University of Nevada

Reno

Quaternary and Environmental Geology of Lemmon Valley, Nevada

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Geology

by

Stephen A. Soeller

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The thesis of Stephen Anton Soeller is approved:

Thesis advisor

Department Chairman

Dean, Graduate School

University of Nevada

Reno

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ABSTRACT

Over 1000 vertical feet of loose to weakly consolidated Tertiary and Quaternary sediments occupy the closed Lemmon Valley basin. Mountains comprising Mesozoic granitic and metavolcanic rocks border the valley.

Fourteen Quaternary geologic units within the forty-eight-square-mile field area include pediment gravels, six varieties of alluvium, beach, forebeach, lake, landslide and playa deposits, windblown sand and playa-bordering clay dunes.

North-south and northeast-southwest trending normal faults cut early Pleistocene deposits and delineate subordinate horsts and grabens within the basin. The prominent Airport fault offsets Tertiary and early Quaternary sediments 120 feet and granitic bedrock over 600 feet vertically.

Hazards to valley inhabitants include flooding, faulting, seismic shaking, landsliding, and expansive soils. Losses of construction aggregate resources and overdrafting of domestic ground water supplies may occur through over-population of the valley as demands for more housing are made by the neighboring Reno-Sparks community.

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INTRODUCTION

PURPOSE AND SCOPE OF WORK

This study was made based on the need for a detailed reconnaissance geologic investigation of the Lemmon Valley area. The need has been expressed by the Regional Planning Commission of Reno, Sparks and Washoe County for the purpose of urban planning, by local geological engineering consultants for engineering design criteria, and by the general public for information. At commencement of work the study focused on the general geologic and environmental geologic features of the valley. Soon after field work began the myriad of Quaternary deposits and features prompted an interest on the part of the author to study the Quaternary geology of the valley in detail. Thus the report is a combination of the Quaternary and environmental geology of Lemmon Valley.

The area mapped is totally within the boundary of the Regional Planning Commission's Lemmon Valley District No. 11 and covers the northern three-quarters of that district. The southeast portion of the district has been mapped on the same map scale as this study (Bonham and Bingler, 1973). The six square miles within the southwest portion of the district has not been mapped on a detailed basis.

LOCATION AND GENERAL FEATURES

Lemmon Valley is located in southern Washoe County

3 1/4 miles east of the Nevada-California state line and between seven and fifteen miles north and northwest of Reno (Figure 1).

The area mapped consists of approximately 48 square miles which totally encompasses Lemmon Valley and includes some large areas of surrounding bedrock exposures. The southern limit of the field area reaches the north slope of Peavine Mountain.

The field area is accessible by Golden Valley, Lemmon Valley and Red Rock Roads, and Stead Boulevard, all of which intersect with U. S. Highway 395.

Buildings have been constructed mainly in the southern half of the field area and the most dense development is in the south-central portion of the field area. There the "Stead Facility" has been named for a large group of structures once used as a military base. South of the Stead Facility several tracts of houses have been built. The Reno-Stead Airport is located north of the Stead Facility and is situated in the center of the field area. The airport, Stead Facility, and housing tracts are within the corporate boundary of the city of Reno. Other dense housing and trailer court developments exist in the southeast portion of the field area.

For purposes of orientation Lemmon Valley (used here to include the entire field area) will occasionally be discussed as the Silver Knolls sub-area, or that area west of

Scale
1:250,000

Figure 1 - Index map showing location of field area

the Stead Facility; and the East Lemmon sub-area, or that area east of the Stead Facility. The Lemmon Valley playa is located in the East Lemmon sub-area; the Silver Lake playa is located in the Silver Knolls sub-area.

PHYSIOGRAPHY AND DRAINAGE

Lemmon Valley is situated within the western portion of the Basin and Range physiographic province and near the eastern border of the Sierra Nevada province. The valley is within a closed hydrographic basin and all surface runoff within the valley discharges into one of five playas. Treated effluent from the Reno-Stead waste water treatment facility perennially discharges into the largest of these playas. Several springs with meager discharges were observed in the southwest portion of the area in February 1978.

The greatest relief in the field area is 1110 feet measured from the 6021 and 6018 foot high peaks in the northeast and southwest corners of the area, respectively, to the approximate 4910 foot elevation of the Lemmon Valley playa. The highest peak in the vicinity is the 8266 foot high Peavine Peak located 2 1/2 miles south of the field area.

Lemmon Valley is flanked by Cold Spring Valley to the west, Freds Mountain to the north, Antelope Valley to the northeast, Hungry Valley to the east, Golden Valley to the southeast, and Peavine Mountain and the Truckee River valley to the south.

CLIMATE AND VEGETATION

Lemmon Valley is in the rain shadow of the Sierra Nevada Mountains and receives precipitation from only the stronger eastward moving storm systems which cross those mountains. The valley has a semiarid climate and receives an average of eight inches of water per year.

During the summer months 50 degree daily variations in temperature are common. The summers are short though hot days often exceed 90 degrees Farenheit.

During most of the winter, snow caps Peavine Mountain and the hills surrounding the valley. Snow falls on the valley floor generally several times during the winter but melts quickly within a few days following each storm. Temperatures rarely drop into the teens during winter months and generally stay below 60 degrees F. during daylight hours. Occasional warmer spring-like conditions may prevail in the midst of a high pressure system.

Many types of native vegetation occur in the valley. Some of the more common brushes are big sagebrush (Artemisia tridentata), spiny hopsage (Grayia spinosa), horsebrush (Tetradymia canescens) and rabbitbrush (Chrysothamnus nauseosas). Grasses include squirrel tail (Sitanion hystrix), cheat grass (Bromus tectorum) and needle and thread grass (Stipa comata). Crested wheat grass (Agropyron desetorum), not native to the valley, was planted in the Silver Knolls sub-area following a range fire in the western portion of that area. The only tree native to the valley is the juniper (Juniperus osteosperma) which grows in the hills surrounding the valley.

HISTORY OF THE VALLEY

Man's presence in the valley possibly dates as far back as 3500 years before the present (B.P.) when Indians occupied the valley. Basalt arrowheads characteristic of the Martis Complex, dated at 3500 to 1500 years B.P., were found by the author in Lemmon Valley. Jasper flakes and projectiles characteristic of the Kings Beach Complex, 500 A.D. to the historic time, were found in many locations scattered throughout the valley. Speculation has been made that the valley served as a regional annual gathering place for these Indians. The event is termed a gumsaba and would involve large-scale trappings of game.

In 1861 the valley's first white settler, Fielding Lemmon (after whom the valley is named), established a ranch in the southwest corner of the field area. The ranch, located by several springs, served as an overnight rest stop for travelers and teamsters in transit to and from Reno.

The first railroad in Lemmon Valley was constructed by a company originally termed The Nevada and Oregon Railroad Company. The N & O began work on a narrow gauge railroad in 1880 which headed north out of Reno. Encountering a series of financial struggles in its infancy the company nearly collapsed but gradually was able to make construction headway. In 1881 the company constructed a sinuous rail line through Lemmon Valley which entered the valley in the southern portion of the field area, crossed the current location of the Reno-Stead Airport, and exited into Cold Spring Valley at the northeastern portion of the field area.

The first regular passage began on the N & O in 1882 when passengers were carried to Oneida, California located 30 miles from Reno. The line eventually ran to Lakeview, Oregon under the new title of the Nevada-California-Oregon Railway Company. Due to outstanding debts and the threat of crippling competition the N-C-O Railway Company sold the southernmost 64 miles of track between Reno and Herlong, California to the Western Pacific Railroad. In 1918 Western Pacific removed the portion of track which passed through Lemmon Valley, and constructed a bypass grade along the north slopes of Peavine Mountain. A portion of that grade, which is still in use, passes through the southwest corner of the field area. Where recent construction has not encroached upon the line, the old N-C-O railroad grade, now 60 years old can still be seen.

In 1922 to 1923 the Nevada Highway Department built a gravel road from Reno to the Nevada-California state line. The road, which passes through the southwest corner of the field area, was to later become a segment of U. S. Highway 395. The gravel road was paved and became a two lane highway in 1933. In 1976 after major construction this segment became a four lane divided highway.

Ore mining operations have been meagerly successful in Lemmon Valley. Several workings were observed by the author which included adits into brecciated quartz dikes; shallow excavations in copper mineralized thin shear zones; a vertical shaft into granodiorite; and a claim on a purported gold-silver vein. Apparantly none of these workings has been profitable. One other site was worked by the Nixon-Nevada Mining Co. in the late 1910's. The site, located on the east face of Granite Peak, consisted of two inclined shafts with 2,849 feet of workings on three levels to depths of 300 feet. Four hundred tons of copper, silver and gold ore were removed from the mine. The copper portion of the ore was rated at an average of 31 percent. In 1920 the company went bankrupt and the machinery was removed. Through an exchange of stock the Copperfield Mining Company, under the same management as Nixon-Nevada, gained control of the former company's holdings. Apparently no significant mining activity was done at the site by the Copperield Mining Company.

In 1941 an Air Transport Command ferrying and training base was built in Lemmon Valley at what is now the Stead Facility and Reno-Stead Airport. The base served as a stopover and refueling station for airplanes flying from the eastern United States to the Pacific theater during World War II. The base was later used for survival training by the Strategic Air Command, as a helicopter pilot school by the Air Force, and by the Nevada Air Guard before it was finally deactivated on June 30, 1966. During the years of operation the base became known as the Stead Air Base following an airplane crash and resultant death of Croston Stead, a pilot stationed at the base.

During 1966 to 1967 the city of Reno took over the base and on February 26, 1968 the 10.04 square miles of land was incorporated into the city.

Currently the Reno-Stead Airport functions as an uncontrolled non-commercial municipal airport and is the center of the annual Reno Air Races. At the Stead Facility the old military structures are being used by the University of Nevada extension, the U. S. Army Reserve, various air travel-related companies and other small businesses.

Population estimates by the Regional Planning Commission of Reno, Sparks and Washoe County indicate the population of Lemmon Valley was 8,519 in 1973. Based on growth trends they project the population will approximate 16,000 by 1980. With the high level of commercial construction in Reno proper the demands for new housing will weigh heavily on surrounding areas such as Lemmon Valley. The valley is certain to see expansion with the present construction of J. C. Penney's regional warehouse and current restriction on housing construction in Reno.

Current mining within the valley is being made on sources of aggregate and fill. Loose sand and gravel is actively being quarried from beach deposits at the Sha-Neva borrow pit in the east side of the field area. At the Reno-Stead Airport sand is being quarried from loose Tertiary sediment.

PREVIOUS INVESTIGATIONS

The earliest known geologic report to include Lemmon Valley is by Hague and Emmons (1877) who briefly discuss the Granite Hills in the western portion of the field area. Russel (1885) recognized the existence of a Pleistocene lake in Lemmon Valley and shows it on a regional map of Lake Lahontan. Nielsen (1964) mapped the bedrock outcrops in western Lemmon Valley and in Cold Spring Valley. Bonham (1969) mapped the geology of Washoe County, which includes Lemmon Valley, at the scale of 1:250,000. Bonham and Bingler (1973) mapped the Reno quadrangle which borders the eastern portion of the Lemmon Valley field area to the south. Bingler (1975a) mapped the Quaternary geology of Cold Spring Valley which borders the field area to the west.

Rush and Glancey (1967) reported on the ground water environment in Lemmon and Warm Springs Valleys. Harrill (1973) followed with a more comprehensive hydrogeologic study of Lemmon Valley.

METHOD OF INVESTIGATION

Two months of field mapping was done during the period from the summer of 1977 through the winter of 1977-78. The mapping was done on portions of the Reno NW and Reno NE

7.5 minute topographic quadrangles (scale 1:24,000), and on aerial photographs at the scales of 1:60,000, 1:36,000 and 1:26,500. The field area is covered by the majority of the western half of the Reno NE quadrangle and the majority of the eastern half of the Reno NW quadrangle.

One hundred and sixty samples of the sedimentary deposits were collected and analysed. Classification of these samples is based on grain size, mineral composition, and sorting classifications presented by Folk (1954 and 1974). The Wentworth scale was used for grading the samples. The relative percentages of gravel to sand to mud, and the breakdown of the percentages of each division of sand (very coarse to very fine) are visual estimates. Grain sizes of each coarse grained sample were determined by visual comparison with a set of standard grain sizes. Colors and color codes of the various geologic units were determined by comparisons of the samples when dry with the rock-color chart (Geological Society of America, 1951).

The degree of accuracy of the geologic contacts on the accompanying map is variable. Contacts between granitic bedrock and Quaternary sediments are generally distinct. Contacts between granitic bedrock and Tertiary sediment are generally approximate with blending of granitic colluvium and Tertiary sediment. Contacts between all sediments from the Tertiary to the Holocene range from distinct to indistinct and include some contacts concealed by the works of man. The indistinct contacts are due to thinning of these surficial sediments at their distal ends and grading into adjacent sediments. The concealed contacts were located on aerial photographs taken prior to the time the contact was concealed, or were located by inference.

DESCRIPTIVE GEOLOGY

REGIONAL GEOLOGY

The oldest rocks in the region are the presumed Triassic and Jurassic metavolcanic and metasedimentary rocks of the Peavine sequence which have their type section at Peavine Mountain (Bonham, 1969). The rocks formed as thick accumulations in the Cordilleran eugeosyncline and were later intruded by late Mesozoic granitic rocks of the Sierra Nevada batholith.

Geologic events of the early Tertiary period are not recorded in the rocks exposed in the region. However, volcanic rocks of a wide compositional and genetic variety were extruded during Oligocene through Pliocene times, with some intercalated sediments, and are collectively identified as the Hartford assemblage by Bonham (1969).

The assemblage includes early Miocene rhyolitic ash-fall and ash-flow tuff; early to middle Miocene andesite flows and flow breccias; middle Miocene to Mio-Pliocene basaltic and andesitic flows and flow breccias; early Miocene to Pliocene granitic intrusives; Mio-Pliocene dacite flows, flow-breccias, tuffs, tuff-breccias, shallow intrusives, and volcanic sandstone and conglomerate; Mio-Pliocene to middle Pliocene fluviolacustrine sediments, basaltic tuff and olivine basalt.

Some pre-late Miocene or pre-Mio-Pliocene rocks, principally volcanic rocks, have been involved in base-metal epithermal mineralization (Bonham, 1969). The Peavine and Wedekind mining districts south and southeast of the field area are on sites of such mineralization.

Though Tertiary sediment is not as prevalent as Tertiary volcanic rocks, large accumulations of Tertiary sediment occur in other parts of the state (Albers, 1964) in block faulted basins.

Widespread lacustrine deposits accumulated during late Pleistocene "Lahontan time" in western Nevada. Morrison (1964) indicates lacustrine deposits, probably exceeding 1000 feet, accumulated during five major stages of Lake Lahontan. The lake reached a maximum depth of at least 715 feet. Similar lacustrine deposits accumulated in smaller closed basins and glacial deposits developed in the Sierra Nevada during that time.

Subaerial sediments have been accumulating throughout the Quaternary through the processes of gravity, and deposition by water and wind.

LOCAL GEOLOGY

GEOLOGIC SETTING

Lemmon Valley is almost completely surrounded by bedrock mountains comprising Mesozoic metavolcanic, metasedimentary and granitic rocks including granodiorite, quartz monzonite and aplite dikes. These rocks constitute a large portion of the field area. The only other rock type in the valley is a nugatory exposure of Tertiary andesite. All other geologic units in the valley are weakly consolidated or unconsolidated bolson deposits of a wide variety.

Tertiary sediment constitutes the major thickness of sediments in the valley and reaches thicknesses exceeding 800 to 1000 feet. Tertiary sediment also constitutes a large portion of the surficial area in the valley. Many of the younger deposits in the valley are composed of sediments reworked from Tertiary sediment.

Fourteen Quaternary deposits were mapped in the field area. Some of the oldest deposits directly overlie the Tertiary sediment and are extensively dissected and eroded by wind and water action.

Lemmon Valley, being a closed basin, was the site of a large lake which had variable high water levels during the Pleistocene age. At its maximum elevation the lake, named Lake Lemmon, had a surface area of 24 square miles and was 130 feet deep. Deposits associated with Lake Lemmon include beach, forebeach and lake deposits, the later of which were deposited in the center portions of the lake. These deposits grade from coarser to finer from the beach to lake deposits, respectively.

Landslides have developed on oversteepened exposures of Tertiary sediment in the southwest corner of the field area. The sliding appears to be a late Pleistocene event and has since stabilized.

Collectively alluvium, alluvial fans, and alluvial plains occur in all portions of Lemmon Valley. Alluvial fans debouch from bedrock canyons and spread out onto the more shallow sloping land, often coalescing. Portions of nearly all of the Quaternary deposits have been reworked and deposited as alluvium in stream channels or as sheets of sediment on shallow sloping ground. Alluvial plains occur in the lowermost portions of the Silver Knolls sub-area though slightly upslope from the playas.

Five playas with a combined surface area of 2.2 square miles occur in Lemmon Valley. Silver Lake and Lemmon Valley playas occupy the lowest positions in the valley and are sites of annual winter and spring lakes fed by surface runoff.

Unusual dunes composed of clay occur adjacent to the Silver Lake and Lemmon Valley playas. The clay is agglutinated into granules and was transported in that manner by wind from the adjacent playas.

Windblown sand sporadically occurs on the lee side of ridges in the northeast quarter of the field area.

MESOZOIC METAVOLCANIC ROCKS (Mzv)

The metavolcanic rocks are the oldest rocks that crop out in the field area. These rocks are very hard, highly resistant to erosion, and underlie prominent hills in the southwest corner and northwest quarter of the field area. They are in intrusive contact with the younger granodiorite and aplite rocks and are in noncomformable depositional contact with Tertiary sediments and a few Quaternary deposits. Outcrops are rugged and, though rare, usually occur on ridge tops. The map unit includes areas of sandy colluvium containing abundant pebble to boulder size float derived from underlying rock. Many mine workings have been made in the metavolcanic and granitic rocks near the contact of these two rock units. Copper bearing samples are commonly scattered on the surface near these workings.

The metavolcanic rocks are composed predominantly of metamorphosed andesite and dacite with minor occurrences of flow breccia and metasediments. The metavolcanic rocks are greenish gray (5Y 6/1) to light bluish gray (5B 7/1), fresh to very slightly weathered and closely to moderately closely fractured with epidote lining the fractures. In some exposures the rock is moderate pink (5R 7/4) to pale red (10R 6/2) due to alteration. Generally relict volcanic textures can be seen and in very rare instances the original volcanic rock occurs unchanged. Near contacts with the granitic rocks the original volcanic texture is generally indistinct.

The metasedimentary rocks consist of very thinly bedded, i.e., less than one millimeter thick beds of mudstone and in one location a nonbedded pebble conglomerate. The metasediments are fresh, very hard, light olive gray (5Y 5/2) to olive gray (5Y 3/2) and usually occur as float.

The metavolcanic and metasedimentary rocks are part of the Peavine sequence described by Bonham (1969). Based on Mesozoic fossils within the Peavine sequence and the similar age and lithology of the Peavine sequence and the Early to Middle Jurassic Sailer Canyon and Milton Formations in the Sierra Nevada, Bonham has assigned a Mesozoic age for the metavolcanic and metasedimentary rocks.

MESOZOIC GRANITIC ROCKS

GRANODIORITE (Mzgd)

Granodiorite is a prominent rock unit which underlies nearly all of the hills in the periphery of the field area. It is resistant to erosion, being a very hard rock, forming abundant distinct knobby outcrops. Granodiorite has intruded the metavolcanic rocks and is intruded by aplite and quartz monzonite. It is in nonconformable or fault contact with Tertiary sediment and is in nonconformable contact with many of the Quaternary deposits.

The rock is typically a light gray (N7) biotite-hornblende granodiorite. Variations of the composition are either enriched or depleted in the mafic fraction, approaching gabbro and quartz monzonite compositions respectively. The mapped areas contain outcrops of rock and colluvium composed of sand derived from underlying weathered granodiorite. Outcrops are generally fresh and are closely to widely fractured. Very severely weathered exposures are rare.

APLITE DIKES (Mza)

Aplite dikes which have intruded granodiorite occur in large masses surrounded by, or adjacent to, the granodiorite. Small isolated islands of aplite are surrounded by Tertiary and Quaternary sediments. In areas where it has been mapped aplite generally forms abundant low lying outcrops.

The rock is yellowish gray (5Y 8/1) and composed primarily of fine grained quartz and orthoclase. It is very hard, closely fractured and fresh to slightly weathered in exposures.

QUARTZ MONZONITE (Mzqm)

Quartz monzonite is the youngest intrusive rock in the field area. It is a distinctive rock unit which intrudes the granodiorite. It occurs as a large block in the northeast corner of the field area, and as nearby isolated dikes within the granodiorite. The rock type rarely forms outcrops. It is usually very severely weathered and forms a grussy colluvium overlying hill slopes in areas where it is mapped. The rare outcrops are rugged, protuberant and occur on hill tops in these areas.

The rock is a very light gray (N8) to yellowish gray (5Y 8/1) quartz monzonite consisting primarily of quartz, plagioclase and orthoclase with very minor percentages of biotile and hornblende. It is very hard, fresh to slightly weathered in outcrops and is closely to widely fractured.

Based on the intrusive relationship between granitic and Mesozoic metavolcanic rocks and the nonconformable relationship between granitic and overlying Tertiary sediment in other areas, Bonham (1969) places the age of the granitic rocks at Mesozoic, specifically Cretaceous in age.

TERTIARY ANDESITE (Ta)

One small isolated outcrop of an andesite flow occurs at the northernmost border of the field area. The outcrop is perched on a hill top overlying granodiorite and is bisected approximately by the east-west section line which bounds the field area.

The rock is an andesite and is light brown (5YR 5/6) to pale reddish brown (10R 5/4) on weathered surfaces and dark gray (N3) on fresh surfaces. It is very hard, very slightly weathered and very closely to closely fractured. It yields a rubble talus lying on the flanks of the hill.

The rock is probably part of the lithologically similar Alta Formation of many areas north of Reno and Sparks. The closest known exposure of the Alta is one quarter mile south of the field area.

TERTIARY SEDIMENT (Ts)

Tertiary sediment is a prominent geologic unit in Lemmon Valley. Major exposures occur in the Silver Knolls sub-area from Silver Lake to the northern boundary of the field area and from south of the Stead Facility to a mile north of the Reno corporate boundary. The upper surface of the sediment in these locations lies at elevations intermediate between the bedrock peaks and alluvial lowlands. Isolated exposures are in the extreme northwest and southwest corners of the field area and in stream channels cut through the locally overlying alluvial fan deposits of Peavine Mountain in the south. Exposures of Tertiary sediment were not seen in the easternmost portion of Lemmon Valley.

Based on reported thicknesses of sediments penetrated by various wells drilled in the valley, the Tertiary sediment exceeds 800 feet and is as much as 1000 feet in depth. One well drilled east of the East Lemmon playa completely penetrated the Tertiary sediment and encountered bedrock at 850 feet. Harrill (1973) indicates one well drilled at Silver Lake encountered bedrock at 1055 feet and three wells drilled northwest of the airport partially penetrated the Tertiary sediment at depths exceeding 800 feet.

Tertiary sediment unconformably overlies Mesozoic bedrock exposed in the field area. Locally dip-slip fault movement has occurred along the contact of these units. The Tertiary sediment is unconformably overlain by many of the

Quaternary deposits in the valley.

In large portions of the Silver Knolls sub-area the upper surface of the Tertiary sediment is a deeply incised, shallow sloping, eroded pediment surface. This surface resembles a bowl sloping from the valley westward up to the granitic outcrops and eastward up to the low ridge east of the airport. A thin pediment gravel layer (Qpg) which once covered a large portion of this surface has been extensively eroded. It now occurs only in patches and as a lag gravel intermixed at the ground surface with the Tertiary sediment.

As observed in exposures throughout the field area the Tertiary sediment is rarely lithified. Most commonly it exists as loose deposits with indistinct structural features. This makes it virtually impossible to measure the thickness and determine the type and degree of bedding within the Tertiary sediment. It is rarely possible to measure the strike and dip of these sediments. However, bedding can be seen in recent man-made cut sections adjacent to railways and roadways. Some fresh exposures can be observed in deeply incised stream channels near the mouths of granitic bedrock canyons.

The Tertiary sediment is composed primarily of sand in all textural sizes. The sand is arkose to impure arkose and comprises poorly sorted coarse to fine sand, moderately well-sorted medium to very fine sand and slightly granular very coarse to medium sand. Dominant colors of the sands are grayish orange (10YR 7/4), pale yellowish brown (10YR 6/2), dark yellowish brown (10YR 6/6), pale brown (5YR 5/2) and yellowish gray (5Y 8/1), though a wider range of colors was observed. Less commonly, clay, fine sandy clay and sandy mud, and silt form the Tertiary sediment. These finer sediments are usually grayer than the sand and include light olive gray (5Y 6/1) to yellowish gray (5Y 8/1), pinkish gray (5YR 8/1) and very pale orange (10YR 8/2). Rarely outcrops of well-rounded pebble gravel composed of metavolcanic, metasedimentary, granitic, and volcanic rocks occur in patches near bedrock outcrops and exposures of lithified Tertiary sediment.

Anomalously lithified Tertiary sediment crops out in several isolated locations directly adjacent to granitic or metamorphic bedrock. Sandstone beds up to two meters thick occur in two locations northeast of the airport runways and in a few locations in the far northwest. These sandstone beds are very hard to moderately hard, crop out boldly relative to softer surrounding sediment and dip at angles between 35 and 45 degrees.

The sandstone beds are lithologically similar in all locations. They are yellowish gray (5Y 7/2) to grayish orange pink (5YR 7/2), arkosic and consist predominately of subrounded to subangular, pebbly coarse sandstone to sandy granule conglomerate. One outcrop consists of moderately well sorted fine sandstone and contains fossils of plant stems. Generally the rocks are not bedded though cross-bedding was observed in one location.

Adjacent to one of these sandstone outcrops a bed of fresh, light olive gray (5Y 5/2) cryptocrystalline silicified rock is partially exposed. The rock is very closely fractured and soft though individual fragments are very hard.

In a few locations within the Tertiary sediment partially lithified ash and diatomite are exposed. These rocks are white to very light gray (N8), very soft to soft and closely fractured into angular blocky or platy fragments. At the ground surface these rocks are completely weathered.

No useful fossil evidence was discovered nor have radiometric dates been made of the Tertiary sediment in Lemmon Valley. The age of the sediment is therefore based on work done outside the valley on thick accumulations of sediment of similar origin. The sediment in Lemmon Valley was deposited in a basin similar to many in Nevada which received large quantities of sediment during the Tertiary Period. Albers (1964) concluded that the bulk of this sedimentation formed between 8 and 13 million years ago. Outcrops of Tertiary sediment in the northwest and southwest corners of the field area are contiguous with Tertiary sedimentary rocks mapped by Bingler (1975a) in Cold Spring Valley. Bingler indicates those rocks are probably coeval with the sandstone of Hunter Creek mapped in the Reno quadrangle. Parts of the Hunter Creek may be as old as 10 million years and the uppermost beds as young as Blancan (Bingler, 1975b)

QUATERNARY DEPOSITS

ALLUVIAL FAN DEPOSITS OF PEAVINE MOUNTAIN (Qpf)

The alluvial fan deposits of Peavine Mountain is an informal term used by Bonham and Bingler (1973) for semi-lithified gravelly deposits exposed in Lemmon Valley and other areas north of Reno. These deposits are exposed in the south-central portion of the field area and are generally one meter to three meters thick. At the northern distal end of the alluvial fan deposits of Peavine Mountain, deep channels incised through these deposits expose the underlying Tertiary sediment.

The western extent of these deposits is a seemingly gradational contact with the older alluvium - 1. However, farther to the west the older alluvium - 1 has a texture and color which are distinctly different from the alluvial fan deposits of Peavine Mountain.

These alluvial fan deposits are composed of semi-lithified, poorly bedded and poorly sorted, slightly muddy sandy pebble to cobble gravel. At the ground surface the mud matrix is usually winnowed or washed away leaving a sandy granule gravel to pebble gravel layer. The clasts are rounded to angular and contain white altered andesite and dark greenish gray metavolcanic rocks. The muddy matrix and coating on gravel gives the sediment high chromatic colors including moderate reddish brown (10R 4/6) and dark yellowish orange (10YR 6/6) to dark yellowish brown (10YR 4/2).

These deposits are gently dipping and are faulted in a normal sense. At the ground surface a desert pavement occurs locally and some clasts have ventifacts and desert polish.

Near Reno alluvial fan deposits of Peavine Mountain underlie all known glacial deposits in the Truckee River system and are tentatively regarded as early Pleistocene in age (Bingler, 1975b).

PEDIMENT GRAVEL (Qpg)

Evidence of a pedimented surface is present in the valley as remnants of a pediment gravel layer which lies unconformably on the Tertiary sediment. Eroded remnants of this pediment gravel occur as patchy deposits on shallow sloping hills west and northwest of the airport and on low-lying peaks immediately east and northeast of the airport runways.

The pediment gravel is generally less than a meter thick and may be one to two meters thick east of the airport. In rare vertical sections cut through the pediment gravel, it was observed to overlie the Tertiary sediment with a sharp contact. Laterally, the pediment gravel tapers off and is intermixed at the ground surface with the Tertiary sediment.

A disperse veneer of lag gravel lies on the erosion surface cut on Tertiary sediment in many areas. This veneer is the eroded remains of the pediment gravel which once covered large areas of the Tertiary sediment in the geologic past. Streams have since eroded the layer and deeply incised the underlying Tertiary sediment.

The pediment gravel has probably undergone extensive winnowing of its finer textured material. Clasts within the pediment gravel, especially east of the airport, have ventifacts up to 1/8 inch deep and a desert polish, both indicative of wind erosion.

The pediment gravel is composed predominantly of poorly lithified to unconsolidated, subrounded, sandy granule to cobble gravel and pebbly very coarse sand. Variations in texture range to slightly pebbly muddy coarse to medium sand. Rare boulder size gravel is contained within this deposit.

The gravel is composed of a wide range of lithologic types. These include the granitic rocks granodiorite and quartz monzonite; metavolcanic rocks; metasedimentary rocks comprising chert, schist, quartzite and metaconglomerate; petrified wood; and an unexpectedly large percentage of volcanic rocks, generally andesite and rhyolite (volcanic rocks are rarely exposed in the valley). The relative percentage of each rock type varies with the location.

Regardless of the multilithologic types comprising the gravel, a ubiquitous weather staining on the clasts and sand causes the pediment gravel to be consistently pale brown (5YR 5/2) and pale yellowish brown (10YR 6/2) to dark yellowish brown (10YR 4/2).

A desert pavement occurs in several locations on the surface of the pediment gravel. It probably formed by deflation of finer grained particles and settling of the coarser portion remaining at the ground surface. Recent research has shown that desert pavements underlain by soils containing expanding lattice clays may have been produced not by deflation but by heaving to the surface of the larger clasts by the expanding clays (Howard and others, 1977). However, the preponderance of sand in the underlying Tertiary sediment and the presence of ventifacts and desert polish on the clasts points to an origin by deflation in Lemmon Valley.

The pediment gravel is not in contact with any other Quaternary deposits in the valley except for overlying Holocene windblown sands. However, the gravel is a local source for the late Pleistocene and Holocene alluvium. The lack of contacts with older Quaternary deposits makes correlation or determination of relative ages of the pediment gravel to other deposits difficult. Due to extensive erosion and faulting of the pediment gravel this geologic unit may be closely related in time to the early Pleistocene alluvial fan deposits of Peavine Mountain.

OLDER ALLUVIUM - 1 (Qoa-1)

Older alluvium - 1 is a term used in this report to distinguish alluvium of probable pre-Lake Lemmon sedimentation (beach, forebeach and lake deposits), or pre-Wisconsin stage, from the younger geologic units named older alluvium - 2 of late Pleistocene to Holocene age, and alluvium of Holocene age. Older alluvium - 1 is exposed in the northeast, north-central and southwest portions of the field area.

The deposits at these three locations are descriptively grouped together even though they have different provenances and each is lithologically distinct. At each location the older alluvium - 1 is extensively dissected and eroded.

Exposures of older alluvium - 1 in the northeast portion of the field area comprise decomposed quartz monzonite from exposures of that rock type at higher elevations to the northeast. The very pale orange (10YR 8/2) to moderate yellowish brown (10YR 5/4) color of the sediment contrasts sharply with exposures of underlying granodiorite at that location. There the older alluvium - 1 is composed of arkosic slightly granular coarse to medium sand.

In the northwest older alluvium - 1 occurs as several isolated and deeply eroded patches, some of which directly overlie Tertiary sediment. The deposit is composed of arkosic, cobbly to pebbly, very coarse sand and sandy pebble to cobble gravel. Boulders lie on the surface of some ridge tops in that location. The gravel is composed of quartz monzonite, large crystals of perthite, and volcanic rocks; these fragments were apparently transported from areas to the north and outside the field area. The larger clasts are weather stained and have desert polish and ventifacts on the surface.

In the southwest portion of the field area the older alluvium - 1 consists of a very poorly sorted mixture of sediments ranging from cobble gravel to mud. This deposit ranges from muddy pebble and cobble gravel to slightly pebbly coarse sandy mud. The gravel consists of subrounded to angular metavolcanic rocks eroded from Peavine Mountain to the south. The medium gray (N5) color of this deposit contrasts with the adjacent, more reddish alluvial fan deposits of Peavine Mountain. The older alluvium - 1 at this location unconformably overlies Tertiary sediment.

The older alluvium - 1 deposits are probably of early to middle Pleistocene age due to their position directly overlying Tertiary sediment and the extensive erosion of these deposits.

BEACH DEPOSITS (Qb)

The beach, forebeach and lake deposits are sediments deposited by the waters of a Pleistocene lake that once filled large portions of the valley. That lake has been named Lake Lemmon by Hubbs and Miller (1948) and though the name has not been used by other authors referred to here, the name is used in this study. The existence of a Pleistocene lake in Lemmon Valley was recognized and first recorded by Russell (1885) in his studies of Pleistocene Lake Lahontan. Subsequently, various authors, referred to in this section, made studies of Lake Lahontan and Pleistocene lakes in general. These authors make direct reference to a lake in Lemmon Valley or simply present it on a map of Pleistocene lakes in the western states.

Evidence that Lake Lemmon occupied Lemmon Valley to an elevation of at least 4980 feet is substantial. Features in the northern East Lemmon sub-area such as the elongate beach deposits and adjoining lagoon deposits (east and outside of the field area); a general gradation of sediment from coarser material at the beach becoming finer toward the deepest portions of the lake; and an abrupt break in topography on the lake side of the beach are remnants of a lake which had a stabilized elevation in the geologic past. As well developed as these features are, Mifflin and Wheat (1977) indicate that in comparison with the development and preservation of landforms associated with Pleistocene Lake Lahontan in other parts of the state, the Lemmon Valley landforms are weakly developed and have limited preservation.

Poorly developed shore features directly east of the field area, first reported by Hubbs and Miller (1948), indicate Lake Lemmon stabilized at an elevation of approximately

5050 feet. This elevation is highly significant since it also represents the highest lake level attainable in the valley. A drainage divide between Lemmon Valley and Hungry Valley to the east is at the approximate 5050 foot elevation. Lake water exceeding this elevation would discharge into Hungry Valley.

Free (1914) first presented the idea of waters from Lake Lemmon spilling over into Hungry Valley and then into Lake Lahontan. As proposed, the stream course passed through Hungry Valley and then into Warm Springs Valley, located to the northeast. Stream flow finally reached Lake Lahontan, a bay of which occupied a small portion of Warm Springs Valley through a gap in the Virginia Mountains. This hypothesis is supported by Hubbs and Miller (1948) and Snyder and others (1964).

Measuring from the 5050 foot maximum elevation of Lake Lemmon to the 4920 foot present elevation of the valley floor the lake had a maxiumum depth of approximately 130 feet. Subsequent to desiccation of the lake, deflation of the Lemmon Valley playa has been significant areally though not enough in depth to strongly affect this approximation. At its maximum possible elevation Lake Lemmon had a surface area of about 24 square miles.

Beach deposits which occur in several locations within Lemmon Valley could represent fluctuating lake levels (Twenhofel, 1932, p. 824) or stable lake levels combined with strong wave action. These deposits occur as strands of sediment at equal elevations on sloping ground or patches of sediment on nearly flat-lying ground. All of the deposits are incised by more recent stream channels and are covered partially by younger subaerial sediments. Probably the beach deposits directly overlie Tertiary sediment and older alluvium - 1 though contact relationships were not observed in the field.

The best exposures of beach deposits occur in two locations in the East Lemmon sub-area. Of the two, the best preserved deposits occur in the central and east central portion of that sub-area at an elevation of 4980 feet. For several years loose aggregate has been mined from the beach deposits in the Sha-Neva borrow pit at that location.

The second exposure occurs south of the main exposure of beach deposits at an elevation of approximately 4930 to 4940 feet. The beach at that location functioned as a barrier to surface water flowing from the northeast. As a result a lagoon developed northeast of this beach and occupied a position much lower in elevation than the strand line at the 4980 foot elevation. This beach is difficult to distinguish in the field though the high water strand line associated with the beach and less distinct strand lines, which developed during desiccation of the lagoon, can be readily seen on high altitude aerial photographs.

Strand lines in the Silver Knolls sub-area are more weakly developed than those in the East Lemmon sub-area. The most dominant strand line occurs southwest of the airport at an elevation of approximately 4970 feet. A series of weaker strand lines (recognizable on aerial photographs) occur immediately to the south of this dominant strand line in the forebeach deposits. The occurence of strand lines higher in elevation than 4970 feet in the Silver Knolls sub-area is rare. One subtle, poorly developed, and eroded set of strand lines associated with beach deposits occurs west of the Reno-Stead Airport at an elevation of 5015 to 5025 feet.

Cut sections in the beach deposits can be seen in the Sha-Neva borrow pit on the east side of the field area in sections 14 and 23, T.21 N., R.19 E. There the beach deposits consist of interbedded granular very coarse sand, sandy pebble gravel, and well sorted granule gravel. Cross-beds in the sand dip 30 degrees to the west. These deposits are yellowish gray (5Y 8/1), arkosic and contain subrounded to subangular grains. Surface exposures in other areas of the valley are stained and are pale yellowish brown (10YR 6/2) to dark yellowish brown (10YR 4/2) and moderate yellowish brown (10YR 5/4). These deposits consist of slightly granular to granular medium to coarse sand and moderately sorted coarse to medium sand.

Fossil bones were found in the Sha-Neva pit eight feet down from the original ground surface in the southwest corner of the southeast quarter of section 14, T.21 N., R.19 E. James R. Firby (oral communication, 1978) identified the bones as Camelops sp. and suggested an age of 10,000 to 70,000 years b.p. This falls within the range of the Wisconsin Stage.

FOREBEACH DEPOSITS (Qfb)

Forebeach deposits are subaqueous granular sediments formed in shallow near-shore waters of Lake Lemmon. These deposits are shallow-sloping, lie between the beach deposits and the flat-lying lake deposits, and grade from coarser material near the beach deposits to finer material near the lake deposits. The forebeach deposits occur in two general isolated locations at lower elevations of both the Silver Knolls and East Lemmon sub-areas. In the East Lemmon subarea there is a distinct break in topography between forebeach deposits and beach deposits; the latter lie at a higher elevation.

In the Silver Knolls sub-area forebeach deposits are in contact with, and contain coarse material derived from, alluvial fan deposits of Peavine Mountain. Several younger deposits overlie the forebeach deposits in both sub-areas.

On aerial photographs numerous strand lines are seen to cross forebeach deposits in both sub-areas. These lines probably formed during late stages of desiccation of Lake Lemmon.

The forebeach deposits include a wide range of textures. In the East Lemmon sub-area near the largest accumulations of beach deposits, the forebeach deposits generally contain a poorly sorted mixture of coarse and fine grained sand and fine gravel. This mixture includes granular coarse sand to slightly granular muddy very fine sand. Away from these main beach deposits the sediments are finer textured and include moderately sorted silty fine sand, muddy very fine sand and very well sorted very fine sand. The sediment is composed of pale yellowish brown (10YR 6/2) to moderate yellowish brown (10YR 5/4) and yellowish gray (5Y 8/1) arkose to impure arkose.

In the Silver Knolls sub-area the forebeach deposits contain granular very coarse sand and sandy granule gravel near the beach deposits and alluvial fan deposits of Peavine Mountain. Away from these deposits the forebeach deposits grade to moderately sorted and muddy very fine sand. In that sub-area the forebeach deposits are pale yellowish brown (10YR 6/2) and grayish orange (10YR 7/4) to moderate yellowish brown (10YR 5/4) and are composed of arkose to feldspathic graywacke.

The forebeach deposits are coeval with beach deposits having been formed in late Pleistocene.

LAKE DEPOSITS (Ql)

Lake deposits occur at valley floors in both the Silver Knolls and East Lemmon sub-areas at nearly the lowest surface elevations in the valley. Though contact relationships are not exposed the lake deposits probably directly overlie Tertiary sediment with an unconformable contact.

Because of their light color and fine texture the lake deposits are easily distinguished from surrounding Quaternary deposits. They are overlain by alluvium, older alluvium - 2, alluvial fan deposits, clay dunes, scattered windblown sands and playa sediments. Also, the lake deposits appear to be overlain by a veneer of forebeach deposits near the contact of these two geologic units. However, the two deposits may have an interfingering relationship. The principal thickness of the lake deposits probably accumulated when Lake Lemmon was at or near its highest lake level. Forebeach deposits overlying the lake deposits formed when the lake was at a lower level.

The lake deposits are flat lying, thin bedded, and composed of yellowish gray (5Y 8/1), pale yellowish brown (10YR 6/2), light gray (N7) and medium light gray (N6) clay.

East of the airport lake deposits are cut by numerous shallow anastomosing stream channels. These channels collectively discharge into the Lemmon Valley playa by way of two main channels which bypass or dissect clay dunes. During winter months the lake deposits locally become flooded from direct precipitation.

LANDSLIDE DEPOSITS (Qls)

Landslide deposits comprising a surface area of approximately 140 acres occur in the southwesternmost corner of the field area and in areas adjacent to that location outside the field area. The landslide deposits are composed of sandy and gravelly Tertiary sediment.

The deposits formed as a result of sliding, possibly due to oversteepening of Tertiary sediment. The landslides come under the classification of rotational bedrock slides (Eckel, 1958). Islands of Tertiary sediment overlain by older alluvium - 1 occur surrounded and unaffected by the landslide deposits.

The landslides appear to be stabilized and the deposits are incised by streams. Though the age of the landslides and deposits is unknown, they post-date older alluvium - 1 which is involved in the sliding, and predate alluvium. Potentially the sliding occurred during the late Pleistocene (Wisconsin) age.

Minor debris slides, not indicated on the geologic map, occur on the steep lower faces of Granite Peak north of Highway 395.

OLDER ALLUVIUM - 2 (Qoa-2)

Older alluvium - 2 is a name for Quaternary alluvial deposits which are younger than the sediments of Lake Lemmon though older than the alluvium. These deposits occur in two locations south and north of the Lemmon Valley playa, and rest unconformably on beach, forebeach, and lake deposits. North of the playa the older alluvium - 2 overlies beach deposits and is in turn overlain by alluvium. South of the playa older alluvium - 2 is overlain by alluvium and alluvial fan deposits.

The deposits at each location are distincly different. North of the playa older alluvium - 2 was probably derived principally from older alluvium - 1. The deposits at that location consist of pale yellowish brown (10YR 6/2) to moderate yellowish brown (10YR 5/4), arkosic, moderately sorted medium sand and slightly gravelly medium to fine sand.

South of the playa older alluvium - 2 is derived primarily from alluvial fan deposits of Peavine Mountain. Older alluvium - 2 at that location is composed of moderate yellowish brown (10YR 5/4) pebbly very coarse sand to granular coarse sand. Toward its distal end near the playa the deposit grades to a granular medium sand. The gravel is composed predominately of altered andesite and the sand is a feldspathic graywacke.

Because of their position with respect to older Lake Lemmon sediments and younger alluvial deposits, the older alluvium - 2 was probably deposited during late Pleistocene.

ALLUVIAL FANS (Qf)

Material derived from the weathered bedrock hills is deposited near the mouths of bedrock canyons as fans of alluvium on adjacent lowlands. These alluvial fans spread out from mouths of bedrock canyons in nearly all areas of the valley where bedrock crops out. In some areas, such as north of the Lemmon Valley playa, these fans coalesce to form a bajada.

The mineral and textural composition of the fans is dependent on local bedrock lithology and as such is highly varied. The fan deposits consist of slightly granular to granular coarse sand and slightly pebbly to moderately sorted medium sand. Boulder gravel debris flows occur sporadically at the mouths of bedrock canyons. Colors of the deposits are typically pale yellowish brown (10YR 4/2) to dark yellowish brown (10YR 4/2) and moderate yellowish brown (10YR 5/4) and are less commonly light olive gray (5Y 6/1). The sediment is generally arkosic due to the preponderance of granitic bedrock exposures.

Contacts between alluvial fans and alluvium are generally gradational though they are commonly marked by a break in slope.

Near their apices, north of the Lemmon Valley playa, alluvial fans are locally overlain by Holocene eolian sands. Portions of the eolian sand have been reworked and deposited near the toes of the fans on areas actively receiving sediment. Thus the fans range in age from probable late Pleistocene to the present.

ALLUVIUM (Qa)

One of the most widespread Quaternary deposits in Lemmon Valley is the alluvium. This geologic unit consists of reworked sediment derived from all other geologic units in the valley except playa deposits. The alluvium occurs in narrow stream channels incised into granitic and metamorphic bedrock and Tertiary sediment, and as shallow sloping sheets of sediment spread onto lower portions of the valley.

The alluvium has a very wide range of textural and mineralogical compositions. Basically the alluvium is composed of moderately to poorly sorted medium to fine sand and granular coarse to medium sand. Some very poorly sorted sediments composed of slightly granular and pebbly silty very fine sand occur. The mineral composition is generally arkose to impure arkose though variations include feldspathic graywacke and graywacke especially in the southern portion of the field area. Colors of these deposits are generally pale yellowish brown (10YR 6/2) to dark yellowish brown (10YR 4/2), moderate yellowish brown (10YR 5/4) and pale brown (5YR 5/2).

Sediments are actively accumulating as alluvium indicating a Holocene age of these deposits. However, some areas of the alluvium may be as old as late Pleistocene.

ALLUVIAL PLAINS (Qap)

Alluvial plains exist in the Silver Knolls sub-area from a short distance north of the Silver Lake playa to nearly the northern border of the field area, and as minor occurrences surrounded by alluvium or Tertiary sediment. The alluvial plains are nearly flat-lying having slopes of only 30 feet per mile. They occupy lower portions of the sub-area and receive runoff and sediment from deposits at higher elevations. During times of heavy precipitation the alluvial plains may become flooded with shallow standing water.

The deposits in these alluvial plains are fine textured. They include moderately sorted to well sorted fine to very fine sand, and sandy clay and mud. Colors are pale yellowish brown (10YR 6/2) to dark yellowish brown (10YR 4/2) in the sands and light olive gray (5Y 6/1) in the muds and clays.

The alluvial plains probably began forming in late Pleistocene and are continually receiving sediment.

WINDBLOWN SAND (Qws)

Abundant deposits of windblown sand are located sporadically in the northeastern quarter of the field area. This windblown sand is a distinct depositional unit and, where deposited, contrasts sharply with granitic bedrock, Tertiary sediment, and other Quaternary deposits it rests on. The sand generally lies on the northeast or north sides of ridges at elevations up to 5800 feet. Where wind-blown sand is located at the mouths of bedrock canyons it is deeply incised.

The windblown sand is composed of moderately well sorted to well sorted medium sand. It is moderate yellowish brown (10YR 5/4) to grayish orange (10YR 7/4), arkosic, and subrounded to subangular. Frosting is weakly developed on the sand grains. In some areas the windblown sand has a veneer of scattered coarse sand, granules and pebbles washed down from coarser sediments or outcrops of igneous rock at higher elevations.

The windblown sand is probably derived principally from sandy Tertiary sediment. The sand was moved by southwesterly winds and deposited on the lee side of ridges. McKinney (1976) reported similar eolian sands moved by southwesterly winds in the Carson City area. Within Lemmon Valley features such as deflated playas and winnowed Quaternary deposits, and desert polish and ventifacts on gravel and bedrock outcrops indicate a period of intense wind action in the valley. As such the windblown sand was probably deposited during the dry windy Altithermal age described by Antevs (1948). He indicates the Altithermal occured 4000 years B.P.

CLAY DUNES (Qcd)

Unusual wind blown deposits in the form of dunes and composed primarily of clay occur in three locations in Lemmon Valley. The term "dune" usually implies a mound or ridge of eolian origin composed wholly or predominately of sand. Clay dunes are unusual since clay would expectedly be dissipated by the wind rather than accumulated into elongate ridges as it is in Lemmon Valley. Clay dunes are not rare however. Coffey (1909) reported on clay dunes in south Texas near Raymonville which formed ridges several miles long, 30 feet high and up to 300 yards wide. He indicates the clay exist as granules and almost always is associated with a lagoon. Johnson (1902) and Meinzer (1911) report on clay dunes adjacent to saline lakes in eastern Valentia County and Estancia Valley, New Mexico. Stone (1956) observed silt-clay dunes at almost all of the seventy-three dry lakes he studied in southeastern California and western and southwestern Nevada. A grain size analysis of samples from silt-clay dunes at Rosamond, El Mirage and Buckhorn Lakes by Stone revealed an average content of 43% clay, 24% silt and 35% sand. Butler (1956) borrowed the aboriginal term "parna" and applied it to vast thin sheets of wind blown clay which he studied in the Riverine Plain of southeastern Australia. The sheets are everywhere less than ten feet thick yet have a surface area exceeding 150 miles in length. He uses the term "dune parna" for dunes composed predominately of clay. Since "parna" refers primarily to sheet-like deposits and since the term has not entered into American usage the term is not adopted in this study.

Coffey (1909) interpreted the dunes in Texas to have originated from the adjacent lagoon sediments as follows:

> "During dry weather these lagoons became partially or entirely dry, and the mud then cracks and curls up, giving the wind a chance to get hold upon the material which is then broken up by its action into small grains and driven out upon the surrounding higher land. The wind velocity in this section is rather high and prevailingly from the southeast; therefore the dunes are formed principally upon the northwest side of the lagoons. As soon as the small gran-

> ules of clay are blown out of the lagoons they encounter vegetation and are stopped. The first rain causes them to break down and coalesce, thus forming a compact mass which is no longer moved by the wind."

Though Huffman and Price (1949) differ slightly in their interpretation of formation of the clay granules at that site the hypothesis as presented by Coffey is applicable to the clay dunes in Lemmon Valley.

The Lemmon Valley dunes are in three locations: one adjacent to the Silver Lake playa and two adjacent to the Lemmon Valley playa. The Silver Knolls clay dune is on the north side of the playa and trends northwest-southeast. It is roughly arcuate in plan, being concave to the northeast. The dune is about 1.8 miles long and 600 feet to 3500 feet wide. The crest is about 24 feet above the Silver Lake playa and 12 feet above the surface of a small playa bounding a portion of the dune to the north side.

Two clay dunes occur in the East Lemmon sub-area adjacent to the Lemmon Valley playa. The larger dune is located on the northeast side of the triangular shaped playa, trends north-northwest, is smooth in outline and is faintly concave to the southwest. It is 2.1 miles long and from 400 to 1600 feet wide. The crest of the dune is about 30 feet above the Lemmon Valley playa and 18 feet above lake sediments northeast of and adjacent to the dune. The smaller of the two dunes is located on the northwest side of the playa, trends northeast-southwest and is relatively sinuous in outline. It is about 4500 feet long and 1200 feet wide. The crest is about 18 feet above the playa and 9 feet above the alluvium located to the northwest of the dune.

Each dune is consistently similar in color and textural composition. The dunes are composed of dark yellowish brown (10YR 4/2) to light brownish gray (5YR 6/1) clay to slightly sandy silty clay. At the ground surface the clay occurs as agglutinated angular granules. Neither soil horizons nor eolian bounding surfaces were observed in the dunes.

The clays are highly expansive possibly indicating a montmorillonitic composition. When wet the clays are very sticky and very plastic. When the clay desiccates polygonal cracks form on the ground surface of the dune and the clay, at and near the ground surface, segregates into angular granules.

Each of the three dunes in Lemmon Valley has a topographically abrupt smooth line contact with their respective playa and a more sinuous topographically gradational contact with sediments on the opposite side of the dune. Meinzer (1911) observed a similar relationship with clay dunes and salt flats in New Mexico. Several elongate ridges can also be detected on each dune in Lemmon Valley. The ridges parallel the long axis of the respective dune.

The material contained within the dunes originated in the adjoining Silver Knolls and Lemmon Valley playas and are "source bordering lee dunes" (Melton, 1940). Genesis of the dunes by wind action is supported by differences in elevation between the playa, or windward side of the dune, and the lee side of the dune which is consistently higher in elevation. This elevation difference is inferred to be the result of deflation of the playa. Other factors such as the dunes' positions adjacent to the playa; sets of parallel ridges within each dune; and orientation of the long axes (consistent with a common wind direction) point to an eolian origin.

Many factors indicate the dunes are of pre-late Holocene age. The dunes are stabilized with sagebrush growing on the surface and do not show signs of receiving appreciable new material from the playas. Each dune is dissected by two or more stream channels which drain into the playas. Since the dunes and other eolian features in the valley (windblown sands, ventifacts and desert polish) indicate a strong eolian event in the geologic past, and since these dunes are well preserved, though not of late Holocene origin, they probably formed during the dry windy Altithermal.

The orientation of the axes of each dune indicates they formed transverse to a prevailing southwesterly wind direction. Currently winds are westerly and northwesterly. Other features in the valley such as ventifacts observed on southwest facing surfaces of granitic outcrops, and abundant deposits of windblown sand on south and southwest sides of mountain canyons indicate a southwesterly direction of wind movement in this region during the geologic past.

The presence of channels cut through the centers of these dunes indicates they once functioned as dams to water moving either from the playa area to the opposite side of the dunes, or vice versa. Larger accumulations of water than presently exist in the valley are known to have existed in the basin subsequent to the Altithermal age. Hubbs and Miller (1948) site archeological evidence in support of this.

The water was probably more abundant in playa areas since the playas currently accumulate the most surface water. Ponded water breached and incised channels in the dunes. Currently small discharges upstream from the dunes move through the channels in a direction reverse to the original stream flow and discharge onto the playas.

PLAYAS (Qp)

Five playas are located in Lemmon Valley: four in the Silver Knolls sub-area and one in the East Lemmon sub-area. The word "playa" is a physiographic term of Spanish origin defined by Thompson (1929) as "nearly level areas of alluvium in the lowest part of closed basins in arid regions which in wet seasons may be covered with temporary lakes and which are generally devoid of vegetation".

The largest playa in the valley, the Lemmon Valley playa, occurs east of and 130 feet lower in elevation than the Reno-Stead Airport. It has a relatively distinct, roughly triangular outline and a surface area of 1.3 square miles.

The Silver Lake playa occurs in the Silver Knolls sub-area, southwest and 100 feet lower in elevation than the airport. It has a surface area of 0.7 square miles and a distinct outline.

Three smaller playas are located in the Silver Knolls sub-area and have a combined surface area of 0.2 square miles and are slightly higher in elevation than the Silver Lake playa. These playas have less distinct outlines than the two larger playas.

Each of the five playas is a topographic depression and thereby actively receives surface water runoff and sediment from surrounding portions of the basin. During winter months the playas flood and become sites of ephemeral lakes. The water evaporates during the dryer months and a dry flat-lying surface remains.

The playa sediments are composed of loose, olive gray (5Y 4/1) to yellowish gray (5Y 8/1) and pale yellowish brown (10YR 6/2), slightly pebbly to granular mud and well sorted very fine sand and silt. When dry the surfaces of the playas range from puffy, in the two larger playas, to a crusty pavement-like surface on the three smaller playas.

Each of the playas is in a location where lake sediments accumulated during the Pleistocene. Silver Lake and Lemmon Valley playas are partially bound by lake sediments.

Major deflation of these two playas began about 4000 years B.P. during the dry windy Altithermal (see Quaternary clay dunes).

Relative rates of sedimentation versus deflation are not known for these playas. However, dust storms caused by deflation of the playas by dry summer winds are substantial enough to be a nuisance to local residents.

STRUCTURAL GEOLOGY

REGIONAL TECTONICS

An account of the pre-Cenozoic regional structural evolution, largely abstracted from Wallace (1964), must encompass large areas of the state of Nevada. Four periods of mountain building affected Nevada subsequent to the Precambrian Era and have been responsible for structural patterns observed within mountain blocks across the state.

During the Paleozoic Era chert, shale, silty sandstone and volcanic rocks of the "western assemblage" and limestone, dolomite and lesser quartzite and shale of the "eastern assemblage" formed in eugeosynclinal and miogeosynclinal troughs of the Cordilleran geosyncline. The continental margin was east of Nevada during that time while major thicknesses of these sediments accumulated at the present location of the state.

During the late Devonian Period the Antler orogeny began and is distinctly marked by the Roberts Mountain thrust. Along that thrust rocks of the western assemblage traveled eastward and over the eastern assemblage rocks at least 90 miles. The classic interpretation states that a north-northeast trending structural rise developed across the center of the state and was the terminus for gravity sliding lobes which moved in a shallow downhill and eastward sense along the Roberts Mountain thrust. A recently developed contrary hypothesis suggests an obductive mechanism whereby offshore sea-floor spreading centers forced western assemblage sediments eastward and slightly uphill over their eastern counterpart.

Though reference was not made to the obduction hypothesis, Van Wormer and others (1974) concluded from seismic evidence that a 50 km thick section of continental material near the Aleutian trench is being "rafted" over a subducting limb of oceanic crust. Apparently this rafting occurs along a shallow dipping thrust fault miles from the subduction zone. This evidence supports the obduction hypothesis as the mechanism of thrusting in Nevada. However, the direction of movement of the thrust (or rafted) plate, driven by this mechanism would require a spreading center east of the eastern assemblage sediments. Later periods of thrusting in Nevada developed westward-moving thrust plates which could be explained by the process of rafting.

Following a period of continued sedimentation, thrusting occurred again during the Permian Period in association with the Sonoma orogeny. As a result the Golconda thrust developed in north-central Nevada.

Marine sediments and volcanic rocks were deposited over wide areas of Western Nevada during the Triassic and Early Jurassic time. The Peavine sequence is a local remnant of those deposits. Middle and Late Jurassic and Early Cretaceous mountain building followed the Mesozoic sedimentation and was accompanied by additional thrusting in the western portion of the state. Granitic masses of the Sierra Nevada batholith were implaced near the conclusion of this orogeny. Though the intrusives are mainly confined to the Sierra Nevada Mountains in California, the batholith extends 50 miles east of the Nevada-California state line and has plutonic representatives in Lemmon Valley.

Near the end of the Cretaceous period the fourth orogenic event in Nevada, the Laramide orogeny, affected rocks in the easternmost portion of the state. Eastward thrusts and folds developed during that time.

Late Cenozoic north-northeast trending normal faulted horst and graben blocks have developed throughout the majority of the state giving rise to the Basin and Range province. Though this block faulting commenced during the Miocene (Noble, 1972) major faulting within the province has occurred subsequent to the Mio-Pliocene (Slemmons, 1967).

The field area is within a transition zone between the Sierra Nevada province to the west and the Basin and

Range province to the east. The transition zone is a disruption of the dominant Basin and Range pattern and has developed through strike-slip movement along a north-northwest trending belt which crosses the western and south-western portions of the state. The belt is identified as the Walker Lane and purportedly extends from Honey Lake, California to Las Vegas, Nevada, parallels and is potentially related to the San Andreas fault in California (Bell and Slemmons, 1978). Bell and Slemmons site evidence of late Cenozoic right-lateral strike-slip movement along the Pyramid Lake fault zone, a segment of the Walker Lane, located 20 miles northeast of the field area.

An unusual orbicular feature 25 miles in diameter and recognizable on high altitude photographs is located west of, and tangential to, the Pyramid Lake fault zone. This "ring" is outlined in several locations by curving range-front faults. The southern extent of the ring runs north of Peavine Mountain and includes the Lemmon Valley field area. No detailed study has been made to interpret the origin and development of the ring. Speculation surrounding a caldera collapse feature bears little weight considering the preponderance of granitic rocks and paucity of volcanic rocks within its margins. Probably the ring is a secondary structure associated with crustal movement along the Walker Lane.

LOCAL STRUCTURE

Lemmon Valley is a structural trough, or graben, trending north-south and bound by mountains on all sides. The southern boundary of the graben is delineated by range front faults at the northern base of Peavine Mountain located south of the field area. The northern boundary of the graben is next to Freds Mountain one mile north of the field area. Though few measurements of strike and dip could be made, the general structural orientation of the Tertiary sediment indicates the central portions of the valley are depressed relative to surrounding mountains.

Within the valley, north-south and northeast-southwest trending faults bound subordinate grabens and horsts. In the center of the field area most of the airport was built on one of these subordinate horsts. This "airport horst" is bound by north-south trending normal faults on the west and east side, the latter of which was named the Airport fault by Harrill (1973). The airport horst includes the mountain block north-northeast of the airport. East of its highest peaks, the mountain slopes steeply down to the valley below. West of those peaks the mountain slopes much more gradually down to the valley to the west. This same relationship was observed at the location of the airport, though not as obvious, and indicates the airport horst tilted to the west.

West of the airport horst a north-south trending subordinate graben occurs between the normal fault on the west end of the airport and the set of normal faults west of Osage Road. This graben appears to become narrower and angle to the northeast in the northern portion of the field area, and widen to the south.

A horst is located west of this graben and extends into eastern Cold Spring Valley. This horst contains Granite Peak and portions of the Granite Hills. The eastern side of this horst is broken into several smaller blocks which tilt to the north. The existence of these blocks is shown by the north-northeast dip and offset position of pediment gravel which overlies Tertiary sediment at that location. Apparently the offsetting movement was along numerous east-west trending, southward dipping normal faults which cut the Tertiary sediment and are presently concealed by alluvium. Figure 2 ideally shows the dip of the pediment gravel and inferred location of some of the normal faults in that area. A similar tilting of the Tertiary sediment may occur in the vicinity of the airport though the tilting is not as easy to recognize at that location. This faulting and tilting may indicate a north-south dilation of the valley.

Another subordinate graben is located east of the airport horst. Though the western limit of this graben is distinctly delineated by the Airport fault, the eastern side is not faulted at the surface.

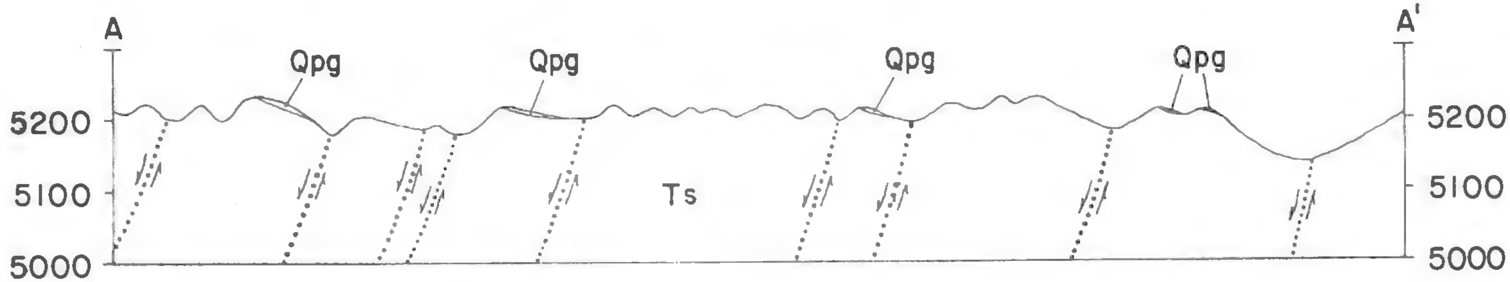

Figure 2 - Idealized Crossection Along Line A - A'

The normal faults in the valley have cut or offset bedrock and older sediments in the valley including Tertiary sediment, alluvial fan deposits of Peavine Mountain, pediment gravel and older alluvium - 1. Within the field area no faults cut beach deposits or younger sediments.

The Airport fault extends from southeast of the airport northward out of the field area and into Antelope Valley. East of the airport the Airport fault is distinctly convex to the west, the same direction as the tilt of the airport horst. This relationship between range front faults being convex in the same direction as the tilt of associated mountain ranges was observed by Moore (1960) in his study on the curvature of Basin and Range faults. East of the mountain block in the airport horst, the Airport fault is difficult to locate due to an alluvial cover and therefore is not shown on the geologic map. However, the eastern face of the mountain block indicates the fault has a stepped, or en echelon pattern, at that location. Including the en echelon portion and the extension into Antelope Valley, the Airport fault is about 16 miles long.

Escarpments occur throughout the valley at locations which reflect particularly persistent levels of Lake Lemmon. These escarpments can easily be misinterpreted as normal fault scarps. This confusion may develop especially where escarpments are viewed at the 4980 foot elevation in the East Lemmon sub-area.

GEOLOGIC HAZARDS AND RECOMMENDATIONS FOR LAND-USE PLANNING

The U. S. Geological Survey (1973a,b) has mapped areas in Lemmon Valley that are subject to 100 year floods. During the winter of 1977-78 the amount of precipitation by rain and snow in the region surrounding Lemmon Valley was about 130 percent of normal. No evidence of wet mantle flash flooding was observed in the valley by the author during that time. However, several flat low-lying areas have shallow standing flood waters as a result of direct precipitation or surface runoff. These areas are generally outlined by the flood prone designation on the U.S.G.S. map but also include other areas.

The flooded areas were the five playas, large portions of the lake deposits east of the Lemmon Valley playa and much of the area designated alluvial plains on the geologic map. Travel across these areas by foot during the period of flooding was restricted or impaired. When dry these surfaces can be crossed by foot or off-road vehicle without difficulty.

Gravel roads on the lake deposits have functioned well in the valley. If roads are to be built across the playas, causeways should be considered since deep floods may occur. For this reason building construction should be restricted on the playas.

Building construction should also be restricted at the mouths of bedrock canyons. Remnants of debris floods were observed at some of these sites indicating large instantaneous discharges of water. Likewise, channels incised in Tertiary sediment (recognizable as streams of alluvium on the geologic map) and narrow canyons, as in the center of section 12, T. 21 N., R. 18 E., can potentially be the focus of large quantities of flood water.

No evidence of Holocene faults were observed in the valley though numerous faults cut Tertiary and early Quaternary deposits. Construction of buildings is not advised on traces of faults located on the geologic map.

The potential for earthquake shaking is high in the valley though the source of shaking would probably be outside the valley. Fault movement along the Walker Lane 20 miles northeast of the valley could generate a magnitude 7.0 to 7.5 earthquake (Bell and Slemmons, 1978). In Lemmon Valley the intensity felt from that earthquake could be as much as VIII to X on the Modified Mercalli intensity scale (Krinitzsky and Chang, 1975, Fig. 15). This conclusion is supported by the 1977 edition of the Uniform Building Code. The U.B.C. designates Lemmon Valley to be in seismic zone 3 meaning major damage corresponding to intensities VIII and higher could be expected from an earthquake in the vicinity of Lemmon Valley.

Within the valley strong seismic shaking could develop from movement along the Airport fault. Based on worldwide relations between earthquake magnitude and length of fault rupture (Slemmons, 1977), an earthquake generated by rupture on the Airport fault, with a maximum inferred length of 16 miles, would have a magnitude of 6.5 to 7.0.

The landslide deposits in the southwest corner of the field area are apparently stabilized. However, if houses are constructed there and abnormal quantities of water are introduced to the ground by irrigation, sliding may resume. Soil slides on the lower face of Granite Peak are active. The precipitous face and slides are clearly hazardous to construction.

Large boulders have recently become dislodged and rolled short distances downhill from peaks where granodiorite and quartz monzonite crop out. The frequency of rocks becoming dislodged is probably low at those sites.

Expansive soils may be encountered in lake deposits, playas and clay dunes. Building foundations may shift, if constructed on these deposits. Leach field sewage systems constructed in these deposits may fail due to the clay content.

Though a discussion of the hydrogeologic features of the valley (covered thoroughly by Harrill, 1973) is not made in this study, the subject of ground water in the valley is important to land-use planners. Lemmon Valley was designated a hydrographic basin in 1973 by the Nevada State Engineer. This means virtually no new municipal ground water appropriations can be made in the valley. The designation was made because the State Engineer's office determined there are insufficient quantities of ground water to supply all wells in the valley.

Whether this condition actually exists is out of the scope of this study. However, during the field season many new ground water wells were being constructed, principally north of the Lemmon Valley playa and in the Silver Knolls sub-area a mile west of the airport. An immanent limit on new wells in the valley will place a premium on existing water rights and create a need for more imported water (2380 acre-feet per year from the Truckee River is appropriated to incorporated areas in Lemmon Valley) as pressures for construction in the valley increase.

Non-metallic mineral resources consisting of sand and gravel are prevalent in the valley. Sha-Neva Inc. has one major sand and gravel borrow pit at the east border of the field area. The city of Reno has a borrow pit at the Reno-Stead Airport which is a source of sand, and Washoe County obtains aggregate from a pit on the west side of the field area. Many of the alluvial fans on the periphery of the valley have been mined for aggregate. Based on field observations many more sites could be an economic source of sand and gravel. The influx of population is a threat to this resource since developments would physically cover the aggregate sources. A loss of resources of this type would necessitate importing aggregate from distant outlying areas.

Transportation costs would result in higher prices for aggregate and eventually construction.

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APPENDIX A

DESCRIPTION OF ROCK PROPERTIES

Weathering

Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 inch. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick. Rock goes "clunk" when struck.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent Some fragments of strong rock usually left.
Very severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" not discernible or discernible only in small scattered locations. Quartz may be present as dikes or stringers.

Rock Hardness

Very hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately hard	Can be scratched with knife or pick. Gouges or grooves to 1/4 inch deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 inch deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1 inch maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1 inch or more in thickness can be broken with finger pressure. Can be scratched readily with fingernail.

Fracture and Bedding Spacing in Rock

Spacing	Fractures	Bedding
Less than 2 in.	Very close	Very thin
2 in.-1 ft.	Close	Thin
1 ft.-3 ft.	Moderately close	Medium
3 ft.-10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

APPENDIX B

MODIFIED MERCALLI INTENSITY SCALE OF 1931

(Abridged and rewritten)

I. Not felt. Marginal and long-period effects of large earthquakes.

II. Felt by persons at rest, on upper floors, or favorably placed.

III. Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.

IV. Hanging objects swing: Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing motor cars rock. Windows, dishes, doors rattle. Glasses clink. Crockery clashes. In the upper range of IV wooden walls and frames creak.

V. Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rate.

VI. Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks, books, etc., off shelves. Pictures off Walls. Furniture moved or overturned. Weak plaster and masonry D cracked.

VII. Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken Damage to masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices, also unbraced parapets and architectural ornaments. Some cracks in masonry C. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.

VIII. Steering of motor cars affected. Damage to masonry C; partial collapse. Some damage to masonry B; none to masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.

IX. General panic. Masonry D destroyed; masoncry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged. General damage to foundations. Frame structures, if not bolted, shifted off foundations. Frames cracked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluviated areas sand and mud ejected, earthquake fountains, sand craters.

X. Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.

XI. Rails bent greatly. Underground pipelines completely out of service.

XII. Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

Quality of Masonry

(Brick or other)

Masonry A. Good workmanship, mortar and design; reinforced, especially laterally and bound together by using steel, concrete, etc., designed to resist lateral forces.

Masonry B. Good workmanship and mortar; reinforced, but not designed in detail to resist lateral forces.

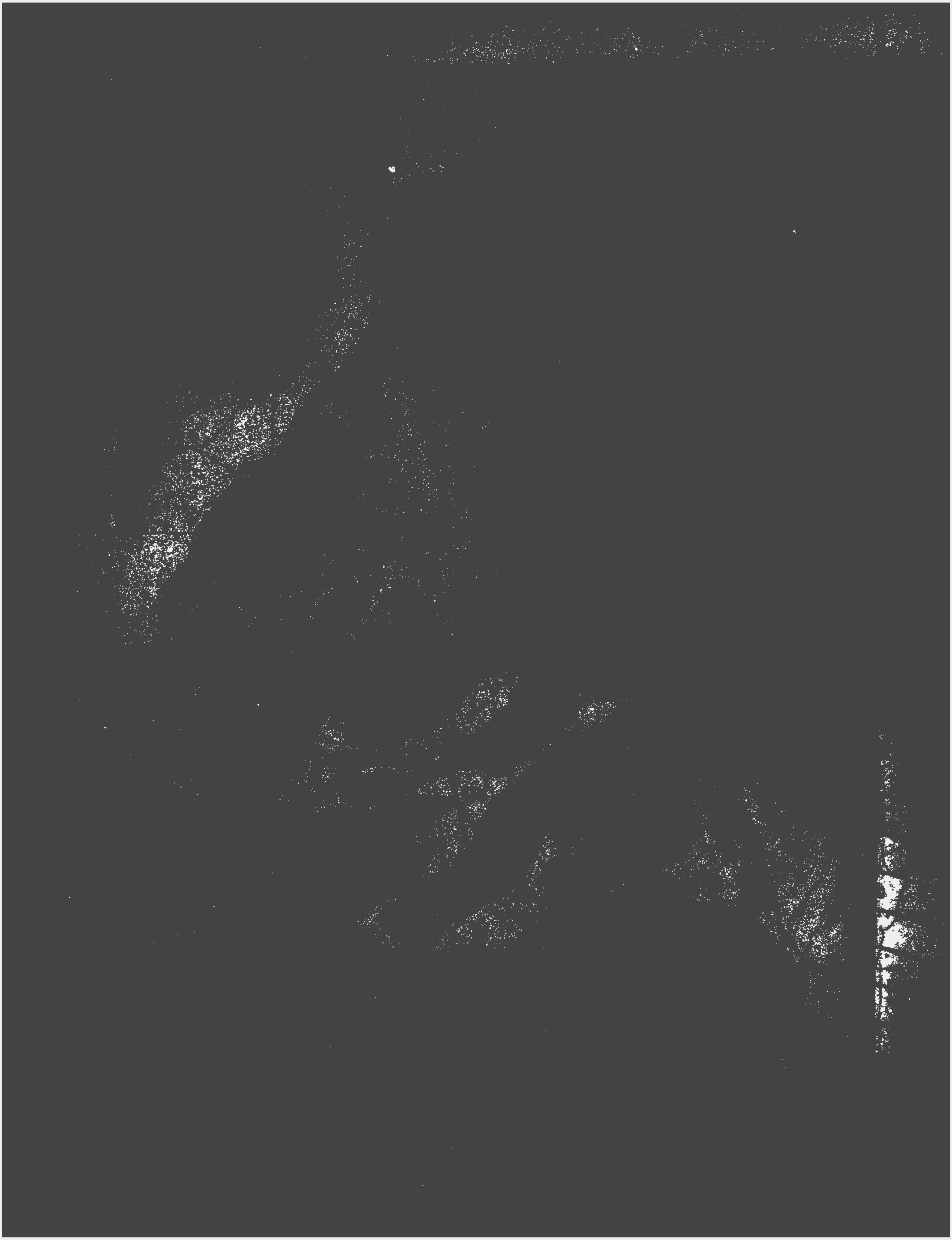
Masonry C. Ordinary workmanship and mortar; no extreme weaknesses like failing to tie in at corners, but neither reinforced nor designed against horizontal forces.

Masonry D. Weak materials, such as adobe; poor mortar; low standards of workmanship; weak horizontally.

Representative Magnitude-Intensity Relations

Magnitude	Maximum Intensity
2	I-II
3	III
4	V
5	VI-VII
6	VII-VIII
7	IX-X
8	XI


R. 18 E.
R. 19 E.
Ts
Qa
Qf
Qap
12
Qpg
Drag Strip
RAILROAD GRADE
BOUNDARY
CORPORATE
RENO
18
Qb
19
U
D



EXPLA

CENOZOIC — QUATERNARY — Holocene / Pleistocene

Qp

Playas. Slightly pebbly to granular

Qf Qa Qap Qws

Qcd Clay dunes. Granular aggregates

Qws Windblown sand. Moderately well

Qap Alluvial plains. Moderately sort
mud.

Qa Alluvium. Moderately to poorly sort

Qf Alluvial fans. Slightly granular t
medium sand.

Qls Qoa-2

Qoa-2 Older alluvium. Heterogeneous uni
medium sand and slightly gr

Qls Landslide deposits.

Ql

Qb Beach deposits. Granular medium t

Qfb Forebeach deposits. Laterally grad
muddy very fine sand.

Ql Lake deposits. Thinly bedded cla

EXPLANATION

Slightly pebbly to granular mud and well sorted very fine sand and silt.

Qap Qws

nes. Granular aggregates of clay.

wn sand. Moderately well sorted to well sorted medium sand.

plains. Moderately sorted to well sorted fine to very fine sand, and sandy clay and
nud.

n. Moderately to poorly sorted medium to fine sand and granular coarse to medium sand.

fans. Slightly granular to granular coarse sand and slightly pebbly to moderately sorted
nedium sand.

2

alluvium. Heterogeneous unit depending on location; includes pebbly to granular coarse sand,
medium sand and slightly gravelly medium to fine sand.

deposits.

eposits. Granular medium to coarse sand, sandy pebble gravel and granule gravel.

h deposits. Laterally gradational unit; granular coarse sand and sandy granule gravel to
nuddy very fine sand.

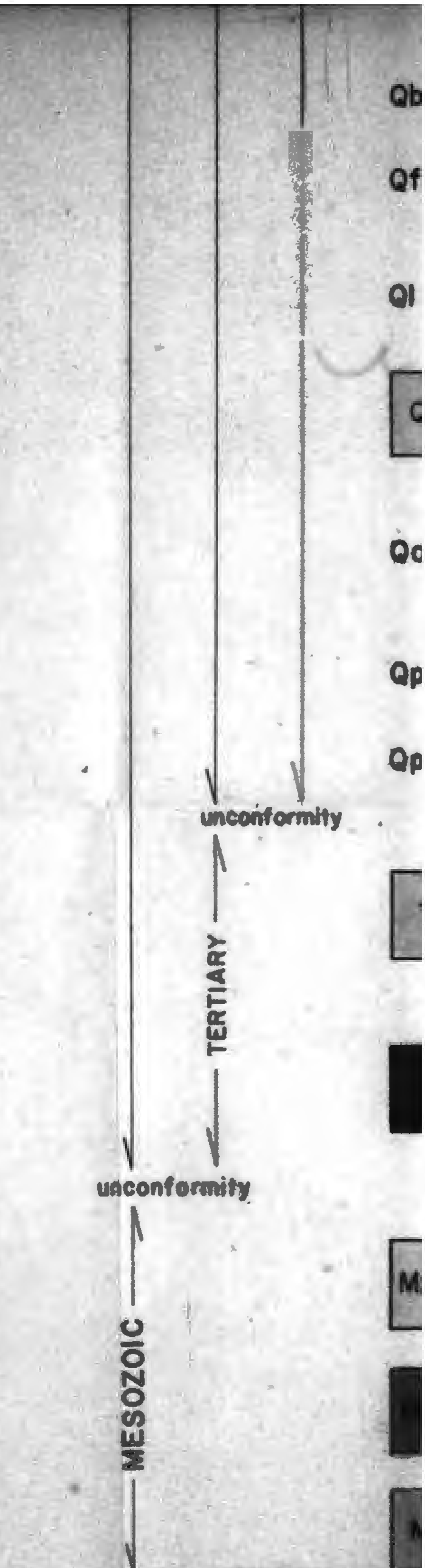
eposits. Thinly bedded clay.

Topographic Base from U.S. Geological Survey
Reno NE & Reno NW 7.5' quadrangles, 1967

GEOLOGIC MAP O

MAP OF LEMMON VALLEY, NEV


Mzgd
Qws
Ql
26
Mzgd
27
Ql
Qws
Qf
Qa
34
Mzgd
Qf
Qf
Mzgd
Qf
Mzgd
Dump


Qb
Qf
Ql
unconformity
TERTIARY
unconformity
MESOZOIC

NEVADA

Qb Beach deposits. Granular medium to coarse sand, sandy pebble gravel and granule

Qfb Forebeach deposits. Laterally gradational unit; granular coarse sand and sandy gr
muddy very fine sand.

Ql Lake deposits. Thinly bedded clay.

Qpf Qpg Qoa-l

Qoa-l Older alluvium. Heterogeneous unit depending on location; includes granular coarse
gravelly very coarse sand to sandy and muddy pebble and cobble gravel, and pebbly

Qpg Pediment gravel. Sandy granule to cobble gravel and pebbly very coarse sand.

Qpf Alluvial fan deposits of Peavine Mountain. Slightly muddy sandy pebble to cobble gravel

nformity

Ts Tertiary sediment. Coarse to medium sand and slightly granular coarse to medium sand
coarse sandstone, and sandy granule conglomerate, ash and diatomite.

Andesite.

Mzqm Quartz monzonite.

Granodiorite.

Mza Aplite dikes.

Mzv Metamorphosed andesite and dacite.

Contact, long dashes where approximately located, short dashes where uncertain, dotted where concealed.

its. Granular medium to coarse sand, sandy pebble gravel and granule gravel.

deposits. Laterally gradational unit; granular coarse sand and sandy granule gravel to
y very fine sand.

its. Thinly bedded clay.

um. Heterogeneous unit depending on location; includes granular coarse to medium sand,
ally very coarse sand to sandy and muddy pebble and cobble gravel, and pebbly coarse sandy mud.

avel. Sandy granule to cobble gravel and pebbly very coarse sand.

deposits of Peavine Mountain. Slightly muddy sandy pebble to cobble gravel.

iment. Coarse to medium sand and slightly granular coarse to medium sand; minor pebbly
e sandstone, and sandy granule conglomerate, ash and diatomite.

onite.

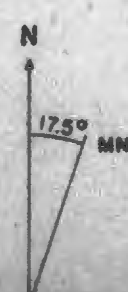
Aplite dikes.

ed andesite and dacite.

dashes where approximately located, short
where uncertain, dotted where concealed.

Topographic Base from U.S. Geological Survey
Reno NE & Reno NW 7.5' quadrangles, 1967

GEOLOGIC MAP O



MAP OF LEMMON VALLEY, NEVA

SCALE 1:24,000

1/2 0 1 MILE

1 .5 0 1 KILOMETRE

CONTOUR INTERVAL 20 FEET

Qpf

Qoa-l

Qpg

Qpf

unconformity

TERTIARY

Ts

unconformity

MESOZOIC

Mzgm

Mzv

EVADA

Ql Lake deposits. Thinly bedded clay.

Qpf Qpg

Qoa-l Older alluvium. Heterogeneous unit depending on location; includes granular coarse
gravelly very coarse sand to sandy and muddy pebble and cobble gravel, and pebbl

Qpg Pediment gravel. Sandy granule to cobble gravel and pebbly very coarse sand.

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Andesite.

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Mzqm Quartz monzonite.

Granodiorite. Mza Aplite dikes.

Mzv Metamorphosed andesite and dacite.

Contact, long dashes where approximately located, short dashes where uncertain, dotted where concealed.

Fault, dashes where approximately located, dotted where concealed.

36 Strike and dip of bedding

[illegible]
d.

ded clay.

ous unit depending on location; includes granular coarse to medium sand, sand to sandy and muddy pebble and cobble gravel, and pebbly coarse sandy mud.

ule to cobble gravel and pebbly very coarse sand.

vine Mountain. Slightly muddy sandy pebble to cobble gravel.

to medium sand and slightly granular coarse to medium sand; minor pebbly sandy granule conglomerate, ash and diatomite.

Mza Aplite dikes.

decite.

pproximately located; short dotted where concealed.

ately located, dotted where