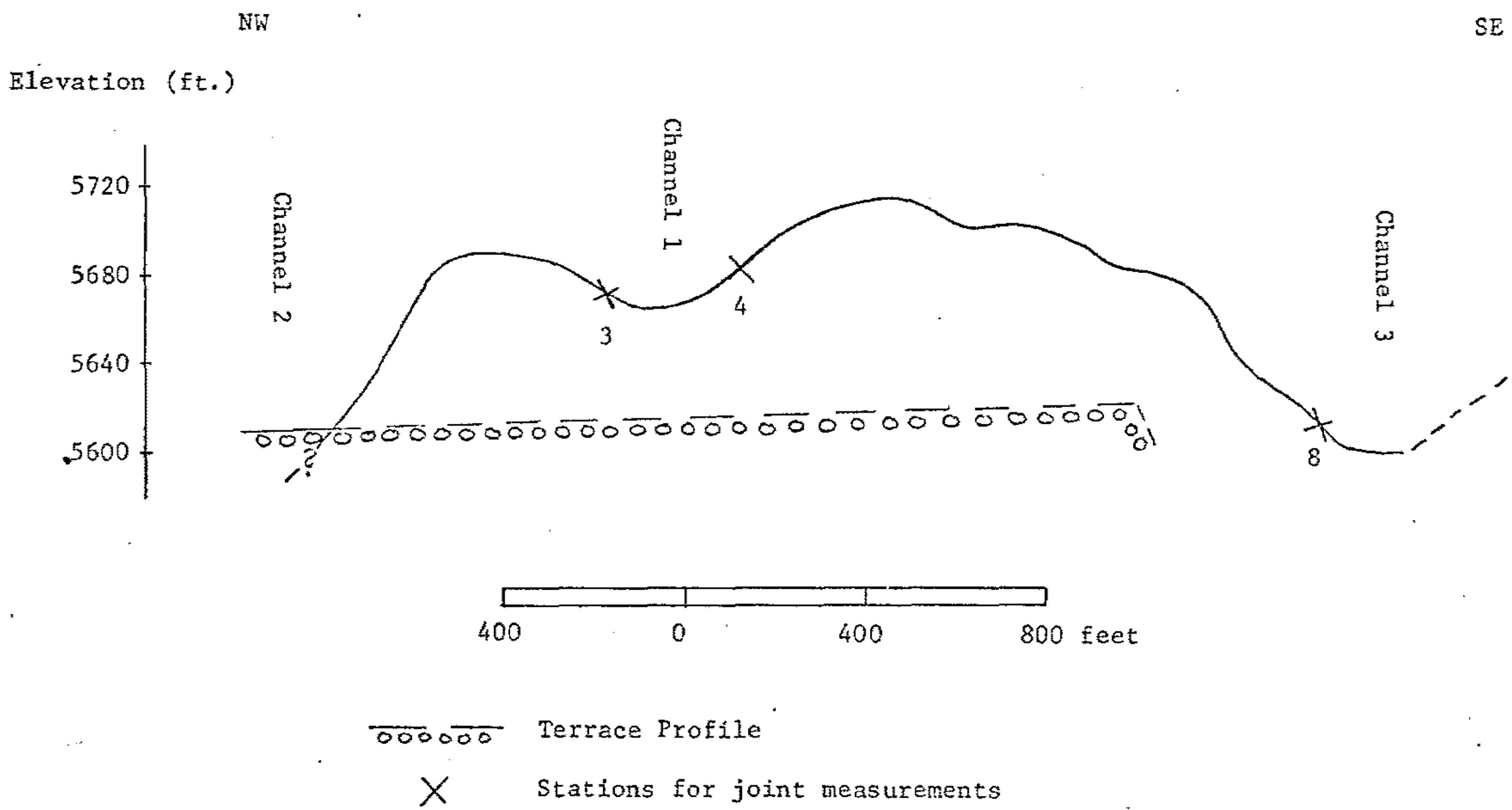


Figure 18. Topographic Profile of the Bedrock Barrier Showing Location of Stream Channels. Terrace profile estimated from altimeter traverse.

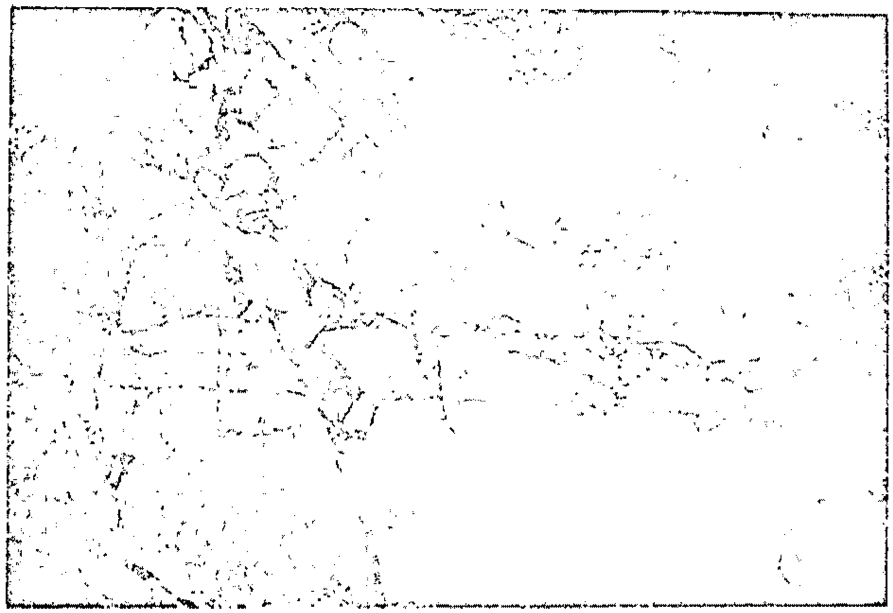


Figure 19. Lesser Jointed Area of the Bedrock Barrier.

the lesser jointed areas and Figure 20 shows one of the more highly jointed areas.

Table 2 is a presentation of joint data from the Bedrock Barrier and is intended to illustrate the variation in degree of jointing across the barrier. A traverse of eight measuring stations separated by a distance of fifty paces (approximately 250 feet) was established along the crest of the ridge. At each station a pair of two-foot measuring traverses were made at right angles to each other. One traverse was arbitrarily chosen to be perpendicular to the trend of the most closely spaced joint set. The number of joints which crossed each traverse were counted and the number of joints per linear foot of traverse was calculated for each station. For a joint to be counted it must have had a well-defined minimum surface expression of at least four inches, and all such joints which intersected a traverse were counted regardless of their trend.

The results indicate a wide variation in spacing of jointing. It should be pointed out that those areas of the Bedrock Barrier which had the highest intensity of jointing were the areas of the barrier which were topographically low. As discussed below these low areas are believed to be former channels of the Lee Canyon drainage and therefore it is believed that the jointing of the barrier exerted an influence on the evolution of this drainage.

At least three of the low areas along the Bedrock Barrier have characteristics which indicate that they might have been stream channels of the Lee Canyon drainage. The most obvious such area is

Figure 20. Highly Jointed Area of the Bedrock Barrier.

Table 2

Joint Data from the Bedrock Barrier

Station	Number of Joints		Average Number of Joints per Trav.	Joints per Linear Foot
	Trav. A	Trav. B		
1	9	3	6	3.00
2	9	5	7	3.50
3*	12	10	11	5.50
4*	15	12	13.5	6.75
5	14	6	10	5.00
6	12	11	11.5	5.75
7	11	11	11	5.50
8*	20	9	14.5	7.25

* stations which are located in areas believed to be channels of the Lee Canyon drainage (Figure 18)

located in the southern portion of the barrier and separates it from one of the major flanking ridges. The present Lee Canyon drainage flows through this area. The next most obvious low area is located on the northern side of the barrier and separates it from the other large flanking ridge. A drainage network established on the remnant of Level II, which is located on the northern side of the present drainage (Plate 1) and which slopes toward the north (Figure 18), indicates that the Lee Canyon drainage was once directed around the northern end of the Bedrock Barrier. The third low area is located in the central portion of the barrier and is characterized by a large swale (Figure 14) and a bare bedrock surface. This area has been classified as an ancient channelway solely on the basis of its physical appearance and it is believed that the stream occupied this channel during an earlier stage of the erosion of the Lee Canyon fill.

Joint measurements were not feasible in the low area on the northern edge of the Bedrock Barrier, but in the low in the central portion and along the southern edge now occupied by the Lee Canyon drainage, joint measurement data (Table 2, stations 3-4, and 8) indicate the highest intensity of jointing. It is believed that stream channels were established in these areas because the high degree of jointing development made erosion of the bedrock relatively easy. Therefore, headward working streams extending through the highly jointed areas could capture and divert the Lee Canyon drainage.

Geomorphic History

The geomorphic history of Lee Canyon can be discussed by subdividing it into various stages and describing the various geomorphic processes and evolution of each stage.

The first stage is the deposition of a large fan-shaped deposit here called the Lee Canyon primary fill. It extended from the head of Lee Canyon to at least eight miles beyond the mountain front. Colluvial remnants on the sides of the canyon and alluvial remnants at the edge of the mountain front have been found at elevations of 9000 and 8000 feet respectively. A minimum height of the depositional surface along the axis of the canyon was calculated by projecting the dips of colluvial remnants and found to be 8400 feet. Well data suggests that in the vicinity of these colluvial remnants the minimum thickness of fill was approximately 800 feet. Plate 2 indicates that, in places, the alluvial facies of the Lee Canyon primary fill reached a thickness of at least 350 feet. The upper surface of the Lee Canyon primary fill is herein called Level I. Observations of similar fills in other canyons (Dolliver, 1968) and on the opposite side of the Spring Mountain Range (Lattman, oral communication) suggest that the variable which controlled deposition was regional in nature. Also there is no evidence of widespread or strong post-Pliocene tectonic activity in southern Nevada (Longwell, et al., 1965). Thus climatic variation appears to be the most likely cause of the canyon fill. However, earlier tectonic activity may have influenced the deposition of the Lee Canyon primary fill. The Spring Mountain Range was an area of intense faulting (Longwell, et al., 1965), and the existence of highly sheared bedrock may have facilitated the production of large amounts of colluvial debris. Melton (1965) in his study in Arizona suggests that a cold climate with intense frost action in the higher elevations, combined with infrequent intense rainstorms brought on by the general cooling of the Pleistocene, would result in large amounts of colluvial debris. A similar process may have been active in the Spring Mountain area to produce the Lee Canyon primary fill as well as the large deposits in neighboring canyons.

The colluvial debris, which was emplaced primarily as talus cones, debris slides, and mud flows, was partially deposited within the mountains and also reworked by streams which deposited it beyond the mountain front as large alluvial fans. The colluvium and alluvium was deposited over a highly irregular topography and there were some bedrock knobs which were not covered.

The second stage of the geomorphic history of Lee Canyon was the incision of Level I by the main Lee Canyon drainage. The cause of this period of incision is not known with certainty, but it also may have been initiated by climatic changes. Similar sequences of down-cutting observed in numerous canyons on both sides of the Spring Mountain Range, and the lateral continuity of Level II with the Mom's Ranch Level of Kyle Canyon support this hypothesis. Plate 2 indicates that the depth of incision was at least 150 feet, and that the depth of incision decreased in a downstream direction.

The pattern of remnants of Level I (Plate 1) suggests that in the vicinity of the mountain front the main Lee Canyon drainage was characterized by a meandering stream pattern. Further downstream, however, this pattern was modified by the effects of a tributary drainage. In the central portion of the study area a large arcuate pattern of the erosional remnants of Level I opposite a large tributary of the main Lee Canyon drainage (Plate 1) suggests that during the incision of Level I this tributary drainage diverted the main Lee Canyon drainage toward the north.

Some time during the incision of Level I the main Lee Canyon drainage appears to have occupied a position in the central portion of the Bedrock Barrier. A topographic low developed in a highly jointed area in the center of the barrier has a form which suggests that it once was a channel of the main Lee Canyon drainage. Headward erosion through this highly jointed area of the barrier by a tributary stream could have diverted the main Lee Canyon drainage through the central region of the barrier. The high density of joints could have facilitated the erosion of the bedrock to form the topographic low. Stream capture by another tributary could have diverted the main drainage away from this area resulting in an abandoned stream channel.

While the main Lee Canyon drainage was developing a large valley in the Lee Canyon fill, other streams were also modifying the surface of Level I. The radial drainage pattern which was associated with the depositional surface of the Lee Canyon primary fill was being incised on the remnants of Level I. This incision resulted in development of a relief of up to 100 feet in Level I.

The third stage of the geomorphic history involved the cessation of incision and the subsequent formation of a large, low relief surface which is here called Level II. This large surface was a flood plain of the main Lee Canyon drainage and represents a period when the stream was not actively down-cutting, but rather widening its valley. Hack (1960) suggests that erosion systems are in a state of dynamic equilibrium where all the variables in a system are adjusted to each other and that a change in one or more variables results in a change in other variables until they have readjusted to each other. If a drainage system were in a state of dynamic equilibrium, the amount of sediment being added to the system by such processes as weathering would be equal to the amount of material being removed by the stream. Such a system is neither aggrading nor degrading. Thus the cessation of incision of Level I would not have required a climatic change, but could have resulted from the drainage system reaching equilibrium.

Level II extends from the head of Lee Canyon to below the Bedrock Barrier (Plate 1) and is developed on both the colluvial and alluvial facies of the Lee Canyon primary fill. Terrace remnants of Level II are graded to, and around, the northern end of the Bedrock Barrier (Plate 1). Thus the main drainage at this time apparently flowed around the northern edge of the barrier.

Sometime following the beginning of formation of Level II a soil profile began to develop. Figure 21 is a photograph of a soil profile which is exposed in a roadcut on the north side of the Lee Canyon Road approximately one-half mile east of its junction with the Deer Creek Road (Plate 1). The profile is characterized by a calcium carbonate enriched B-horizon or soil caliche. At this particular

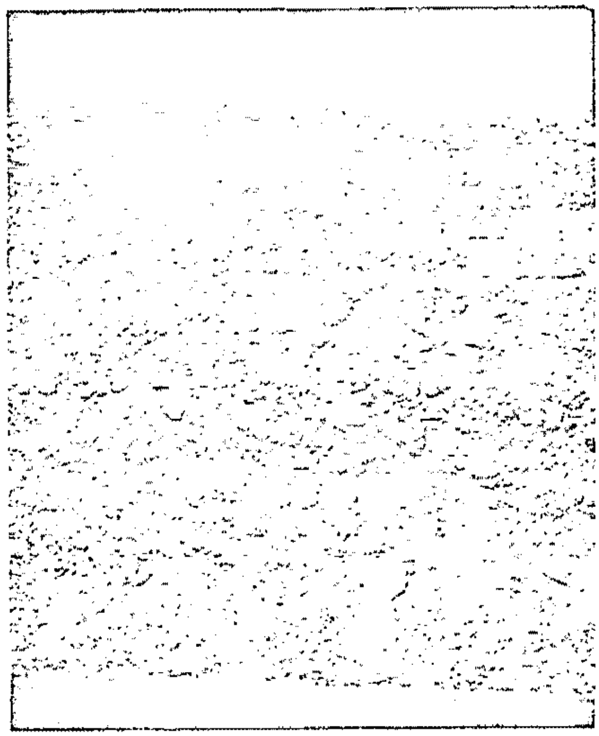


Figure 21. Soil Profile Developed on Level II.

locality the profile is developed on a colluvial sediment and the upper edge of the profile projects to and coincides with, a surface of Level II. Overlying the soil profile is a well stratified fan-shaped deposit which has its source in a small canyon immediately above the roadcut. This stratigraphic sequence is interpreted as follows: 1) formation of Level II on the colluvial facies of the Lee Canyon primary fill, 2) initiation of soil development on this surface and 3) the extension of an alluvial fan over the surface from a side-valley canyon.

Fan-shaped deposits graded to Level II (Figure 13) are also found in other portions of the study area (Plate 1). It is believed that these deposits began forming immediately after formation of Level II and their development has continued up to the present time.

The fourth stage of the geomorphic history of Lee Canyon is the incision of Level II. This incision may be the result of headward erosion by a tributary stream through the highly jointed, southern end of the Bedrock Barrier. Denny (1965) points out that tributary streams which head in the alluvial fan often lie many feet below the main fan building wash which heads in the mountains. Piracy of the main Lee Canyon drainage as a result of headward erosion through the Bedrock Barrier by such a tributary stream would have been sufficient to initiate the incision of Level II. Plate 2 indicates that the incision of Level II is as much as 100 feet. After the diversion of the main Lee Canyon drainage around the southern end of the barrier, some streams may have continued flowing around the northern end of the Bedrock Barrier to join the main drainage further downstream. This drainage is indicated by remnants of Level II located on the northern side of the valley and which are discontinuous in expression (Plate 1).

During the incision of Level II the portion of the Lee Canyon drainage located below the Bedrock Barrier was an area of separate headward working streams. The result of these separate streams was a series of small, discontinuous, unmatched terraces, not all of which were mappable (Plate 1).

The final stage of the geomorphic history involves those processes which are presently active in Lee Canyon. Mass wasting phenomena are forming colluvial slopes of weathered gravel and bedrock. These processes were observed to be extremely active during periods of intense local thunderstorms and have been reported to be intensely active during the winter months.

The main Lee Canyon drainage was observed to have stream flow only after several days of continuous rain. This flow was only observable in the headward regions of Lee Canyon and was of short duration. The high permeability of the channel gravels and the extreme depth to the water table (448 feet) may have permitted the rapid infiltration of this surface runoff. Stream gauge data for Lee Canyon are available only for the years 1961, 1964-67 (Table 1).

SUMMARY AND CONCLUSIONS

Lee Canyon is occupied by alluvial and colluvial sediments which originally filled the canyon to at least a depth of 800 feet. This fill has been partially removed and the erosional history is recorded by terrace remnants contained within the canyon. Lee Canyon's late-Cenozoic geomorphic history can be summarized as follows: 1) Deposition of a large fan-shaped body which extended to the head of Lee Canyon. 2) Incision of this fill, resulting in matched terraces; the cause of this incision was apparently climatic change. 3) A period of no significant incision or deposition, resulting in valley-widening and the formation of a large floodplain which extended from the head of Lee Canyon to beyond the Bedrock Barrier. 4) A second period of incision, which appears to have been initiated by stream capture; field evidence suggests that headward erosion by a tributary stream through a highly jointed area of the Bedrock Barrier resulted in capture of the main Lee Canyon drainage and initiated this second period of incision. 5) Present drainage development, which appears to be a period of predominantly valley-widening.

This sequence is similar to that postulated for Kyle Canyon (Dolliver, 1968), which is located approximately 10 miles south of Lee Canyon. Dolliver has postulated the deposition of colluvial and alluvial sediments which later experienced three periods of incision separated by two periods of nonincision. The second period of incision has been postulated as being climatically controlled and the third was the result of stream capture. The two major levels preserved in Kyle Canyon have been named the Kyle Canyon Level and the Mom's Ranch Level. The third surface is the present valley floor. The sequence observed in Lee Canyon suggests that Level I is correlative with the Kyle Canyon Level in Kyle Canyon. Both levels are approximations of the original surfaces of deposition and represent the same time period. Level II appears to correlate with the Mom's Ranch Level and both represent periods of nonincision and valley-widening. It cannot be stated that these two levels represent exactly the same time period, but they do probably closely coincide. The present valley floors of Lee Canyon and Kyle Canyon are correlative in that they both represent the present activity of the Lee Canyon and Kyle Canyon drainages, but they need not be correlative with respect to stream regimen.

From the evidence gathered in Lee Canyon and Kyle Canyon and reconnaissance observations of other canyons (Lattman, oral communication) in the immediate vicinity, it appears that the late Tertiary or early Quaternary Periods were characterized by the formation of large fan-shaped deposits of alluvium and colluvium which almost buried the mountain ranges.

These deposits underwent a period of incision which was probably climatically controlled. Incision apparently continued until each erosion system readjusted and reached a state of equilibrium. It is believed that the cessation of incision within the various mountain ranges was penecontemporaneous. The end of incision initiated a period of valley-widening which resulted in the formation of large flood plains or pediments in many of the canyons. Incision again occurred in some of the canyons, but it is believed to have been the result of local controls rather than regional ones.

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