

Carlin Trend Exploration History: Discovery of the Carlin Deposit



1968 view of the early developments at the Carlin mine, looking southwest. The mill buildings are in the lower right and the main pit is in the left foreground on the back cover. *Newmont photo.*

Cover photo—A 1968 view of the early developments at the Carlin mine, looking southwest. The mill buildings are in the lower right and the main pit is in the left foreground on the back cover. *Newmont photo.*



UNIVERSITY OF NEVADA, RENO
MACKAY SCHOOL OF MINES

NEVADA BUREAU OF MINES AND GEOLOGY
SPECIAL PUBLICATION 13

Carlin Trend Exploration History: Discovery of the Carlin Deposit

J. Alan Coope

Newmont Exploration Limited

1991

For more information contact:

Nevada Bureau of Mines and Geology

Email: [nbmg@unr.edu](mailto:nbmng@unr.edu)

Web: <http://www.nbmng.unr.edu/>

This One



OBJZ-F57-777Z

Digitized by Google

Foreword

The discovery of the Carlin deposit is one of the most significant events in worldwide mining and in the history of Nevada.

Named for a town on the banks of the Humboldt River, the Carlin deposit was overlooked by the '49ers who rushed by, along the Emigrant Trail, on their way to the gold fields in California. Because of the extremely fine grain size of its gold particles, Carlin was missed by the '49ers and by the prospectors that combed the hills of the western United States in the late 1800s. A few gold deposits of what would later be known as the Carlin type were found in the late 1800s and early 1900s, but their significance was not recognized until the Carlin discovery in 1961 and the opening of the Carlin mine in 1965.

Closely following Carlin were discoveries of other deposits along the Carlin trend, a 50-mile long, 5-mile wide belt that now includes more than 20 major deposits.

The Carlin trend has developed into one of the premier gold fields of the world. Known resources are immense, tens of billions of dollars worth of gold, and growing, as new discoveries continue to be made. The deposits of the Carlin trend and other Carlin-type deposits have catapulted Nevada into the lead among gold-producing states and have made the United States a major gold-producing country and net exporter of gold.

Discoveries of Carlin-type deposits have helped to diversify the Nevada economy. Gold mining directly provides thousands of jobs for Nevadans, indirectly provides thousands more, helps build and maintain infrastructure in rural parts of the state, and broadens the tax base for education and other government programs. Highly skilled miners, including heavy equipment operators and mechanics, engineers, and individuals well versed in computer operations, earn the highest average wages of any industry within the state.

Deposits on the Carlin trend have set new standards for gold mining throughout the world. Large-scale mining, heap leaching, and automation at various levels in the mining, milling, and assaying processes have cut overall costs and allowed lower and lower grades of ore to be mined.

This report, written and reviewed by some of the individuals involved, provides a first-hand account of the Carlin discovery, a milestone in the history of Nevada and in the history of mining.

Jonathan G. Price
Director/State Geologist
Nevada Bureau of Mines and Geology

Introduction

The Carlin mine, owned by Newmont Gold Company and located in the northern part of Eureka County, Nevada, commenced production in April 1965. Ore reserves at the beginning of operations were 11 million tons averaging 0.32 ounces of gold per ton. The Carlin mine had produced a total of 3.2 million ounces of gold when mining was suspended in 1986.

The Carlin gold deposit is hosted within the Silurian-Devonian Roberts Mountains Formation and has a most probable age of between 37 and 14 Ma bracketed by the intrusion of early Oligocene dikes and the extrusion of Miocene volcanics (Kuehn, 1989). The well-bedded Roberts Mountains unit is part of a lower and mid-Paleozoic miogeosynclinal sequence exposed within the Lynn tectonic window. The window is surrounded on

three sides by eugeosynclinal rocks of Ordovician, Silurian, and Devonian age which were moved into position along the major Roberts Mountains thrust during the late Paleozoic Antler orogeny.

The mine was the first large development along what is now known as the Carlin trend—a northwesterly trending belt of mineral deposits over 50 miles long and 5 miles wide extending through northern Eureka County into Elko County on the northwest and southeast (fig. 1). Subsequent discoveries and developments along the Carlin trend have led to the identification of over 20 deposits with existing geological resources of gold estimated at approximately 69 million ounces including mineable reserves of 40 million ounces. The Carlin trend has the potential of becoming the largest gold-producing district in North America.

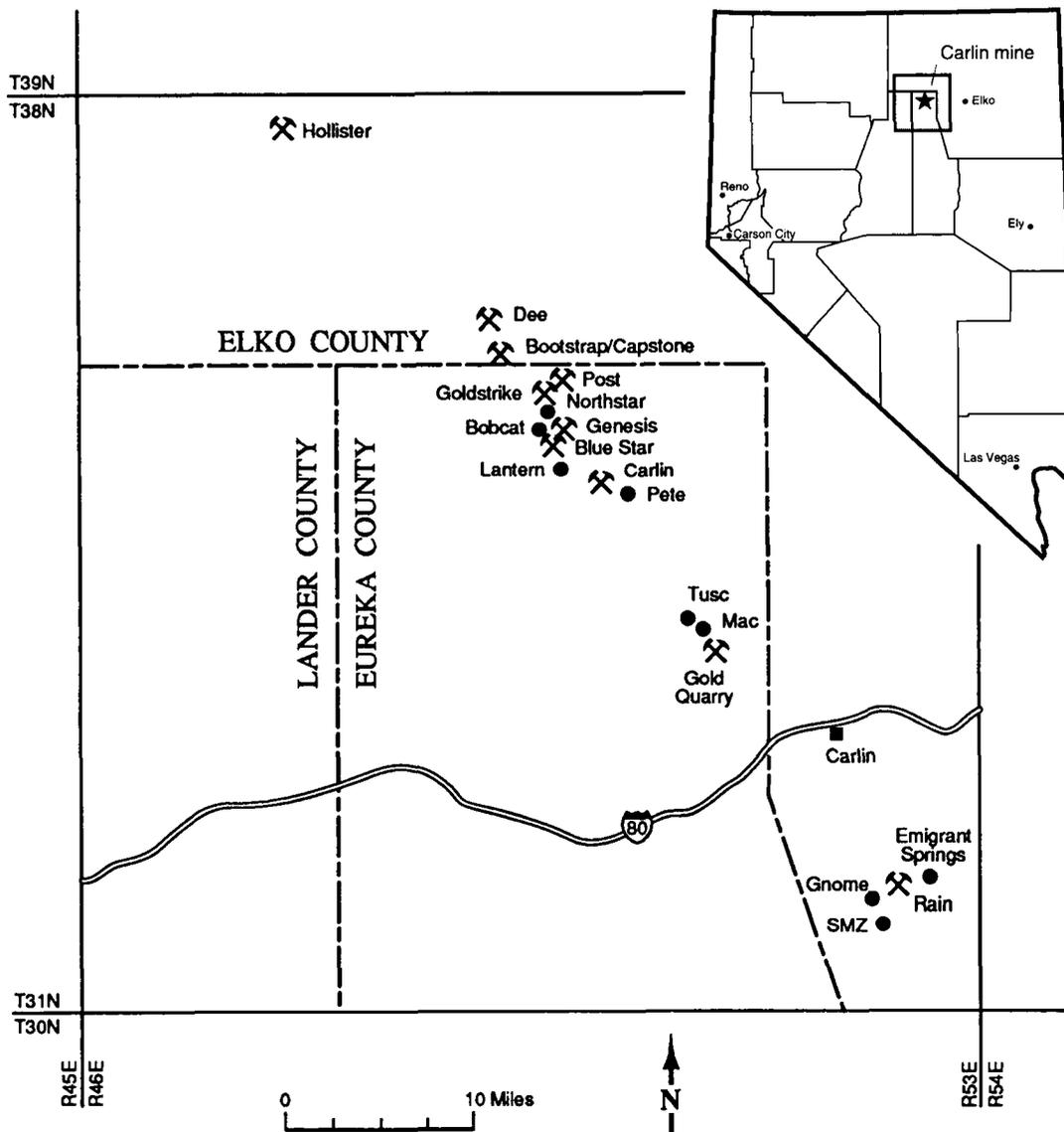


FIGURE 1.—Locations of mines (⌘) and other significant deposits (●) along the Carlin trend, Eureka and Elko Counties, Nevada.

Early Prospecting

The earliest prospecting in the Carlin area was in the 1870s when the Good Hope claims were located in the Maggie Creek district 11 miles northwest of Carlin. The most important metals mined from the vein structures on these claims were lead and silver in association with barite and minor gold.

The first principal gold discovery in the region was made by Fred Lynn in placers on Lynn Creek in 1907 at a location approximately 1.5 miles north of the present site of the Carlin mine (Vanderburg, 1936). Subsequent work led to the discovery of additional placer gold in Sheep, Rodeo and Simon Creeks (fig. 2). The major production from these deposits occurred prior to World War II but

some of the last placer miners were still at work in the early 1960s. Total gold production from the placers is estimated to be at least 7,500 ounces and may have reached 10,000 ounces (Vanderburg, 1936; Roberts and others, 1967). The bedrock source of this gold has been traced to a series of narrow quartz veins and stringers in shattered zones sporadically distributed within the drainage areas. The best known of these bedrock occurrences is the Big Six mine in the headwaters of Lynn and Sheep Creeks (Roberts and others, 1967). Despite attempts continuing to this day, only very limited production has been won from any of these lode occurrences (Vanderburg, 1938).

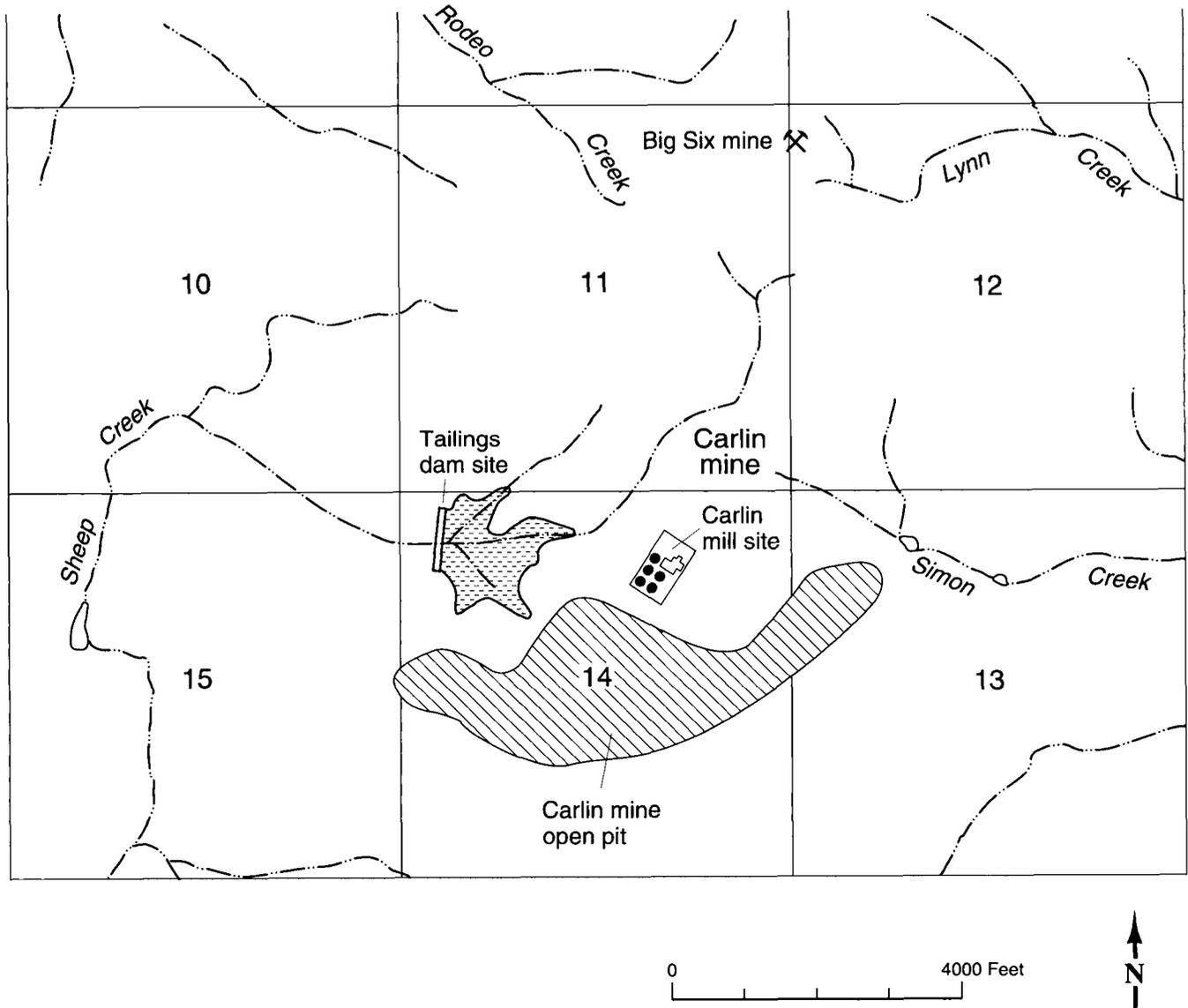


FIGURE 2.—The present location of the Carlin mine and the locations of Lynn, Rodeo, Sheep, and Simon Creeks which were worked for placer gold prior to discovery of the Carlin deposit.

The Significance of Invisible Gold

In marked contrast to the nature of these early gold discoveries, the Carlin trend deposits that are currently being extensively mined are characterized by very fine gold—sometimes referred to as “micron-sized gold” or, more topically, “invisible gold.”

Virtually all the gold in these deposits is so fine that it cannot be concentrated by panning. The old-timers who worked solely with the gold pan were therefore at a distinct disadvantage and, although they must have panned most of the creeks draining the Tuscarora Range north and south of the Lynn district placers, they failed to detect any significant indications of the millions of ounces of Carlin trend gold that have been discovered by more appropriate or more sophisticated methodology during the past 45 years. Not that they did not find the occasional color—there was some placer activity in the Maggie Creek area in these early years—but the amounts recovered were minor and totally disproportionate to the presently known resources in the Gold Quarry-Maggie Creek region (Vanderburg, 1936).

Many people are under the misapprehension that Newmont geologists were the discoverers of “invisible gold” in the early 1960s. This is untrue. The earliest records of very fine gold in the western United States come from the Mercur mine located just a few miles south of the Bingham Canyon copper mine in Utah. Originally located for silver, the gold in the Mercur district was first detected by fire assaying in the 1880s. Ironically but significantly, in the early history of this camp there is a record of legal action against an assayer in Salt Lake City brought by miners who could not confirm the presence of gold on the property using the gold pan (L. Kornze, personal commun.).

In Nevada, invisible gold was recognized at Gold Acres in Lander County several years prior to the initial production from this property in 1936 (Vanderburg, 1939). The first gold discoveries at Maggie Creek (the Maggie group) in Eureka County were made in 1925, and six cars of ore averaging 0.42 ounces of gold per ton were shipped in 1936 (Vanderburg, 1938). The Potosi mining district in the Osgood Range in Humboldt County was established in the 1870–1880 period and some minor tungsten was produced in 1917–1918. It

was not until 1934 that prospectors fire assayed samples from the siliceous outcrops and discovered gold at the present site of the Getchell mine. As reported by Hardy (1941), this gold was found to be invisible and refractory and undetectable by panning although detailed work by Joralemon (1951) records coarser gold in the deposit. Fine-grained gold was also discovered at the Gold Standard mine in Pershing County in 1934. An earlier discovery of fine-grained gold may have been made at the Buffalo Valley Mines Company property in Lander County. Prospectors passed through the Buffalo Valley district in the 1860s but the gold was not identified until outcrops were sampled at the property in 1912.

During the 1930s, W. O. Vanderburg, a mining engineer with the U.S. Bureau of Mines, began documenting activity in hardrock gold and placer mining in northeast and central Nevada. It was Vanderburg’s (1936, 1938, 1939) observations that stimulated the initial inquisitiveness that eventually led to Newmont’s participation in the rebirth of gold mining in the state of Nevada.

Vanderburg (1939) noted that at Gold Acres it was “impossible to distinguish between ore and waste except by assay, and gold is present in such a state that it is impossible to obtain a single color by panning.” In the final paragraph of his report, Vanderburg (1939) re-emphasized that “sedimentary gold deposits do not possess easily recognizable indications” and would have been passed over in former years by prospectors who depended largely on panning. In addition to citing the Gold Acres mine as one of these sedimentary deposits, he also referred to the Getchell mine in Humboldt County, the Standard mine in Pershing County, and other deposits, some of which are now known to have yielded coarser gold. Vanderburg (1939) predicted, however, that other deposits similar to Gold Acres remained “to be discovered in Lander County and other areas in the State, where sedimentary formations, like shale and limestone lying in proximity to acid intrusives, are common.”

John Livermore, a geology graduate from Stanford, first read Vanderburg’s predictions in the late 1940s and was deeply impressed by the exploration possibilities.

Newmont's Gold Exploration Program

Although gold was not in vogue as an exploration and mining target in the 1950s, the search for and development of base metals, particularly porphyry copper deposits in the western United States, was intensely competitive. This industry, over the years, has been revolutionized by new technology and the development of new mining and metallurgical methods, and the grades of copper that could be profitably mined progressively decreased as the scale of operations grew. Newmont actively participated in these porphyry copper developments, and Newmont executives, particularly Robert (Bob) B. Fulton, Fred Searls, Jr., and Plato Malozemoff, began to think of a similar evolution in the gold industry through open-pit mining followed by relatively cheap but highly efficient cyanide extraction.

Concurrently with these developing ideas, the U.S. Geological Survey was advancing its regional geological mapping and related studies of Nevada stratigraphy and structure.

Ralph J. Roberts and other USGS geologists commenced regional synthesis and mapping studies in Nevada in 1939. The Roberts Mountains thrust was first recognized in the Roberts Mountains area northwest of Eureka (Merriam and Anderson, 1942). By the late 1940s and the early 1950s, the USGS mapping program had been extended to cover several quadrangles in the Winnemucca, Golconda, Mount Tobin, Mount Moses, and the Antler Peak areas of central and northeastern Nevada (Roberts, 1986).

Roberts' (1951) work at Antler Peak led to the recognition of the Antler orogeny, and later regional correlations permitted the USGS to extend the Roberts Mountains thrust from Eureka on the east to Manhattan on the south and to Mountain City on the north (Roberts, 1986). Roberts and Lehner (1955) mapped the Carlin, Lynn, and Bootstrap windows and they presented their interpretations at a Geological Society of America meeting in 1955. It was during this presentation that they identified the northwestern alignment of the lower plate carbonate windows between Eureka and Battle Mountain (the Battle Mountain-Eureka belt) and the Bootstrap and the Copper King (the Lynn-Railroad belt)—now more popularly referred to as the Battle Mountain trend and the Carlin trend. Roberts and others (1958) published a comprehensive summary of the USGS mapping program through north and central Nevada. Figure 3, adapted from that paper, depicts the extent of the Roberts Mountains thrust, the distribution of the upper plate rocks, and the alignment of the lower plate windows.

Following publication of Roberts' (1960) Professional Paper on the alignment of base and precious metal mineral districts in northeastern Nevada and their rela-

tionship to major thrust faults (fig. 4), Newmont geologists began to take full advantage of the USGS mapping and geological interpretations.

In early 1961, John Livermore of Newmont was managing a drilling program on the silver/base-metal deposit at Ruby Hill in Eureka on behalf of a syndicate of mining companies. Through various contacts and periodic examination of the Eureka Courthouse records, Livermore was able to monitor the various prospecting and mining developments in Nevada. Contact was made with USGS personnel active in the mapping programs. He also visited the "Big" Gold Acres mine in Lander County and spoke with the manager, Harry Bishop. Mr. Bishop expressed the opinion that a favorable area for the discovery of additional fine gold deposits was not in nearby Lander County but in northern Eureka County.

In the spring and summer of that year, Ralph Roberts delivered several talks throughout the state on the regional stratigraphy and structure in northeastern Nevada and the alignment of the mineral districts. John Livermore attended one of these talks in Ely and, afterwards, met with Roberts to discuss these geological relationships in more detail.

Meanwhile, Newmont's Nevada gold exploration program had commenced in March 1961 in the Battle Mountain region where Alan Coope was investigating the potential of the Marigold and the Buffalo Valley properties near Valmy. These investigations revealed that neither of these properties had mine potential with gold at \$35.00 per ounce. Based on a recommendation by John Livermore, however, Newmont had decided to proceed with an exploration program in Eureka and Elko Counties to prospect the Roberts Mountains thrust zone for fine-grained gold deposits and, in an initial move, had secured verbal permission to examine the Maggie Creek prospect, 8 miles northwest of Carlin (also known at that time as the Maggie group and/or the Gold Quarry mine), in May 1961.

When the Ruby Hill drilling was completed, Livermore and Coope were instructed to meet in Carlin and proceed with the Eureka-Elko Counties program. The date was June 1961.

At this time, there was only limited mining activity in the area north of Carlin, principally at the Bootstrap and the Blue Star mines (fig. 5). Since the early history of these properties chronicles numerous events and discoveries relevant to the commercial evolution of the Carlin trend, a brief review of these historical developments is appropriate.

Antimony was discovered at the Bootstrap property in 1918, but it was not until 1946 that Frank Maloney collected samples for fire assay and identified gold on

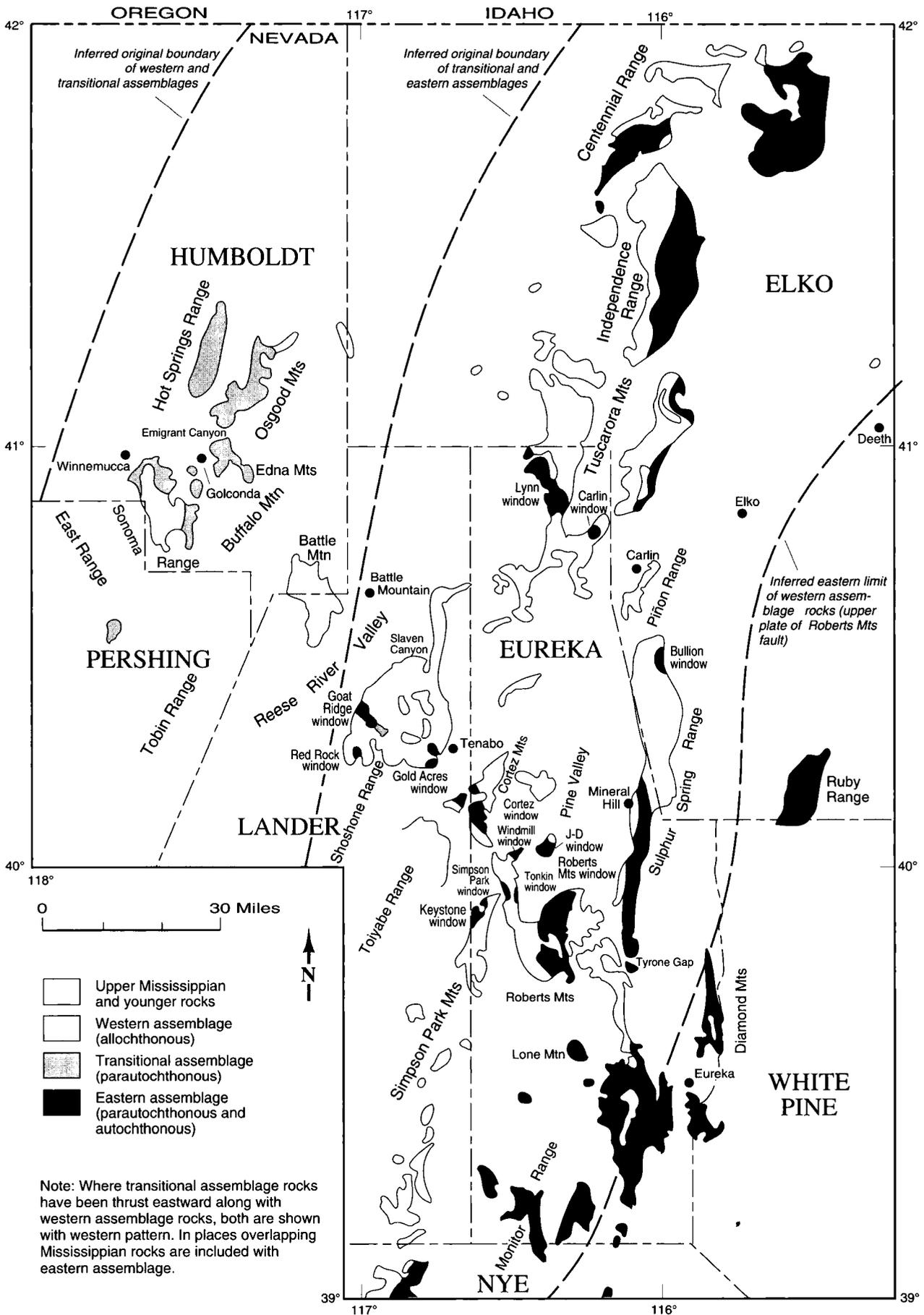


FIGURE 3.—Map of north-central Nevada showing outcrop areas of western assemblage (upper plate), eastern assemblage (lower plate), and transitional assemblage rocks and the extent of the Roberts Mountains thrust (adapted from Roberts and others, 1958).

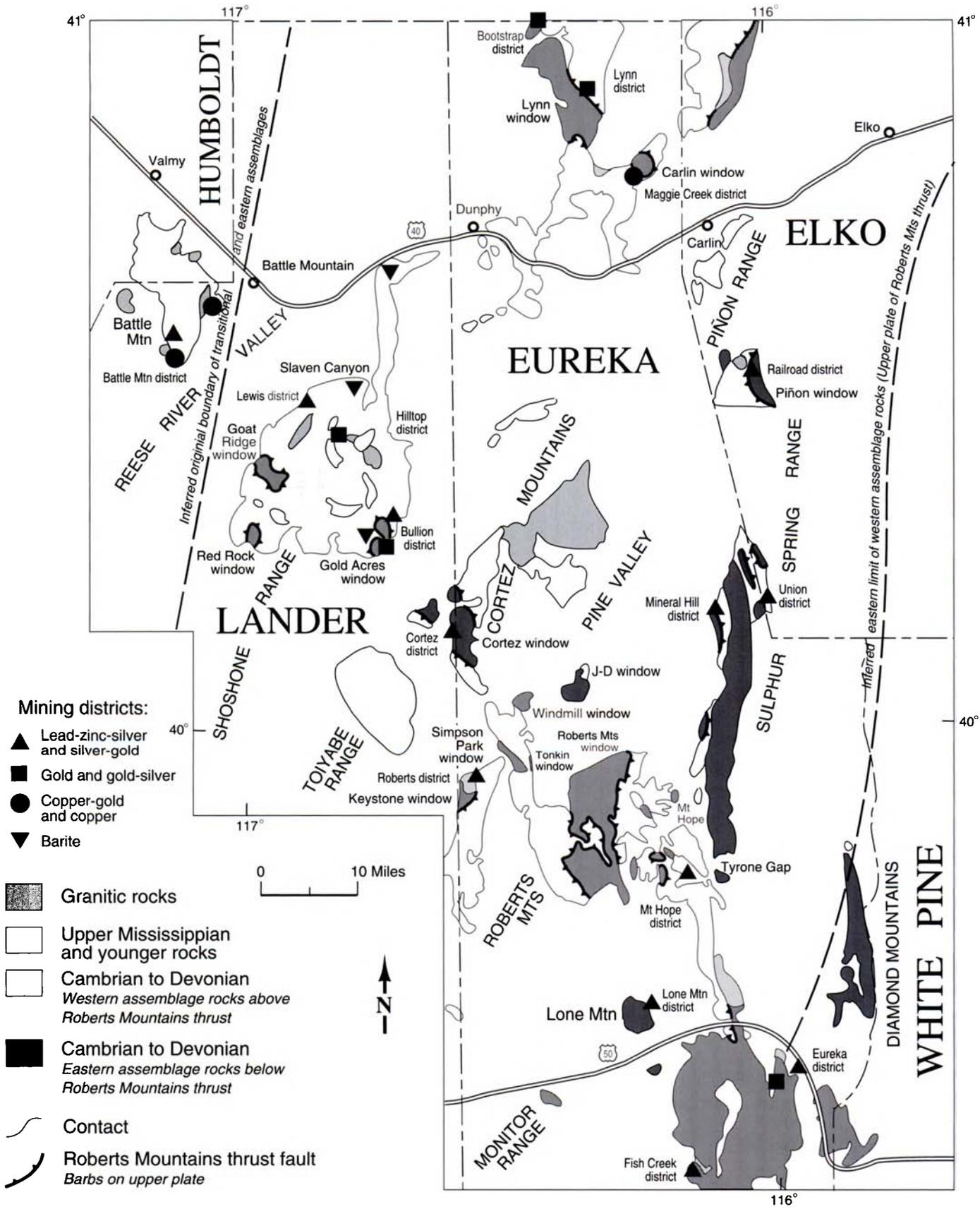


FIGURE 4.—Distribution and alignment of Paleozoic facies, granitic rocks, and principal mining districts in Eureka County, Nevada, and adjacent areas (adapted from Roberts, 1960).

this property (Ryneer, 1987). The first gold production (100 tons averaging 0.65 ounces of gold per ton) was achieved in 1948. When Marion Fisher of Battle Mountain acquired a lease and option on the property in October 1955 from the Modoc Mine and Exploration Company, workings included a 535-foot tunnel driven by the Getchell Mines Company in 1949 which failed to intersect any ore of commercial value, a 24-foot shaft and two deep open cuts. Mr. Fisher invited Robert Taylor of Battle Mountain and Harry Treweek of Gold Acres into equal partnership in his Bootstrap lease and an agreement was negotiated with the Homestake Mining Company which conducted additional exploration in the summer of 1956. Homestake subsequently terminated this agreement and 13 other companies declined the invitation to participate in further work on the property before a mining and milling agreement was concluded with R. R. Reed of Fallon, Nevada in January 1957.

During the next 3 years a 100-ton plant was completed and, despite numerous difficulties, total production from the Bootstrap through early 1960 was 40,000 tons of \$11.00 rock, from which between 10,000 and 11,000 ounces of gold were recovered. (Marion Fisher, personal commun.) This was, by far, the largest gold production from a lode deposit along the Carlin trend to that time. In June 1961, the property was under option to a construction contractor from San Francisco, but there were operational difficulties and the property was idle.

Initial development at the Blue Star mine (also known as the No. 8 mine) was for turquoise in the 1920s (Ryneer, 1987). Open-pit and shallow underground production of good quality turquoise continued intermittently until the property's added potential was discovered by Marion Fisher who first identified gold in the workings in 1957. By 1961, the property had been optioned from the owners, the Edgar brothers of Battle Mountain, by M M and S Mining, a Carson City-based company. In turn, M M and S had leased the property to Combined Production Associates, an operating company financed by Blake Thomas of Salt Lake City.

Bill Lage, Bob Morris, and Ralph Scott of M M and S had drilled some holes into the Blue Star turquoise workings in 1960 and obtained values up to 0.44 ounces of gold per ton over 10 feet in percussion samples. Channel samples from some of the deeper workings assayed up to 0.65 ounces of gold per ton over 5-foot intercepts. None of this gold was pannable (Bill Lage, personal commun.).

Combined Production established a 200-ton cyanide mill on the property after acquiring used equipment from a number of nearby mining locations. Unfortunately, in early 1961 they encountered serious

operating problems with slimes in the ore, and their production totalled only four 200-ounce doré bars. Subsequently, several major mining companies were contacted but none expressed any interest in the property. John Livermore visited the Blue Star after his conversation with Harry Bishop at Gold Acres. Following an examination and a discussion with Bill Lage, Livermore recommended to Fred Searls, Jr. that Newmont should make a careful evaluation of the Blue Star property. Fred Searls contacted Blake Thomas and the arrangements were made. So when Livermore and Coope arrived in Carlin in June 1961, they had the Maggie Creek claims to explore and the Blue Star mine to examine.

The Blue Star examination extended over three weeks and consisted of detailed geological mapping and extensive sampling. All samples were fire assayed by Harry Treweek, an experienced assayer with a laboratory in Gold Acres, some 50 miles from Carlin. The results were favorable. The deposit was estimated to contain at least 500,000 tons of bulk-mineable ore averaging 0.15-0.20 ounces of gold per ton, and Livermore and Coope recommended to Fred Searls, Jr. that Newmont acquire the property. Fred Searls negotiated with Combined Production but was unable to conclude an agreement.

Livermore and Coope used their newly acquired knowledge of the Blue Star occurrence in their evaluation of the surrounding area. A simple geological model for the Blue Star deposit had been developed in which upward-migrating hydrothermal fluids had been ponded beneath a low-dipping thrust structure leading to the precipitation of major concentrations of fine-grained gold. The surface trace of the Roberts Mountains thrust was readily mappable over the greater part of the Lynn window due to the marked differences in lithologies in the lower and upper plate rocks, and a systematic prospecting program examining the outcrops and float along this tectonic contact was initiated. Within a few weeks, anomalous gold values (in excess of 0.03 ounces of gold per ton) were encountered along the trace of the thrust in strongly silicified (jasperoidal) and barite-veined exposures approximately 2-3/4 miles southeast of the Blue Star. A return visit to the area confirmed these initial indications with several grab and channel samples assaying 0.03-0.20 ounces of gold per ton. Detailed geological mapping was carried out and, at separate times, USGS geologists Ralph J. Roberts and Hal Masursky were invited to visit the area to assist in the identification of the geological formations and collect graptolite fossils. Fred Searls and Bob Fulton returned to the area in late September 1961 and a decision was made to stake some claims. With the assistance of Mort White, a Newmont surveyor, seventeen 20-acre

lode claims were located in October of that year positioned over what eventually became the site of the main pit of the Carlin mine.

A bulldozer was contracted to excavate trenches for the discovery work that followed, and one trench (Trench B, fig. 6) was sited across a NNW-trending quartz porphyry dike which was thought to be related to the gold mineralization. Assaying of the exposures in the trench proved the dike material to be low in gold, but the mildly hornfelsed sedimentary rocks adjacent to the eastern contact assayed 0.20 ounces of gold per ton over 80 feet. This was the first significant discovery of gold in the Carlin mine area.

Heavy snows in late November ended the 1961 prospecting season soon after this discovery. John Livermore was promoted to Manager of Exploration,

Newmont Mining Corporation of Canada, effective January 1962, and Alan Coope and Mort White spent the winter on an exploration project near Pioche, Nevada.

The 1962 season at Carlin began in late April. Initial work consisted of bulldozer trenching and road building for drilling programs at both Maggie Creek and the Carlin prospect. It was at this time that Bob Morris approached Alan Coope and advised that M M and S had negotiated an agreement on the Popovich homestead property adjacent to the Newmont group of 17 claims (fig. 6). Morris offered the property to Newmont and, based on favorable geological knowledge of the property from the 1961 mapping coverage, Coope recommended to Bob Fulton that Newmont acquire the Popovich 80 acres.

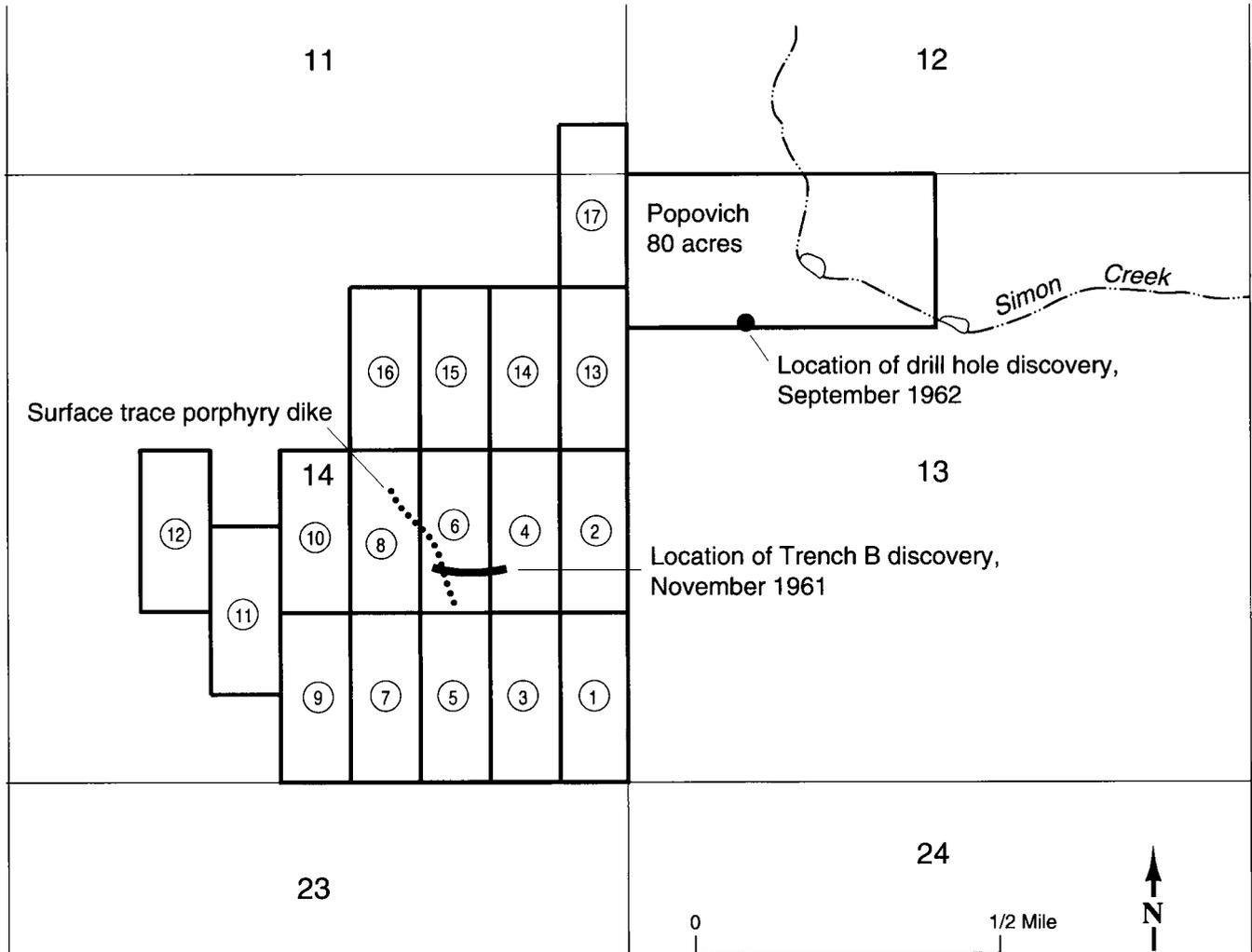


FIGURE 6.—Property map of sections 13 and 14, T35N, R50E showing the location of the original 17 claims, the Popovich 80 acres, and the sites of the significant gold discoveries of the Carlin deposit.

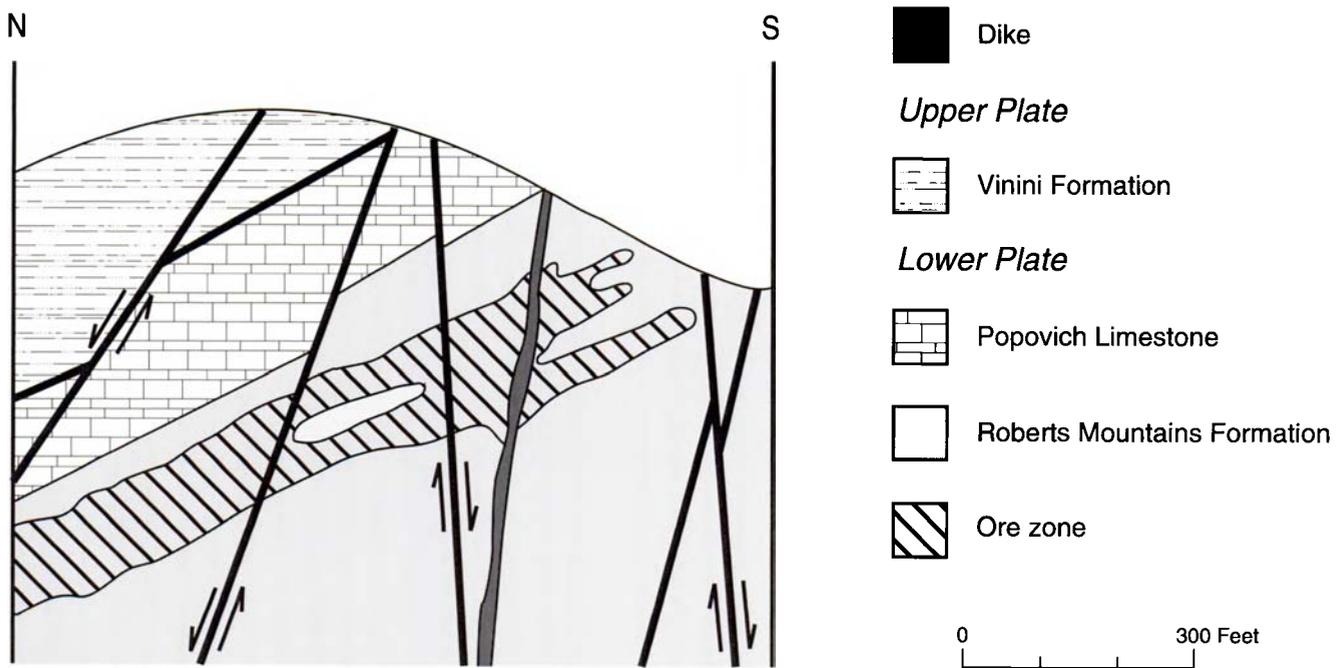


FIGURE 7.—Idealized cross section of the Carlin deposit within the Roberts Mountains Formation.

An agreement was negotiated with M M and S Mining requiring a down payment followed by a second, more substantial, cash payment in the fall of the year.

Trenches and drill sites at Maggie Creek and Carlin were selected based on the previous year's geological work and were surveyed in by Mort White. The bulldozer created many new exposures on the 17 Carlin claims and these were mapped and sampled giving results as high as 0.74 ounces of gold per ton. These results prompted additional property acquisition to cover virtually all the land in section 14, T35N, R50E where the original 17 claims had been staked.

Pete Loncar, a long-time Newmont employee, joined the exploration team to supervise the summer's drilling. Percussion drilling was selected as the most appropriate technique for the sampling challenge. Loncar secured an Ingersoll-Rand down-the-hole hammer drill from a contractor working on the highway near Reno. The drill, which worked exceptionally well, operated only with compressed air and had a depth capacity of approximately 130 feet. Satisfactory sample recovery was not possible below the water table, but the local conditions were such that this was not a major problem during the initial drilling program. Bill Mounts, presently Drilling

Services Supervisor with Newmont based at Carlin, was a member of the original drill sampling crew.

Drilling first began at Maggie Creek. Based on the economics of the time, results were not very encouraging but narrow intersections of 5 feet and 10 feet grading 0.15 ounces of gold per ton were encountered. (Follow-up drilling by Newmont in the late 1970s, when gold prices were considerably higher, proved these narrow intersections to occur on the northeastern edge of the major Gold Quarry orebody.)

While the Maggie Creek drilling was in progress, Alan Coope was mapping the Popovich 80 acres in detail. The geology was complex due to the intensive silicification of many of the exposures and, during the mapping, outcrops were extensively grab and channel sampled. An exposed, NW-trending, iron-stained and slickensided fault surface crossing the south boundary of the 80 acres was sampled several times and consistently returned assays of 0.07-0.08 ounces of gold per ton. The rocks in the footwall of this fault were exposed only as float. Primarily through curiosity, Coope also sampled this float material despite its plain unmineralized-looking gray color. The feature that aroused his curiosity was the rock's finely porous appearance caused by

the leaching of carbonate matrix from a silty limestone. The porous, unmineralized-looking rock assayed a surprising 0.22 ounces of gold per ton. A line of 11 drill sites was positioned by Coope across the strike of this fault, 50 feet north and parallel to the boundary of the 80 acres and the neighboring TS Ranch land.

Because of a scheduled fall payment date in the M M and S option agreement, the Carlin area drilling program commenced on the 80 acres. For expediency, drilling began at the base of the slope near Simon Creek and progressed upslope across the property. The third hole drilled, located in the immediate footwall of the fault where the float with 0.22 ounce of gold per ton was collected, intersected approximately 100 feet of highly sheared and altered carbonate rocks averaging \$36.00 per ton (1.03 ounces of gold per ton). This was the second significant, and most spectacular, discovery in the Carlin area (fig. 6). The date was September 1962.

The high gold value obtained from what appeared to be unmineralized float prompted a more extensive

sampling of float and outcrops that were, at that time, regarded as geologically unspectacular. This program identified gold values in float up to 2.0 ounces of gold per ton and culminated in the rapid outlining of the exposed sections of the Carlin orebody.

The drilling program intensified on the Carlin property. Pete Loncar played a prominent role in the development through into production and Byron S. Hardie supervised the geological work on the project and in the surrounding area from early 1963 onwards. Robert F. Sheldon calculated the ore reserves and Frank W. McQuiston and Paul E. Stucker were responsible for the construction of the mill which was designed and built by the Bechtel Corporation of San Francisco. Eventually 11 million tons of bulk-mineable ore were outlined averaging 0.32 ounces of gold per ton in a stratabound deposit (fig. 7). The Carlin mine commenced production in April 1965 at the rate of 2,000 tons per day. Total project costs through to production were \$10 million.



The Carlin mill in a 1968 photograph looking northwest. The Blue Star workings can be seen in the middle distance beyond the main mill building. *Newmont photo.*

TABLE 1.—Geological gold resources and reserves of the Carlin trend,
December 1989 (modified after Thorstad, 1989).

Deposit	Total geologic gold resources			Reserves
	Thousands of tons	Ounces per ton	Thousands of ounces	Thousands of ounces
Newmont¹				
Gold Quarry/Maggie Creek	535,551	0.037	19,584	10,058
Genesis	35,787	0.044	1,589	941
Post	194,955	0.064	12,457	6,065
Rain	21,947	0.052	1,145	808
Pete	15,753	0.030	470	152
Blue Star	22,243	0.030	661	609
Carlin	20,823	0.029	613	140
North Star	6,941	0.052	357	201
Capstone/Bootstrap	25,119	0.039	975	803
Tusc	15,829	0.059	932	907
Lantern	15,456	0.028	431	0
Bobcat	17,682	0.029	512	0
Emigrant Springs	30,332	0.021	629	0
Gnome	2,699	0.048	130	0
SMZ	1,589	0.019	30	0
	962,706	0.042	40,515	20,684
American Barrick²				
Goldstrike oxide	80,859	0.029		2,322
sulfide	94,608	0.17		16,051
	175,467		24,159	18,373
Dee Gold Mining⁴				
Dee mill ore	2,312 ³	0.090 ³		208
heap-leach ore	2,225 ³	0.025 ³		56
	4,537 ³		690	264
Ivanhoe Gold				
Hollister oxide	18,400 ³	0.035 ³	646	646
sulfide	83,500	0.034	2,800	
	101,900		3,446	646
Goldnev Resources/Barrick				
Maggie Creek	2,500	0.021	52	—
		TOTAL	68,862	39,967

¹Resource calculation at December 27, 1989; cut-off grade is 0.010 oz/ton. Data derived from Newmont's December 1989 News Release.

²Data courtesy of American Barrick Resources; does not include the Screamer, Rodeo, and Purple Vein discoveries.

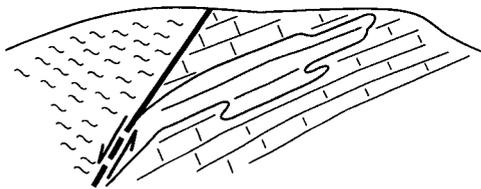
³Reserves only.

⁴Data courtesy of Dee Mining Co.

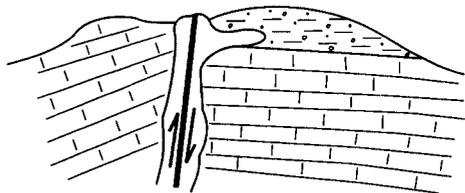
Recent Developments

Although not the first gold discovery, the Carlin mine was the first major development along the Carlin trend. Operations at the mine were suspended in 1986 following the production of 3.2 million ounces of gold over a 21-year period. The geology and mineralization of the mine have been described by Hardie (1966), Hausen and Kerr (1968), Adkins and Rota (1984), Radtke (1985), Bakken and Einaudi (1986), Christensen and others (1987), and Kuehn (1989). The exploration and operational success of the Carlin mine together with (a) the cumulative geological appreciation of the tremendous potential of the Carlin trend, (b) increases in the price of gold and (c) improvements in mining and metallurgical technology in subsequent years has led to additional major discoveries and developments by Newmont and other companies, and the Carlin trend production, gold reserves, and resources are now challenging the Porcupine mining district of Ontario as potentially the largest gold producing district in North America. The Porcupine camp has produced approximately 59 million ounces of gold over the past 80 years. The Carlin trend currently hosts an estimated 69 million ounces in

1. STRATABOUND (Carlin, Deep West)



2. STRUCTURAL "VEIN-LIKE" (Bootstrap-Capstone)



3. STRUCTURAL STOCKWORK (Gold Quarry)

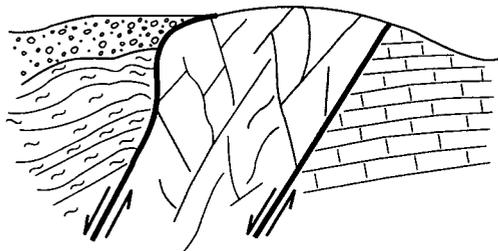


FIGURE 8.—Styles of mineralization of Carlin trend gold deposits.

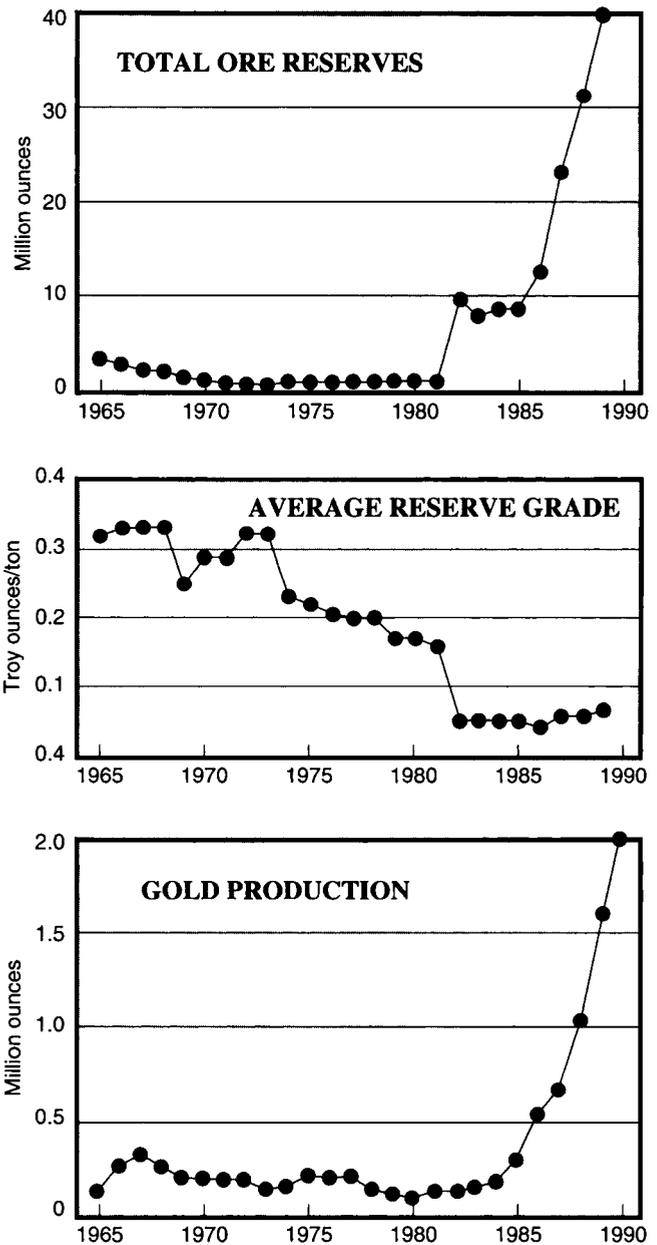


FIGURE 9.—Total ore reserves, average grade of reserves, and annual gold production of the Carlin trend since 1965.

geological resource of which 58% is classified as mining reserves (table 1). Production from the Carlin trend at the end of 1989 totalled slightly more than 8 million ounces.

Several styles of mineral occurrences have been identified (fig. 8) and the graphical representations in figure 9 portray annual total ore reserves, annual average reserve grade, and yearly gold production of the Carlin trend mines since 1965.

Discoveries are still being announced, and it is clear that further development along the Carlin trend will be faced with the challenges of developing and mining deeper mineralization and also overcoming the metallurgical complexities of refractory ores.

Acknowledgements

This compilation would not have been possible without significant input from numerous people who either participated in the early history of the Carlin trend or who had researched the history previously. Thanks are expressed particularly to John Livermore who played the primary role and to Odin Christensen, Allen Cockle, Charles Ekburg, Marion Fisher, Byron S. Hardie, Larry Kornze, Bill Lage, Pete Loncar, Ralph J. Roberts,

Joe Rota, Robert Ryneer, Linda Thorstad, Clemmie Treweek, Perry West, and Mort White, who willingly recalled their experiences or provided information contributing to the accuracy of this account. Suggestions by reviewers John S. Livermore, Harold F. Bonham, Ralph J. Roberts, and Joseph V. Tingley considerably improved the manuscript. The drafting of several preliminary figures by Simon Tuttle is also gratefully acknowledged.

References

- Adkins, A. R., and Rota, J. C., 1984, General geology of the Carlin Gold Mine, in J. L. Johnson, ed., Field trip guidebook, Exploration for ore deposits of the North American Cordillera: Association of Exploration Geologists, p. 17-23.
- Bakken, B. M., and Einaudi, M. T., 1986, Spatial and temporal relations between wall rock alteration and gold mineralization, main pit, Carlin Gold Mine, Nevada, U.S.A., in A. J. Macdonald, ed., Proceedings Volume, Gold '86—An international symposium on the geology of gold deposits: Toronto, p. 388-403.
- Christensen, O. D., Knutsen, G. C. and Ekburg, C. E., 1987, Disseminated gold deposits of the Carlin Trend, Eureka and Elko Counties, Nevada: Society of Mining Engineers of the American Institute of Mining and Metallurgical Engineers Preprint 87-84, p. 7.
- Hardie, B. S., 1966, Carlin gold mine, Lynn district, Nevada, in Papers presented at the AIME Pacific Southwest Mineral Industry Conference, Sparks, Nevada, May 5-7, 1965: Nevada Bureau of Mines Report 13, p. 73-83.
- Hardy, R. A., 1941, Geology of the Getchell Mine: Transactions American Institute of Mining and Metallurgical Engineers, v. 144, p. 147-150.
- Hausen, D. M., and Kerr, P. E., 1968, Fine gold occurrence at Carlin, Nevada, in J. D. Ridge, ed., Ore deposits of the United States, 1933-1967 (Graton-Sales Volume): American Institute of Mining and Metallurgical Engineers, v. 1, p. 908-940.
- Joralemon, Peter, 1951, The occurrence of gold at the Getchell Mine, Nevada: Economic Geology, v. 46, p. 267-310.
- Kuehn, C. A., 1989, Studies of disseminated gold deposits near Carlin, Nevada: Evidence for a deep geologic setting of ore formation [Ph.D. thesis]: Pennsylvania State University, 395 p.
- Merriam, C. W., and Anderson, C. A., 1942, Reconnaissance survey of the Roberts Mountains, Nevada: Geological Society of America Bulletin, v. 53, no. 12, p. 1675-1728.
- Radtke, A. S., 1985, Geology of the Carlin gold deposit: U.S. Geological Survey Professional Paper 1267, 124 p.
- Roberts, R. J., 1951, Geology of the Antler Peak Quadrangle, Nevada: U.S. Geological Survey Geological Quadrangle Map GQ-10, scale 1:62,500.
- Roberts, R. J., 1960, Alinements of mining districts in north-central Nevada: U.S. Geological Survey Professional Paper 400-B, p. B17-B19.
- Roberts, R. J., 1986, The Carlin story, in Sediment-hosted precious-metal deposits of northern Nevada: Nevada Bureau Mines and Geology Report 40, p. 71-80.
- Roberts, R. J., Hotz, P. E., Gilluly, J., and Ferguson, H. G., 1958, Paleozoic rocks of north-central Nevada: American Association of Petroleum Geologists Bulletin, v. 42, no. 12, p. 2813-2857.
- Roberts, R. J., and Lehner, R. E., 1955, Additional data on the age and extent of the Roberts Mountains thrust fault north-central Nevada: Geological Society of America Bulletin, v. 66, no. 12, pt. 2, p. 1661.
- Roberts, R. J., Montgomery, K., and Lehner, R., 1967, Geology and mineral resources of Eureka County, Nevada: Nevada Bureau of Mines Bulletin 64, 152 p.
- Ryneer, Robert, 1987, History of mining along the Carlin Trend, in J. L. Johnson and E. Abbott, eds., Guidebook for field trips, Bulk mineable precious metal deposits in the western United States: Geological Society of Nevada, April, 1987.
- Thorstad, L. E., 1989, Carlin Trend gold belt: The producers: Mining Magazine, October, 1989, p. 263-67.
- Vanderburg, W. O., 1936, Placer mining in Nevada: University of Nevada Bulletin, v. 30, no. 4 [Nevada Bureau of Mines and Geology Bulletin 27], 178 p.
- Vanderburg, W. O., 1938, Reconnaissance of mining districts in Eureka County, Nevada: U.S. Bureau of Mines Information Circular 7022, 66 p.
- Vanderburg, W. O., 1939, Reconnaissance of mining districts in Lander County, Nevada: U.S. Bureau of Mines Information Circular 7043, 83 p.

The Nevada Bureau of Mines and Geology (NBMG) is part of the Mackay School of Mines at the University of Nevada, Reno and is the state geological survey. NBMG scientists conduct research and publish reports on mineral resources and various aspects of general, environmental, and engineering geology.

Current activities in mineral resources and general geology include detailed geologic mapping and stratigraphic studies in Nevada, comparative studies of bulk mineable precious-metal deposits, geochemical investigations of mining districts, resource assessments, igneous petrologic studies, hydrothermal experiments, research on the origin of hydrothermal platinum-group-element occurrences, and examination of the origin and distribution of borate deposits in Nevada.

Environmental, engineering, and urban geology projects include investigations of earthquake hazards and related aspects of neotectonics, examination of issues involved in siting nuclear and hazardous wastes, mapping of geomorphic features, radon hazard studies, studies of landslide hazards, and investigation of land subsidence in Las Vegas Valley.

Geologic information activities include creating and updating databases on mining districts, active mines and prospects, and geothermal and petroleum exploration and production; implementation and development of statewide geographic information systems; and maintenance of core and cuttings facilities, rock and mineral collections for research, aerial photographic imagery and maps, and extensive files on Nevada geology and resources.

NBMG cooperates with numerous state and federal agencies in providing geologic and resource information and in conducting research. Research results are published as NBMG bulletins, reports, maps, and special publications as well as in federal publications and scientific journals. In addition to addressing the needs for geologic information by conducting research, publishing reports and maps, and creating computer databases, staff members assist the public, industry, and government agencies by answering specific questions regarding Nevada geology and resources and by providing some chemical and mineralogical analyses.

Individuals interested in Nevada geology are encouraged to visit or write NBMG or call (702) 784-6691. NBMG offices are located in the west wing of the Scrugham Engineering-Mines Building on the University of Nevada, Reno campus. When visiting NBMG by car please stop at the information booth just inside the Center Street entrance on the south end of the campus. The attendant will issue you a temporary parking permit and give you directions to parking areas and the NBMG offices. Address mail to: Director/State Geologist, Nevada Bureau of Mines and Geology/178, University of Nevada, Reno, NV 89557-0088. A publication list will be sent upon request.

For more information contact:
Nevada Bureau of Mines and Geology
Email: nbmgs@unr.edu
Web: <http://www.nbmgs.unr.edu/>



Editing: Dick Meeuwig
Graphics: Susan Tingley
On: Macintosh, Adobe Illustrator
Typesetting: Rayetta Buckley
On: Compugraphic EditWriter 7770
Text: English Times, 10 pt.
Heads: English Times, 18 pt.
Paste-up: Rayetta Buckley

Printing:
First edition, first printing, 1991
Copies: 6000
By: Dynagraphic Printing, 2001 Timber Way, Reno, NV
Stock, cover: 80 lb #1 coated gloss
Stock, text: Tahoe suede white basis 80
Ink, cover: 4-color process
Binding: saddlestitch

