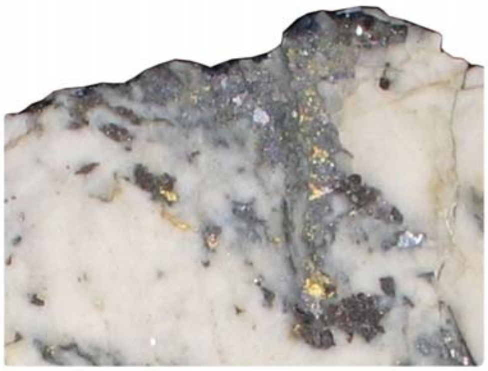
# Gold Deposits of the Chandalar Mining District, Northern Alaska: An Information Review and Recommendations



**An Independent Technical Report– Prepared for Little Squaw Gold Mining Company**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**Captions for photos on cover page:**

**Top Left: Angular-to-sub-angular placer gold-quartz nuggets from Upper Tobin Creek below the Mikado Vein structure. Photo by LSGMC.**

**Center Left: Quartz-sulfide vein showing native gold in association with arsenopyrite at Mikado Mine. Photo by LSGMC.**

**Bottom Right: Chandalar Mining district discoverer Frank Yasuda and prospecting partner Thomas G. Carter, circa 1913. Photo from Yasuda family collections as published in Hawley and Bundtzen (2003).**

**Gold Deposits of the Chandalar Mining District, Northern Alaska: An Information Review and Recommendations Version One**

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## APPENDICES

# I Summary and Conclusions

In January, 2004, Little Squaw Gold Mining Company (LSGMC, or the Company) of Spokane, Washington retained Pacific Rim Geological Consulting, Inc. (PRGCI) of Fairbanks, Alaska to produce an Independent Technical Report that evaluated lode and placer gold mineralization on company holdings in the Chandalar Mining district of northern Alaska. The Chandalar Mining district is above the Arctic Circle, about 190 air miles north of Fairbanks, in low, rugged mountains on the south flank of the Brooks Range. Access has been by winter roads from the Dalton Highway, the village of Beaver, and three fixed-wing aircraft landing strips near the Company holdings. In order to access lands owned and managed by the State of Alaska, plans are underway by the Alaska Department of Natural Resources to permit trail improvements for a 55-mile-long, all-season pioneer road from the Dalton Highway to Chandalar Lake, just west of LSGMC holdings.

At present, Little Squaw Gold Mining Company, Inc. controls mineral rights to 8,550 acres that cover almost the entire Chandalar Mining district. LSGMC was incorporated in Alaska on March 26th, 1959, and is listed on the NASDAQ Over-the-Counter Bulletin Board, under the trading symbol LITS. Little Squaw is a fully reporting company, as it files all federally required documents to maintain its trading status listing. LSGMC files audited financial statements with the US Securities and Exchange Commission.

Data from more than 145 public sector and private industry reports and documents that describe the geology and mineral deposits of the Chandalar Mining district were reviewed by the authors. The Chandalar Mining district contains: 1) high grade gold-quartz lodes that have been exploited by both open-cut and underground mining methods; and 2) placer gold deposits that have been exploited in open-cut and underground drift mining methods in frozen, unconsolidated gravels. More than 84,000 ounces of lode and placer gold have produced since 1905. Previous operators of hard rock mines exclusively focused on the extraction of high grade gold-quartz ores that contained at least 1.0 oz/ton gold. Total historical lode gold production from four high grade quartz vein/shear deposits is 9,039 ounces of gold from 11,819 tons of ore, most of which was processed at a small, 100 ton-per-day mill on Tobin Creek. Because the Tobin Creek mill was not designed to handle the clay-rich gouge present in the low sulfide quartz ores, gold recovery never exceeded 78 percent. Proven, probable, and possible high grade lode gold resources in the Mikado, Summit, Little Squaw and Eneveloe deposits are estimated to total 26,464 ounces of gold.

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Placer operators of underground drifts frequently encountered water in thawed zones, which resulted in flooding and cessation of activities. Limited open cut placer mining operations are responsible for about 50 percent of the historic gold production of the area. Estimated proven, probable, and possible placer resources are projected to be about 372,000 ounces of gold in bench and creek deposits.

The Chandalar low sulfide gold-quartz deposits are hosted in northwest-trending high-angle shear zones that cut Devonian-age or older greenschist facies metamorphic rocks believed to be of the Coldfoot subterrane of the Arctic Alaska terrane. The northwest-trending shear zones have been cut by a conjugate set of northeast structures. This is part of a larger orthogonal stress field extending 10-20 miles both east and west of the Chandalar district. Timing of the quartz-sulfide mineralization that has been injected into the northwest-trending shears is uncertain. In the Chandalar area, dismembered thrust panels of the Coldfoot subterrane are believed present due to northward directed regional nearly flat-lying thrust fault (decollement surface).

After reviewing available geological, mineralogical, structural, tectonic, isotopic, fluid inclusion, and geochemical criteria, the authors conclude that lode gold mineralization in the Chandalar Mining district consists of orogenic, mesothermal, low-sulfide deposits hosted in shear zones that have strike lengths of at least four miles, widths of up to 400 feet, and vertical extents of at least 1,600 feet. The orogenic, mesothermal, low-sulfide gold deposits of the Chandalar district compare with worldwide examples that carry grades of 0.07 - 0.25 oz/ton gold over large widths and strike lengths. Individual mesothermal gold deposits worldwide range from 1,500 tons to more than 100 million tons of ore, and many deposits contain resources of one million ounces or more of gold. In the Chandalar Mining district, there are at least four parallel, quartz-sulfide vein-and-shear zone structures that control the past productive Mikado, Eneveloe, Summit, and

Little Squaw gold deposits and more than 20 additional lode gold prospects that have received very little exploration work.

Placer gold in the Chandalar Mining district was liberated from lode sources during several episodes of erosion and concentration further complicated by repeated advances of Quaternary glaciation from the north. Subsequent downcutting upon each glacial retreat occurred in response to newly established base levels along the wide valleys to the north and west. These glacial events did not scour the placer streams and destroy pre-glacial pay streaks. The geological setting of several of the Chandalar Mining district placer deposits can be compared to the glaciofluvial deposits in the Valdez Creek (south-central Alaska), Porcupine (southeast Alaska), Koyukuk-Nolan (northern Alaska) and the Bolotny-Ravkosky (Russian Far East) placer gold districts. Three out of four of these district examples have cumulative reserve and past production totals exceeding 500,000 ounces of gold.

Specific recommendations are offered in the order of priority:

1) Explore and develop as warranted a gold placer operation capable of producing 15,000 to 25,000 ounces of gold per year. Targets in Lower Big and Little Squaw Creek valleys may contain 300,000 ounces of gold.

2) Explore the potential for bulk minable tonnage deposit(s), based on including lenses of multi-ounce gold quartz veins with auriferous splays and subparallel sheeted quartz vein systems. A detailed study of the mineralized shears should be completed prior to the drill program to assist the location of drill holes. Drill evaluation must include a combination of larger size core and reverse-circulation drilling to properly assess rock containing coarse gold, i.e., the ‘nugget effect’.

3) Conduct geological studies specifically for structural interpretation, age of mineralizing events, and vertical zonation within the shear and quartz vein systems.

4) Evaluate the numerous outlying gold-quartz prospects and unevaluated shear zones throughout the district.

5) As warranted, plan and execute laboratory and on-site pilot plant testing of bulk samples from drill-indicated zones of mineralization.

6) Other subordinate recommendations are also described in this report.

## II Introduction

The following report was commissioned on January 22, 2004, by Mr. Richard R. Walters, President, Little Squaw Gold Mining Company (LSGMC) for the purpose of an independent review, technical data assessment, and recommendation for the company's mineral holdings in the Chandalar Mining district, Alaska. Following review of regional and local geology, the authors compare the mineral deposits in the region with internationally accepted mineral deposit models and provide recommendations that could lead to discovery of an economic gold deposit.

The Chandalar project of LSGMC involves both gold placer and lode mineralization. There has been historic production from both types of deposits. Whereas mineralization is present at numerous locations, there are no reserves presently defined by accepted definition of 'ore reserves' (Bureau of Mines and U.S. Geological Survey, 1980; Industry Guides, www.sec.gov). LSGMC considers the present operations to be an *exploration stage project*.

This report is prepared by Pacific Rim Geological Consulting Inc. (PRGCI) of Fairbanks, Alaska. Author Thomas K. Bundtzen briefly examined the property in 1982 and viewed the open pit and underground geology and mineralization of the Mikado Lode; Bundtzen also worked on the geologic framework and lode and placer deposits of the Nolan-Wiseman Mining district to the west. Author James C. Barker has conducted regional exploration programs in the vicinity of the Chandalar district. His work is reported in several open-file reports and publications of the U.S. Bureau of Mines. Qualification statements for PRGCI and for both authors are contained in Appendices I-III of this report.

In preparation of the following report, the authors attempted to provide as much detail as possible to summarize the important aspects of the gold deposits at the Chandalar district while staying within the confines of a concise, reproducible, easy-to-understand summary document. It is not the purpose of this report to replicate the voluminous files and numerous oversize drawings that exist in the files of the Little Squaw Gold Mining Company. For additional technical detail, the reader is encouraged to examine the documents listed in the *References Cited* section of this report.

The authors gave consideration to which system of measurement to use in this report. It is recognized that much of the world's mining industry is based on the metric system. However, because this report is, in part, a summary report of data held by LSGMC and because all of those historic data are compiled using English units, the authors decided to use the English system of measurements. All gold quantities are given in troy ounces, which is abbreviated to 'ounces' or 'oz' throughout the report. One troy ounce is equal to 31.101 grams.

Writing style and nomenclature uses in this report follow those recommended for use in U.S. Geological Survey technical reports (Hansen, 1991), with additional nomenclature recommendations provided by Thrush (1968). Subcontractor Landon Kelly of Kelly Digital Design completed the digital drafting for the figures. Charlotte Barker and Gay Heath Griffin provided valuable editorial review.

Data, recommendations, and conclusions presented in this report are derived from files of LSGMC, personal knowledge of the subject area, and from public information. Some of the documents, both private and public, were prepared nearly a century ago. While reasonable care has been taken in preparing this report, PRGCI can not guarantee the accuracy or completeness of all the supporting documentation. Furthermore, PRGCI did no sampling to verify reported assays in the documentation. Consequently, the use of this report is at the user's risk, and PRGCI disclaims any liabilities arising out of the use and distribution of this report by any party, or the reliance on the following information for investment purposes.

## III Location, Access and Geography

The Chandalar Mining district lies north of the Arctic Circle at a latitude of about 67°30' (figure 1). The district is about 190 air miles north of Fairbanks and 48 air miles east-northeast of Coldfoot, an important service center on the Dalton Highway. The Dalton Highway, which parallels the Trans Alaska Pipeline, is the highway link to the Prudhoe Bay oil fields on Alaska's North Slope.

Access is either by aircraft from Fairbanks, or overland during the winter season via a 55-mile-long trail from Coldfoot to Chandalar Lake and then to Tobin Creek on the Little Squaw Gold Mining Company (LSGMC) property. Heavy equipment and bulk supplies have been trucked to Coldfoot and then by cat train to Tobin Creek. The winter road season depends on adequate snow cover, but usually extends from early mid-November through March. Aircraft, including multi-engine cargo craft up to C-130, can also land at the State maintained 4,700-foot long airfield at Chandalar Lake, which is connected by an unmaintained mine road to Tobin Creek. A 5,000 foot long airfield about 40 miles south of Coldfoot, also on the Dalton Highway, can be used to shuttle heavy loads about 85 miles by air. The company owns several airstrips on the property; strips at St. Mary's Creek, on uppermost Big Creek, and on the lower end of Little Squaw/Big Squaw Creeks are presently usable, however, the strip at Tobin Creek has deteriorated and needs to be repaired. In the past, ice landing strips have also been cleared on Chandalar Lake for larger aircraft.

The overland route to the Chandalar Mining district is an historic transportation route and, as such, it has been classified under revised federal statute 2477, and for use of which the company holds a permit from the State of Alaska. Furthermore, the State of Alaska has the right to acquire a road easement along this route, known as RST-009 (Coldfoot to Chandalar Lake) and route RST-411 (Chandalar Lake to Chandalar Mine via Tobin Creek), and to conduct feasibility studies and road construction. The Alaska Department of Transportation and Public Facilities is currently reviewing needs for road access under its "Roads to Resources" program. In a draft Memorandum of Understanding (July 31, 2003) between the U.S. Department of Interior and the State of Alaska, Governor Murkowski's office has proposed to the Secretary for consideration of a Federal Recordable Disclaimer of Interest for 14 potential RS2477 routes, including


Figure 1. Location of the Chandalar mining district.

RST-009 (Letter by T.E. Irwin, Commissioner, DNR, to Secretary Norton, Oct. 27, 2003). March 17, 2004, the State of Alaska notified the U.S. Bureau of Land Management that it intends to file a 'quiet title action' for the RST-009 right-of-way from Coldfoot to Chandalar Lake. The recognized RST-009 route departs Coldfoot via the Slate Creek valley, crosses the South Fork of the Koyukuk River, and proceeds to Chandalar Lake. From Chandalar Lake, improved trails lead 16 miles to Little Squaw Creek and 7 miles to Tobin Creek. These routes do not cross any National Conservation units. Another recognized route to the Chandalar Mining district (RST-254) departs the Dalton Highway at Wiseman and connects to the Chandalar Lake airstrip. The historic trail south to Caro and on to Beaver is also recognized by the State of Alaska, but since 1978 it has been of little importance to LSGMC due to the proximity of the Dalton Highway.

The Chandalar district is situated in mountainous terrain on the south flank of the Brooks Range where elevations range from 1,900 feet in the lower valleys to just over 5,000 feet on the surrounding mountain peaks. These peaks form a discrete set of hills that cover about 100 square miles. The area is bounded on the west by the North Fork of the Chandalar River and a lowland area occupied by Chandalar Lake. To the east lies the valley of the Middle Fork, which, like the North Fork, drains south out of the Brooks Range. To the north is a glacial carved valley that is elongated in a northwesterly-southeasterly direction.

The region along the south side of the Brooks Range has undergone glaciation due to ice advances originating from the north. Glacial evidence such as till deposits and erratic boulders occur in the lower trunk valleys of Little Squaw and Big Squaw Creeks, and small masses of ice occupied cirques that formed above 4,000 foot elevation. Otherwise, the district is characterized by deeply incised creek valleys that are actively downcutting. The steep hill slopes are shingled in slabby scree rock, the product of periglacial mass wasting and solifluction. Bedrock exposure is mostly limited to ridge crests and creek bottoms. Permafrost is continuous and extends to depths of several hundred feet.

Vegetation is limited to the peripheral lower country where relatively continuous spruce forest can be found in the larger river valleys. Higher elevations are barren of vegetation except moss, lichen, and some grasses. Spruce has been used for construction and historic mine workings. Forest resources occupying the lowlands along the North Fork and Middle Forks of the Chandalar River are under the jurisdiction of the Alaska Division of Forestry, Fairbanks, and timber sales of up to 0.5 million board feet can be negotiated (Steve Clautice, Alaska Division of Forestry, pers. commun., 2004).

Snow melt generally occurs toward the end of May followed by an intensive, though short, 60-day growing season with more than 20 hours of daylight and daytime temperatures ranging from 60-80° Fahrenheit (F). Freezing temperatures return in late August and generally freeze-up can be counted on by early to mid-October. Records from Tobin Creek refer to the loss of surface water for mining and for the mill occurring some years in mid-September. Winter temperatures, particularly in the lower elevations, can drop to -50° F or colder for extended periods. Annual precipitation is 15-20 inches, coming mostly in late summer as rain and as snow during the first half of the winter. Prospectors and earlier workers in the area have noted better climatic conditions on the more sheltered north side of the district, particularly Little Squaw Creek, as compared to the valleys of Big and Tobin Creeks.

## IV History of Exploration and Development

Figure 2 shows the locations of placer and lode deposits and prospects in the Chandalar district. Placer gold deposits of the Chandalar Mining district were discovered by Japanese immigrant Frank Yasuda and his Eskimo wife Nevelo (also known as Eneveloe), Charles McNett, James Minano, and Thomas Carter, who staked the Discovery Claim on Little Squaw Creek in 1905 (Mertie, 1925; Wolff, 1994). The discovery of the Chandalar Mining district capped a remarkable two-year journey initiated by the Yasudas, Carter, Minano, McNett, and about twenty-five Eskimos, which involved an arduous overland expedition from Point Barrow on Alaska's North Slope to the upper reaches of Chandalar River. The party's route traversed across hundreds of miles of then uncharted Alaskan wilderness. For their many accomplishments in the development of the Chandalar gold mines and the founding of Beaver, Frank and Nevelo Yasuda were inducted into the Alaska Mining Hall of Fame Foundation on July 17, 2003 in Fairbanks, Alaska (Hawley and Bundtzen, 2003). The 1905 Chandalar Mining district discovery followed the earlier 1902 discovery of placer gold in the Wiseman area 60 miles west of Chandalar Lake, and gold seekers from that camp joined the subsequent rush to the Chandalar district. By 1906 rich placers were found on Big Creek and its tributary of St. Mary's Creek, and during the following year it is reported that 100 men were engaged in mining and prospecting the immediate area. Shortly after 1910, the U.S. Congress allocated funds for the construction of a wagon road, which was built by the Alaska Road Commission. The 75-mile-long corduroy road linked the district to Caro, about 50 miles south of Chandalar Lake, and thence to Beaver, a steamboat landing on the Yukon River (Schneider, 1976). Most supplies were brought over this route by dog sled.

Prospectors quickly found at least some of the lode sources of the Chandalar placer gold deposits. Maddren (1910) reported that by 1909, the four principal auriferous quartz veins had been discovered. A small stamp mill was soon freighted into Big Creek to test ore from the Little Squaw Lode and several other lode claims (Carter, 1911).

Much of the Chandalar placer gold was relatively deep with frozen overburden. By 1916, the shallow, easy-to-exploit, open-cut placer gold mines were playing out and most attention shifted to developing placer drift mines (underground operations). Most notable

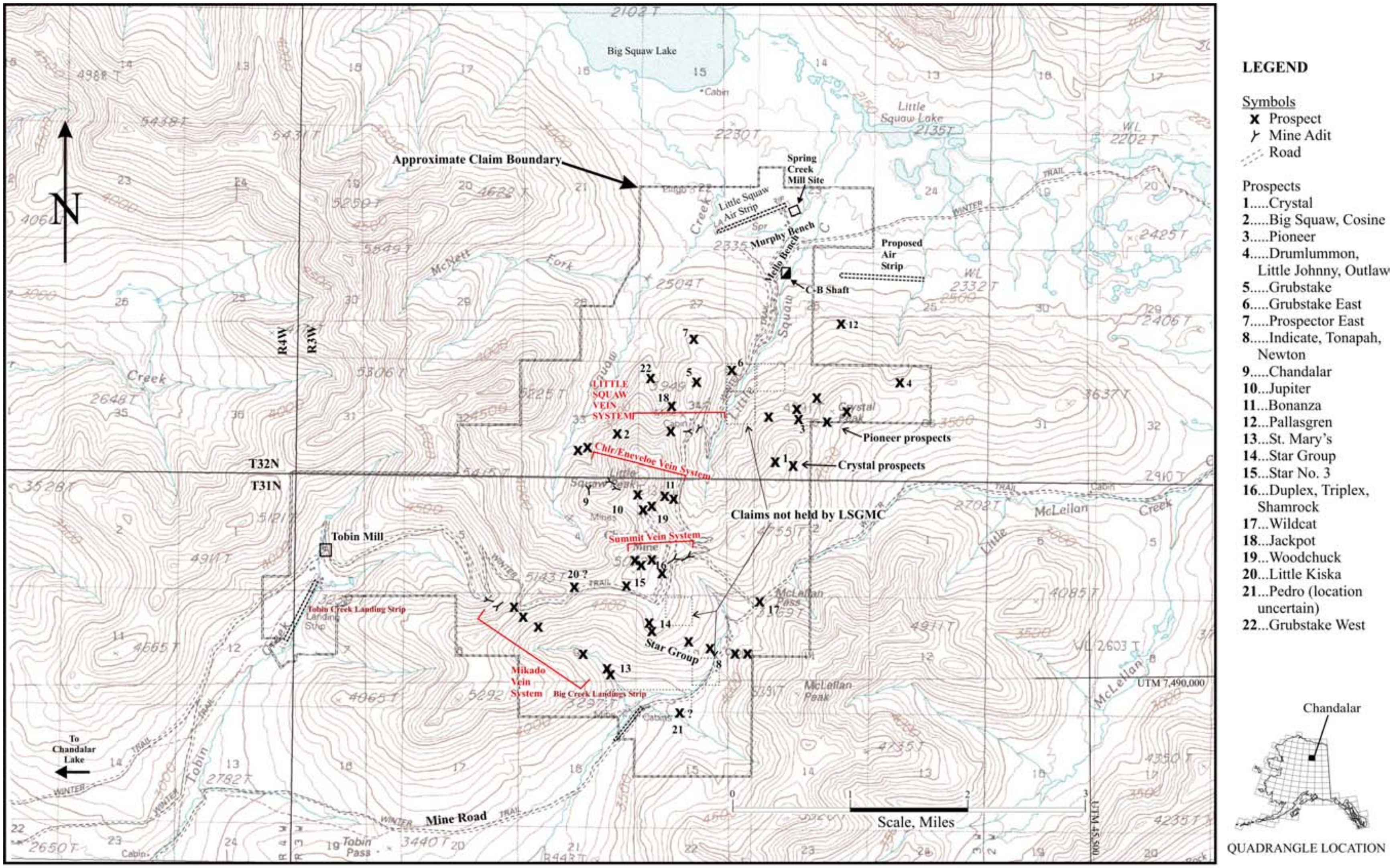



Figure 2. Mineral deposits and prospects of the Chandalar mining district.

was the Little Squaw Bench, including the Mellow Bench, where about 29,000 ounces of gold were recovered from gravel averaging 1.0 oz/cubic yard of gold, but with some clean-ups as high as 4.6 oz/cubic yard of gold (McKee, 1939, Strandberg, 1990). By 1916, gold deposits were similarly developed on Big Creek and St. Mary's Creek. Drift mining continued through the 1920s, but dropped off in the 1930s, as the remaining ground was deeper or lower grade, or in many cases not frozen. A rich pay streak on Tobin Creek was discovered in 1933, but not completely developed at the time. Mechanized mining was not introduced to the Chandalar district until after WW II, mostly after 1954 or 1955, when Chandalar Mining Company (Hugh Matheson Jr.) began mining on Big Creek (Holdsworth, 1957). In 1960, the auriferous bench on Tobin Creek was first exploited by Ellis Anderson with hand-mining methods (Williams, 1960).

Most of the productive and promising prospects were acquired by William Sulzer, a former Governor of New York. Beginning in 1909 and until his death in 1941, Sulzer financed exploration and development as owner of Chandalar Mines Company and later as a major share holder of Chandalar Gold Mines, Inc., when the two companies were merged on April 11, 1926. Boadway (1932, 1933) wrote the first comprehensive report of the district for W.R. Wade, of the Idaho-Alaska Corporation, who held the property under option in 1932 and 1933. The property lay idle until Karl Springer acquired the properties for Chandalar Gold Mines, Ltd. of Toronto, Canada. From 1937-1939, U.S. federal mineral patents were obtained by Sulzer for the principle discovery claims and a lengthy series of examination reports were prepared in hope of placing the lode deposits into production (McKee, 1939). However, there was little mining and no significant exploratory work until 1946, when Eskil Anderson acquired the interest of the Sulzer estate (Swanson and Block, 1975).

Little Squaw Mining Company (LSMC) was incorporated in Alaska on March 26$^{th}$, 1959. In May, 1968, the company name was changed to Little Squaw Gold Mining Company (LSGMC) and on October 9, 1970, LSGMC was listed on the Spokane Stock Exchange. In 1972, Chandalar Gold Mines was merged into LSGMC. When the Spokane Stock Exchange was closed in the mid-1980s, the LSGMC listing was transferred to the NASDAQ Over-the-Counter Bulletin Board, and it trades there under the symbol LITS.

Little Squaw is a fully reporting company, meaning it files all federally required documents to maintain its trading status listing with the United States Security and Exchange Commission, including audited financial statements.

In 1967, the Little Squaw Gold Mining Company issued a lease to Chandalar Gold Mining and Milling Company with general manager Frank Birch, who continued to consolidate remaining claims in the district. Property consolidation continued through 1976 (Sykes, 1977). Birch expanded the Tobin Creek placer mine when it was acquired in 1960, and began some development work and mining on the Mikado Lode, including construction of a 100 ton-per-day (tpd) mill in 1970. Birch also initiated exploration of other lodes of the area. Unfortunately, Mr. Birch was killed in an airplane crash on Tobin Creek in 1971, and his company's assets were subsequently acquired through forfeiture proceedings initiated by LSGMC.

Following Birch's death, LSGMC leased its placer interest to Canalaska Placer Inc., in 1978. Whelan Mining & Exploration then picked up the placer lease, followed shortly by a joint venture involving Jan Drew Holdings, Ltd. and Canadian Barranca (1980-89), and finally by Gold Dust Mines (1989-99).

Lode gold properties were leased by LSGMC to a succession of companies, including Marmac Alaska Mines, Ltd. (1971-73) who merged with Attila Resources in 1972, and subsequently to Noranda Mining Corporation (1974-75), Callahan Mining Company (1975), Mikado Gold Mines, Inc. (1976-77), Whelan Mining and Exploration, Inc. (1978-79), and finally Chandalar Development Corporation (CDC) (1980-83). Operations through 1981 were summarized in unauthored reports (1981). CDC recovered 8,169 ounces of gold from the Mikado and Summit Mines, until losing the lease in litigation to LSGMC in 1984. Total lode gold production from four high grade quartz vein/shear deposits was 9,039 ounces of gold from 11,819 tons of ore. The recovered grade of 0.764 oz/ton gold contrasts with the average mill head grade average of 1.132 oz/ton gold for all deposits, which indicates a significant gold recovery problem during past milling procedures. After these lode mining efforts, LSGMC maintained the claims and its corporate status, but the district slid back into dormancy with the exception of: 1) a small placer lease to Gold Dust Mines Inc., which operated on Tobin until 1993, then moved to Big Creek until 1999; and (2) a 1997 placer exploration lease to Daglow Exploration, Inc., which was limited to Big and Little Squaw Creeks (Fitch, 1997). This exploration work, which involved a drill program, suggested substantial previously unknown placer mineralization on lower Little Squaw Creek.

Early expeditions in the Chandalar region by the U.S. Geological Survey have been documented, including reports by Schrader (1899) and Maddren (1910, 1913). More specific to the Chandalar district was Mertie (1925), who mapped much of the Chandalar Quadrangle and visited many of the mines. From the late 1920s through 1934, personnel with the Alaska Territorial Department of Mines (Reed, 1929, 1930; Stanford, 1931) made repeated visits to the district and mines and issued several reports.

Shortly after Statehood, the U.S. Geological Survey published geologic maps of the Chandalar Quadrangle (Brosge and Reiser, 1964, 1970), which revised stratigraphy and structural interpretations, and provided the first modern isotopic age dates of plutonic and metamorphic rocks in the southern Brooks Range. The newly formed Alaska Division of Mines and Minerals provided the first detailed geologic map of the Chandalar district at 1:40,000 scale (Chipp, 1970). In 1986, the U.S. Geological Survey completed a quadrangle-wide Alaska Minerals Resources Assessment Program (AMRAP) study that included specific studies of geology, geochemistry, geophysics, and mineral resources (DeYoung, 1978; Marsh and others, 1978; O'Leary and others, 1976). A study of the mineralizing fluids responsible for the gold deposition in the Chandalar area was completed and published by Rose and others (1988), which followed an earlier fluid inclusion study by Ashworth (1983, 1984). Dillon and others (1989) and Moore and others (1994) and Mull (1982) provide regional geological coverage of the southern Brooks Range, which includes the Chandalar Mining district.

In 1988, Edward Odin Strandberg was retained by LSGMC to prepare a comprehensive report on the Chandalar Mining district. Mr. Strandberg was a professional mining engineer, registered with the State of Alaska. His work (Strandberg, 1990), which summarized many of the unpublished file reports that were prepared for the Chandalar Mining district, provided a very useful basis for the preparation of this report.

## V Property Description, Ownership, and Infrastructure

The Chandalar Mining district is widely recognized as the easternmost and perhaps best known mineralized area within the mineral belt that extends along the south flank of the central and eastern Brooks Range. As of 2003, over 84,000 ounces of gold have been produced from the Chandalar district placer and lode mines. Of this, 76,000 ounces of gold or about 90 percent of the total was recovered from placer deposits. Most of the remaining 10 percent of the total was recovered from the Mikado Lode. The Mikado is one of several auriferous quartz-sulfide veins found by the early prospectors. Together with the Little Squaw, Summit, and Eneveloe quartz lodes, these deposits have been explored with more than 2,000 feet of underground workings and several hundred feet of trenches and open cuts.

### *Land Issues*

The Chandalar Mining district lies within lands ceded in 1991 to the State of Alaska from the federal government as part of provisions under the 1959 Alaska Statehood Act. The State of Alaska has title to approximately two million acres of land located between the pipeline corridor on the west and the upper reaches of the Chandalar River on the east.

Mineral rights are held by the Little Squaw Gold Mining Co. (LSGMC) as fee simple federal mining patents and Alaska State mining claims. Unpatented federal mining claims that pre-dated Statehood were converted to Alaska State mining claims by previous LSGMC management in 1987. LSGMC presently holds patent title to 426.5 acres on 21 lode and one mill site claims (figure 3). Additionally, there are 1,020 acres within 26 older state claims pre-dating the 2003 management change. In 2003, 55 Alaska state 160 acre mining claims were located under provisions of the new Alaska MTRSC staking regulations. These claims encompass the favorable areas surrounding the previous mining property. Some overlap occurs between the new MTRSC claims and the older claims, which has been adjusted to a total claim holding of 8,553 acres (R.R. Walters, written communication, 2003, 2004; figure 3, this study).

The patented claims include most of the known lode deposits at Chandalar and are configured as four separate tracts aligned with the vein systems. Patents are on file with

U.S. Bureau of Land Management in Fairbanks. State claims are recorded at the Fairbanks Recording District, and claims are further platted and documented at the Alaska Division of Mining, Land, and Water (ADMLW), in the Alaska Department of Natural Resources (ADNR), Fairbanks, Alaska. Because the Chandalar district does not lie within an organized borough, there are no annual property taxes.

Mineral production on state lands is subject to a maximum 3.0 percent net profits royalty with applicable Exploration Incentive Credits of up to $20 million. Alaska requires a mining license tax for all mineral production net income of the tax payer regardless of underlying land ownership. For a major mining operation it is computed as $4,000 plus 7.0 percent of the excess over $100,000 of net income (Alaska Department of Natural Resources, 2002). Furthermore, there is a 3.5 year tax exemption after initial production begins. Depletion is figured as an allowable deduction of 15 percent of annual gross income, excluding from the gross income an amount equal to rents and royalties. The state corporate income tax rate is 9.4 percent if net profit is more than a set threshold amount.

Annual rental of Alaska State mining claims are based on the number of years of continuous activity since a mining claim was first located. The annual rental amounts are as follows: 1) for 0-5 years, $0.50/acre; 2) for 6-10 years, $1.00/acre; and 3) for 11 or more years, $2.50/acre (Alaska Department of Natural Resources, 2002).

LSGMC holds clear title to the federal patents with an overriding 2 percent production royalty due to the previous company management. The 2 percent royalty also applies to the unpatented state claims that were held by the previous management, but does not apply to more recently acquired state MTRSC claims, nor does it apply to seven state claims purchased separately by the present management of LSGMC (agreement signed April 14, 2003). The present company has the option to purchase all of the attached 2 percent production royalty for $250,000 prior to June 23, 2013. Appendix IV (A-D) depicts status of the various claim groups the company holds in the Chandalar Mining district.

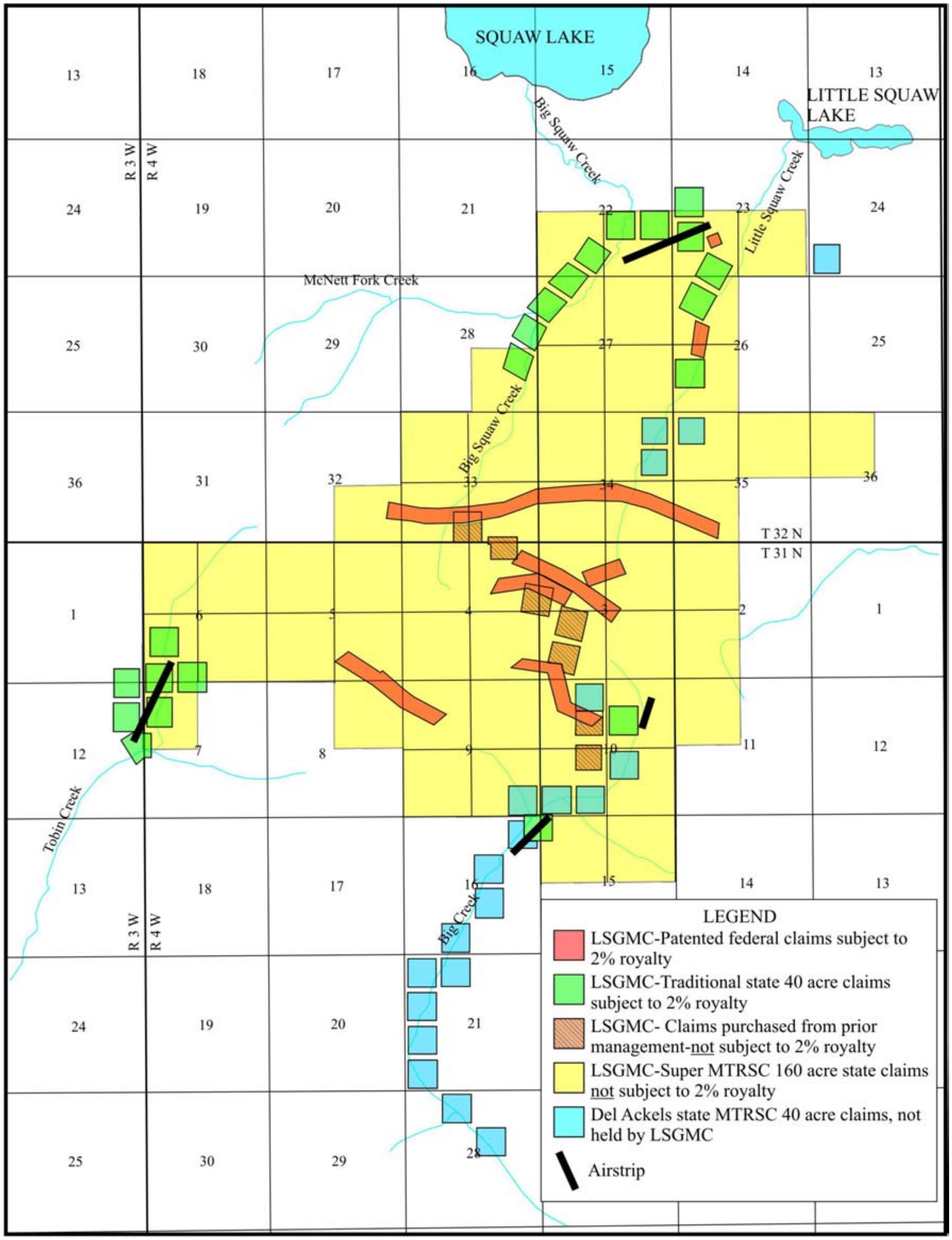



Figure 3. Location of mining property in the Chandalar mining district.

### *Water Rights*

LSGMC holds a right from the State of Alaska, filed under ADL 403439, to withdraw water for mining use. This right has three parts: 1) 3,000 gallons per minute (gpm) for placer mining; 2) 4,800 gallons per day (gpd) for lode mining; and 3) 67,200 gpd for lode mining. This water can be withdrawn from any of the local streams as specified in the permit, and it can be applied to use during the period of April through October within the area of claims held in March, 1985. Water law specifies that some beneficial use be made of the water at least once in any five year period, and this is stated by the company upon submittal of the annual $50 administrative fee. Failure to show beneficial use could be challenged by an adverse party. For continuing protection of water rights, LSGMC should continue to file a *Request for Permit Extension* with ADNR.

An additional right to water has been granted in the past to lessees of LSGMC as part of the Alaska Placer Mining Authorization (APMA) permit required for placer mining as issued by ADNR. These rights are only valid for the period of the permit.

### *Infrastructure*

Since the early 1990s, the Chandalar properties have received little physical attention, and no facilities maintenance has been conducted beyond the mining lease activities on Tobin and Big Creeks. Consequently, only the 3,600 foot long Little Squaw Creek airstrip is still usable. Airstrips on Tobin Creek and on Big Creek need to be cleared of vegetation and repaired. Similarly, about 20 miles of mine road will require blading to clear slide rock and repair local wash outs. Serious slides are reported on upper Little Squaw Creek road. These roads connect all the principal workings and prospects.

There are various structures on the property; all are in a state of disrepair. On Tobin Creek, there is a 100 ton-per-day (tpd) mill contained within a 34 foot by 160 foot steel building and a 35 foot by 38 foot shop. The mill includes gravity, floatation, amalgamation, and cyanide circuits, but it never operated efficiently on the Mikado ore when last used in the mid-1980s. An inventory of mine equipment and supplies is tabulated and updated by Strandberg (1990, 1994). It is unlikely that most of the equipment onsite is worth putting into operation, but may better serve as a valuable source of parts.

There is no electrical power grid in northern Alaska. Previous mining by lessees to LSGMC have relied on diesel powered generators, and at least two 250 kw generators and fuel tanks are located at Tobin Creek.

Should development of the district go forward, previous operators have recommended that permanent camp and mill facilities be situated in the Spring Creek mill site area on lower Little Squaw Creek. Because the site is connected to the historic mine road system, with available water and a better climate compared to the south side of the hills, this site is preferred by those who have worked in the area. A natural spring, located on the patented mill site, is reported to flow 140 gpm year round at a temperature of 40° F. Just north of this location a site suitable for an improved 5,280 foot long airstrip has been identified running southeast from Squaw Lake near the present 3,600 foot long airstrip (Strandberg, 1994).

## VI Regional Geology of the Koyukuk-Chandalar Region

### *Bedrock Geology*

In order to understand the lithologic and structural controls of lode gold deposits and the surficial geologic units that host the placer gold deposits, the authors reviewed the regional geologic framework of the southern Brooks Range. The Koyukuk-Chandalar region is underlain by regionally metamorphosed rocks that were originally referred to as the “southern Brooks Range Schist Belt” by Brosge and Reiser, (1964); Fritts (1970), Fritts and others (1971), Wiltse (1975), and Hitzman and others, (1982). This east-west-trending belt of poly-metamorphic rocks extend across the southern Brooks Range from the Kobuk River basin to the upper Sheenjek River drainage about 50 miles west of the Alaska-Yukon border. The regionally metamorphosed rocks are now considered to be part of the Arctic Alaska terrane (Moore and others, 1994), a large Late Proterozoic-to-Cretaceous, composite tectono-stratigraphic terrane that underlies the bulk of the Brooks Range in northern Alaska (figure 4). According to Dillon (1989), the Arctic Alaska terrane is composed of five (5) subterranes in the southern Brooks Range. From south to north, they are Coldfoot, Hammond, Endicott, Delong Mountains, and North Slope subterranes, each separated from each other by east-west-trending regional thrust faults or ‘thrust panels’. Four of these thrust panels occur in the study area and are described below.

The Coldfoot terrane consists mainly of Proterozoic to Lower Paleozoic, metasedimentary schist that has been intruded and overlain by bimodal metavolcanics, and granitic rocks of Devonian age. The Coldfoot subterrane contains the Ambler sequence, which hosts world class volcanogenic massive sulfide (VMS) deposits west of the Dalton Highway corridor (Hitzman and others, 1982). The metamorphic rocks that have been assigned to the Coldfoot subterrane in the Chandalar Mining district consist of schist, phyllite, and slate, and minor amounts of meta-gabbro and meta-diabase. Based on sparse fossil control found west of Wiseman, Brosge and Reiser (1964) assigned a Devonian age for metamorphosed sedimentary rocks in the Chandalar quadrangle, but there is no firm evidence for that age assignment in the Chandalar area. Rocks underlying the area described in this summary could range from Late Proterozoic to Devonian. As currently mapped, all of the gold-quartz deposits in the Chandalar district are hosted in the Coldfoot subterrane, as are gold-quartz vein deposits in the Nolan-Wiseman and Wild Lake areas.

The Hammond subterrane, which occurs immediately north of the Coldfoot subterrane, consists of Cambrian calc-schist and marble, Ordovician pelitic and graphitic schist that have been overlain by Devonian siliciclastic and volcaniclastic rocks and Upper Devonian marble. These layered rocks have in turn been intruded by felsic bimodal plutons of both Mesozoic and Devonian ages.

The Endicott and North Slope subterranes, which occur north of the Hammond subterrane, include the Devonian Hunt Fork shale and Devonian-Triassic low grade metamorphic metasedimentary rocks. In summary, although stratigraphic and mineralogical comparisons between the Chandalar area with sections in the Dalton Highway corridor are lacking, the Coldfoot subterrane probably underlies most of the Chandalar Mining district.

### ***Quaternary Geology***

Stratigraphic observations by the U.S. Geological Survey of glaciated highlands in the central Brooks Range (Mertie, 1925; Hamilton, 1978, 1979, 1986) provide evidence of Middle? and Late Pleistocene glaciations and development of Latest Wisconsin-to-Holocene lacustrine (lake) formations (figure 5). Glaciers of several ages flowed south from source areas higher in the Brooks Range and eventually terminated within and beyond the mouths of tributaries to the main valley of the Chandalar River (Williams, 1962). Drift of the extensive Gunsight Mountain and Anaktuvuk River Glaciations, which are presumed to be Early-to-mid-Pleistocene age, is not well developed in the Chandalar area. Instead the younger Late Pleistocene Sagavanirktok and Itkillik glaciations are mainly preserved in valley floors below 3,500 feet elevations. Because there are no active glaciers in the southern Brooks Range today, most of the erosional features consist of recent 'V' shaped incisions in formerly 'U' shaped glacially carved valleys, and infilling of former glacially dammed lakes.

### ***Regional Tectonic Setting***

Northeast, east-west, and to a minor extent, northwest trending structures are the major features on the south flank of the Brook Range (Dillon, 1989; Moore and others, 1994; Chipp, 1970; Brosge and Reiser, 1964). Large fold structures with amplitude ranges of 5-15 miles trend generally trend northeast across the central Chandalar Quadrangle (figure 4). The northeast trending Baby Creek batholith about 15 miles west of the Chandalar district forms the core of a large northeast-trending anticlinorium (Duke, 1975; Dillon and others, 1996). The structural deformation is typified by several stacked thrust panels that successively overlie a basement of unknown composition and age (figure 6).

According to Dillon (1982, 1989), two, possibly three, well-defined periods of regional dynamo-thermal metamorphism have affected the layered rocks in the Coldfoot and Hammond subterranes of the Chandalar area; each period of deformation was accompanied by $S_{1}$-$_{3}$ cleavage surfaces. The first prograde metamorphism, which increases in intensity in a southerly direction, resulted in the development of regional penetrative layer-parallel cleavage (S1) and development of upper greenschist to lower amphibolite facies metamorphic conditions. Till (1992) and Dusel-Bacon (1994) cite evidence for Proterozoic and possibly Paleozoic pro-grade blueschist and retrograde amphibolite facies metamorphism in the Brooks Range mainly west of the study area in the Ambler River area. During the Jurassic-to-mid-Cretaceous time (K-Ar ages of 154-172 Ma), the entire Brooks Range ‘schist belt’ was subjected to low-P, high T amphibolite facies conditions (Hitzman, 1982; Dillon, 1989; Dusel-Bacon, 1994). During the second prograde metamorphism, the Hammond subterrane was subjected to two periods of northward verging folds, semi-penetrative cleavage ($S_{2-3}$), and development of the lower greenschist facies retrograde metamorphism. This last period of regional metamorphic conditions is reflected in biotite and muscovite cooling ages ranging from 90-120 Ma reported by Turner and others (1979) and Dillon and others (1989).

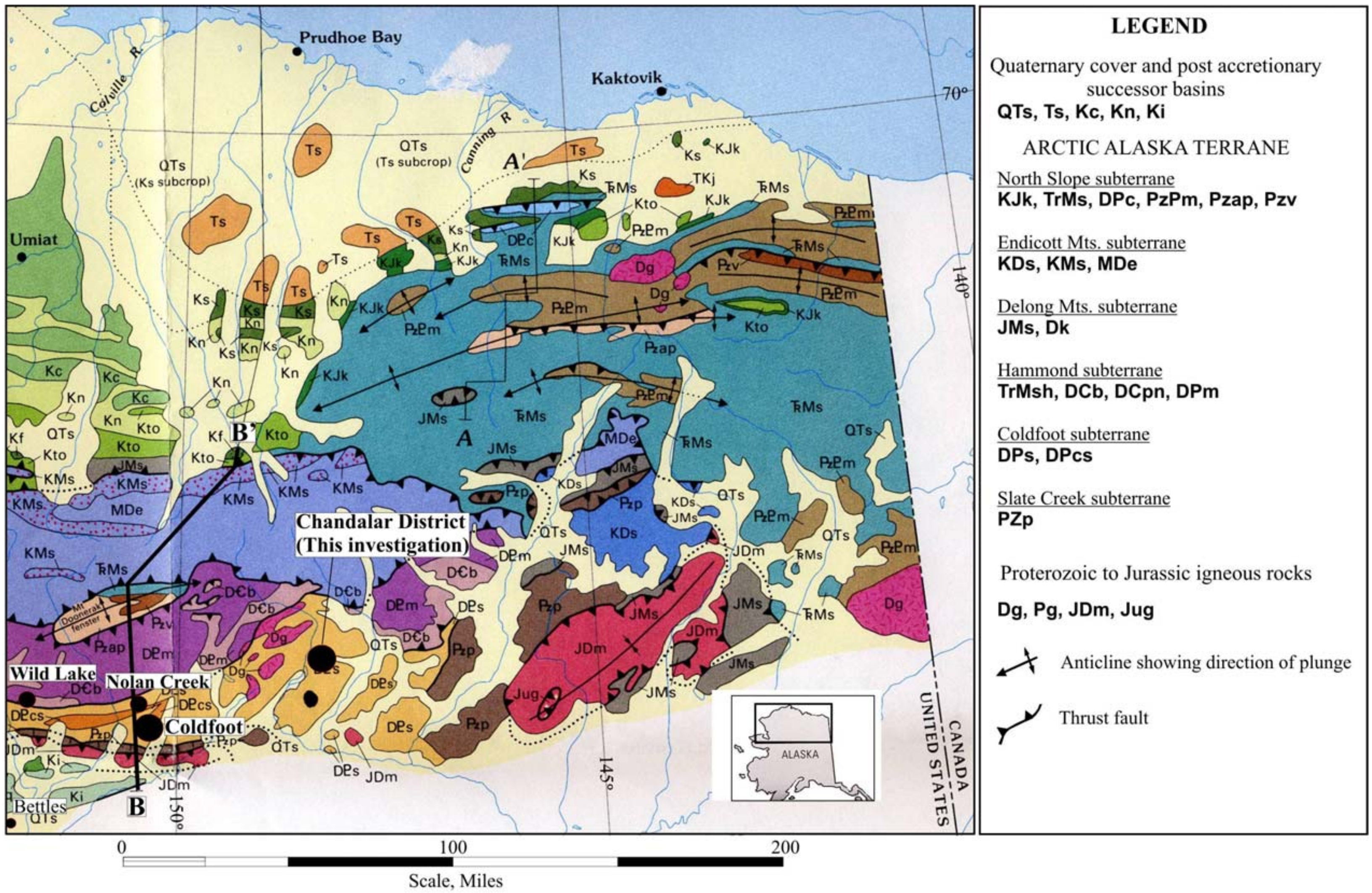



Figure 4. Regional geology of the eastern and central Brooks range, illustrating the location of subunits of the Arctic Alaska Terrane and locations of gold districts; geologic map modified from Moore and others (1994). See figure 6 for B-B' cross section.

The major period of crustal shortening, thrust faulting, and isoclinal folding has been determined by faunal and isotopic control ages to be the Neocomian (130-140 Ma), which coincided with the collision of the Arctic Alaska terrane with the Kobuk suture zone and proto-Pacific ‘Angayuchum Ocean’ (Mull, 1989). A much younger Albian to Turonian (80-110 Ma) uplift and plutonic event post-dated the Neocomian crustal shortening event and resulted in ‘gravity slide’ tectonism, and may have taken place during the late phase of regional greenschist facies, retrograde metamorphism (Dillon,1989). The prominent $S_{2-3}$ foliation surfaces observed in the phyllite and schist of the Coldfoot subterrane in the Chandalar area were likely developed during one or more of the Cretaceous dynamo-thermal events.

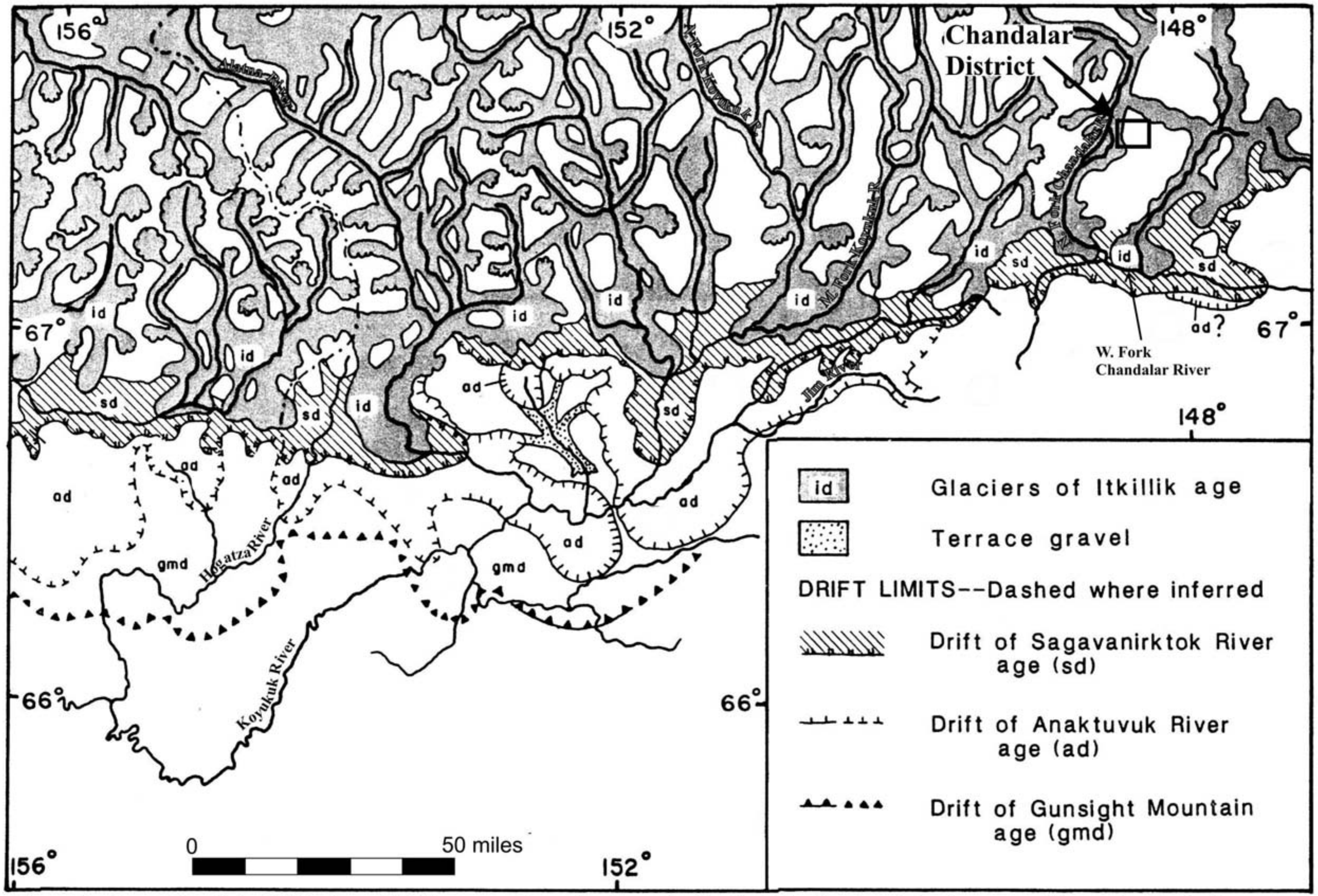



Figure 5. Generalized glacial limits and high terrace deposits along the flank of the Southern Brooks range, illustrating the influence of Pleistocene glaciation in the Chandalar Mining District, from Hamilton (1986).

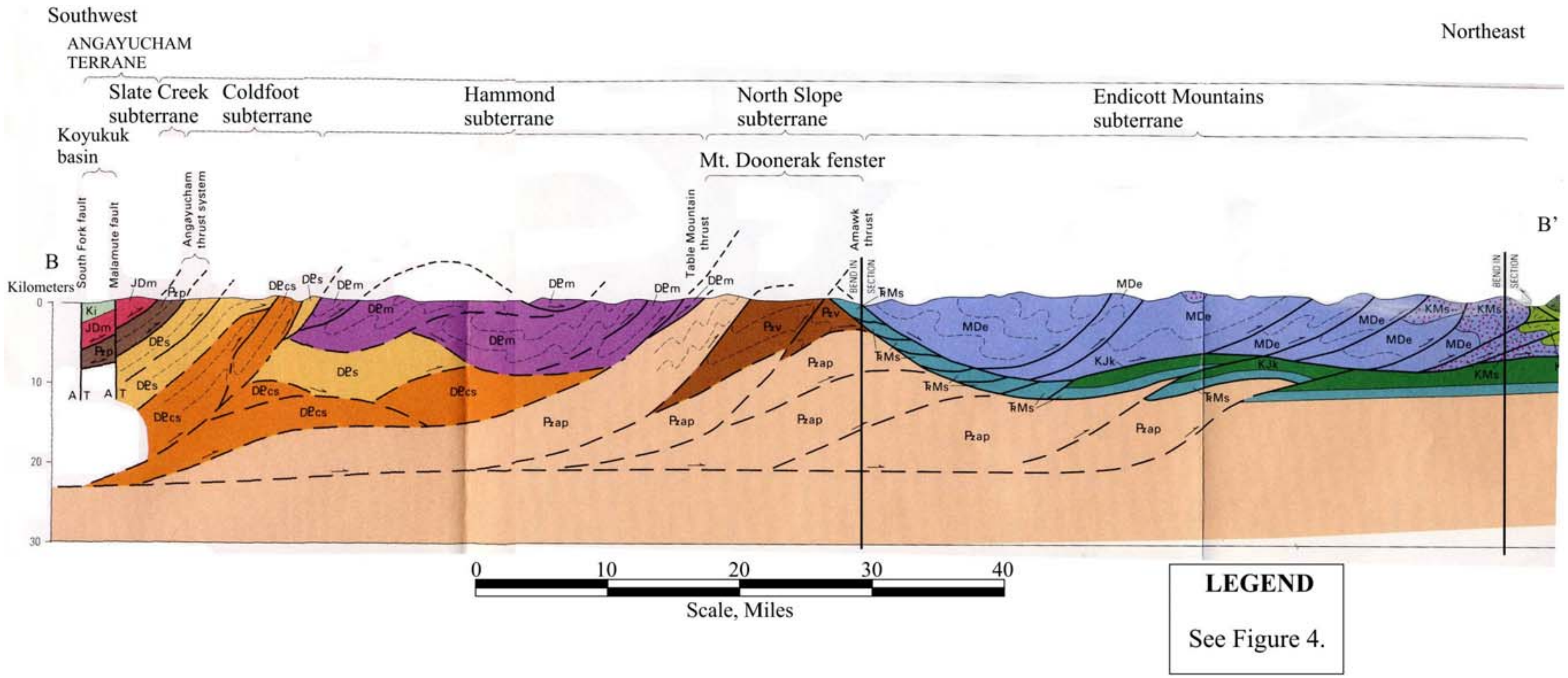



Figure 6. Structural cross section across the central Brooks Range, B-B' (see figure 4 for location), illustrating low angle decollement surfaces and duplex structures characteristic of the Brooks Range orogen; modified from Mull (1989) and Moore and others (1994).

## VII Geology of the Chandalar Mining District

Several geologic interpretations of the Chandalar Mining district were reviewed for this study, and three were judged to contain the most important information. Brosge and Reiser (1964, 1970) completed the first modern mapping of the Chandalar district at 1:250,000 and 1:63,360 scales, respectively. These workers provided the first modern isotopic ages of igneous and metamorphic minerals in the southern Brooks Range, and they mapped a thrust surface within Devonian quartz mica schist in the Chandalar Mining district. Rock unit descriptions and a geologic map (figure 7) used in this report are from Chipp (1970), who provides detailed descriptions of the district-scale geology of the Chandalar area at 1:40,000 scale. Chipp mapped phyllite, schist, shale, limestone, and meta-igneous mafic rock units in a N50-60W trend across the district and subdivided the rock units into lower plate and upper plate sequences, which are separated by a major decollement surface (thrust fault). Duke (1975) produced geologic mapping products of the district on behalf of Callahan Mining Corporation. His mapping includes an outcrop map at 1:10,000 scale and a more regional, 1:31,500 scale, map that emphasizes structural features with the use of photo geologic interpretation (figures 8, 9).

### ***Lower Plate Sequence***

The lower plate sequence consists of black schist, phyllite, slate, and quartzite (pCPzbs) that has been intruded locally by greenstone/gabbro sills or dikes (pCPzg). These lower plate rocks crop out southwest of the ridge summit between lower Tobin and Big Creeks and on the low north-facing slopes west of Squaw Lake (figure 7). The lower plate sequence is equivalent to the quartz-muscovite-chlorite-schist unit of Brosge and Reiser (1964). The black schist-dominant unit (pCPzbs; figure 7) is in thrust contact with the overlying schist section in the upper plate sequence.

The pCPzbs unit varies in texture and composition. In the Dome and upper Tobin Creek areas, it is composed of black slate and phyllite beds that are interbedded with quartzite beds. In lower Tobin Creek and east of Big Creek, the pCPzbs unit contains thin boudins of mafic schist that are frequently rolled into small isoclinal folds.

Pelitic sediments are the likely provenance for the pCPzbs unit. The appearance of albite+biotite+chlorite+quartz+garnet indicates upper greenschist facies regional metamorphic conditions in the pCPzbs unit. However, the ragged appearance of garnet porphyroblasts and extensive chlorite rims around biotite grains observed in the many samples studied by Chipp (1970) indicate an original higher metamorphic rank, possibly the lower amphibolite facies, that has subsequently undergone a period of retrograde metamorphism.

Greenstone sills, dikes, and possible metavolcanic bodies (pCPzg) intrude the lower plate sequence in many areas. Because many are too small to show on the geologic map, only those bodies of sufficient size are shown on figure 7. Brosge and Reiser (1964) have assigned the schist-hosted greenstone bodies throughout the Chandalar Quadrangle a Devonian age, but there are sparse isotopic or fossil data to support such an age. $^{40}K/^{40}Ar$ ages reported by Turner and others (1979) indicate metamorphic ages of Jurassic or younger for the greenstone bodies across the expanse of the southern Brooks Range. Similar amphibolite-rich greenstone bodies that occur throughout the Yukon-Tanana metamorphic terrane north of Fairbanks have yielded Permian-to-Upper Triassic U/Pb zircon ages (Jim Mortensen, pers. commun., 2002). The pCPzg unit in the Chandalar Mining district contains several textural and compositional varieties of mafic metamorphic rocks that include: 1) fine-grained granoblastic greenstone; 2) highly schistose, sulfide-rich, albite-bearing amphibolite; and 3) coarse-grained actinolite-albite-chlorite quartz amphibolite.

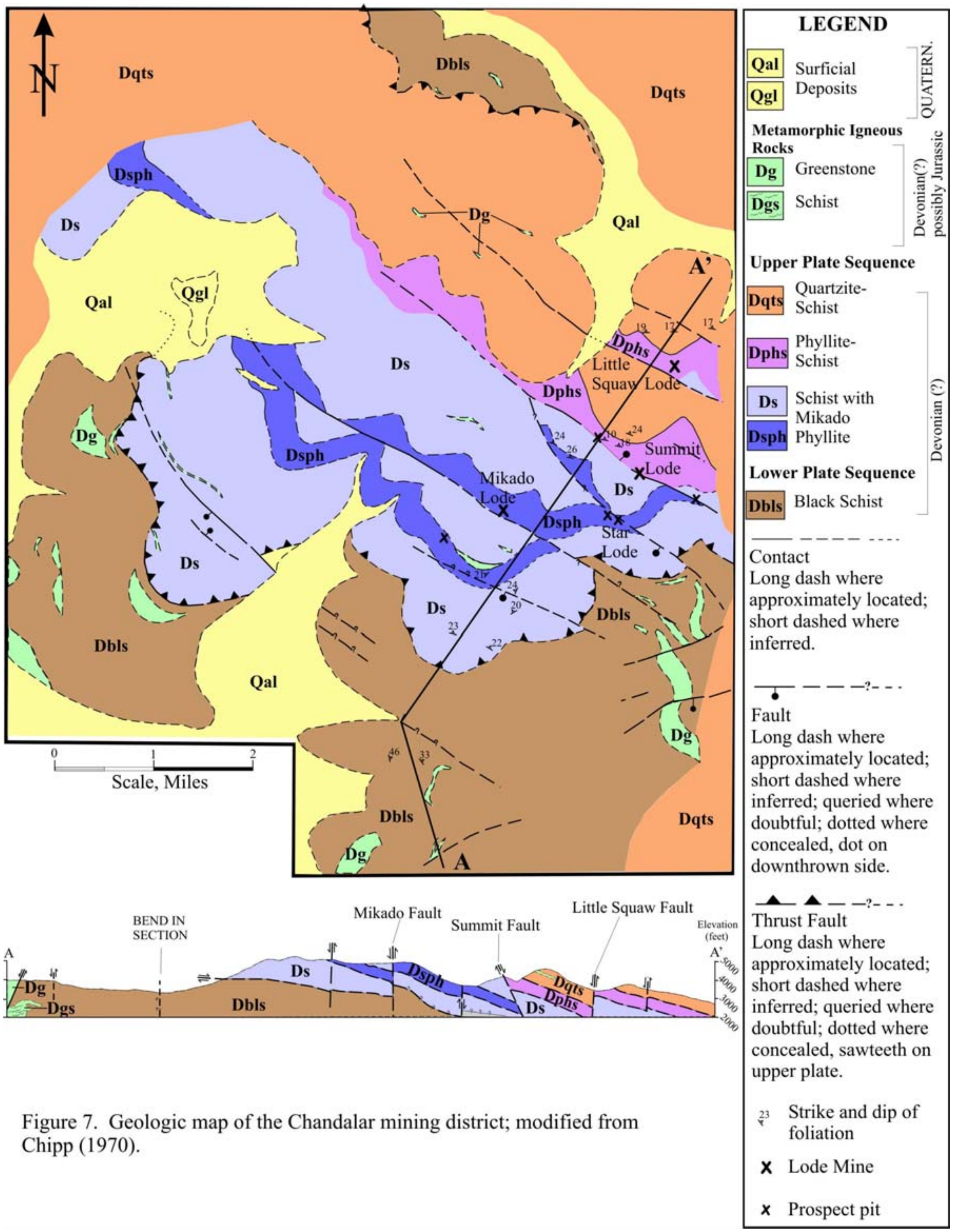



Figure 7. Geologic map of the Chandalar mining district; modified from Chipp (1970).

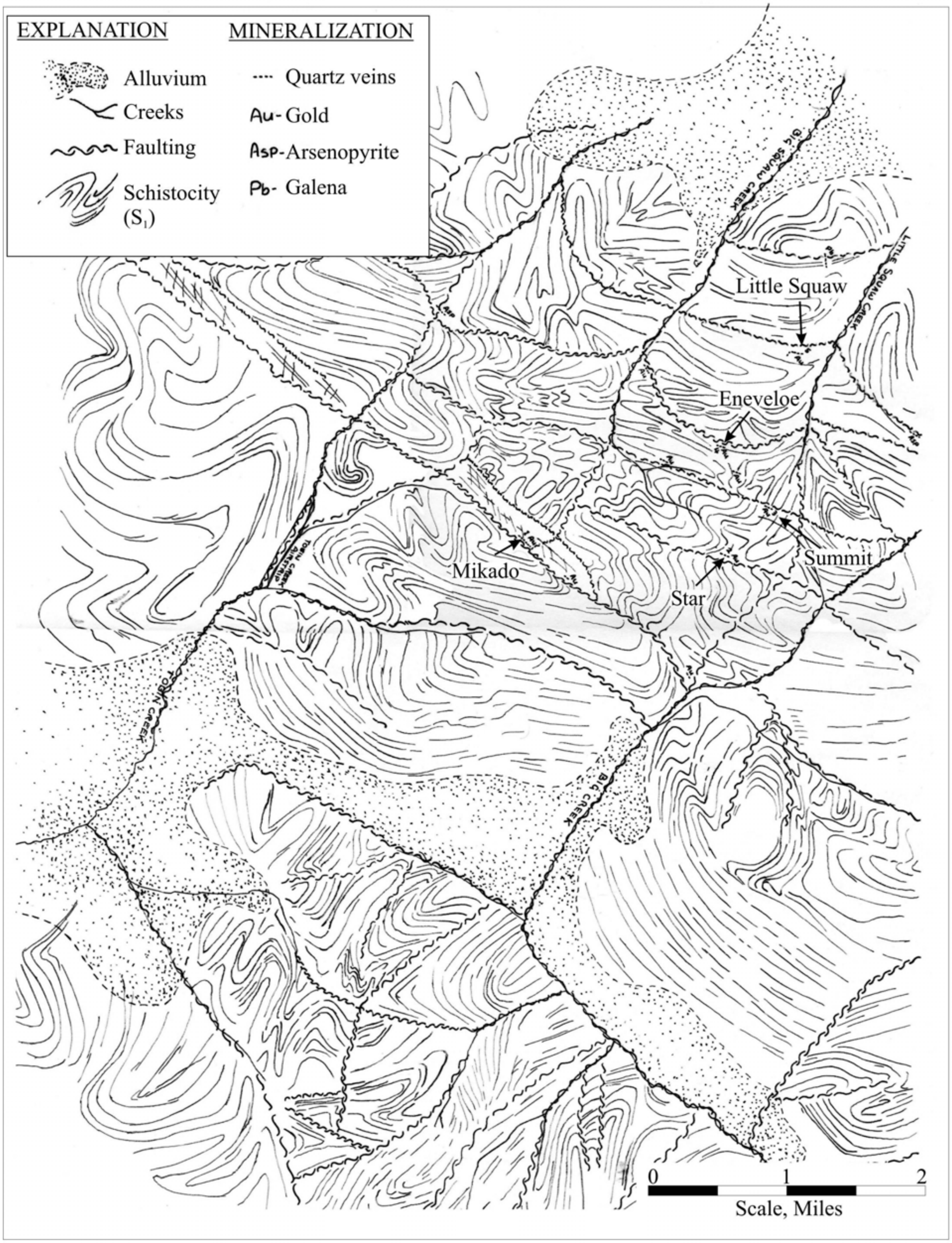



Figure 8. Structural interpretation of the Chandalar Mining district at about 1:40,000 scale, with an emphasis on photo geologic interpretation; modified from Norm Duke (1975).

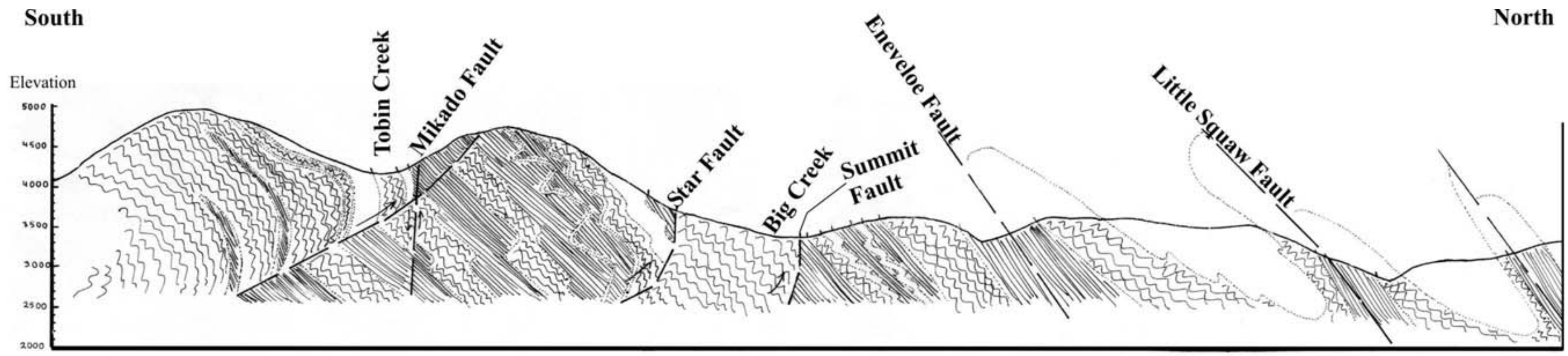



Figure 9. Structural cross sectional interpretation of the Chandalar Mining district from southwest to northeast, from Duke (1975). The cross section is about 5 miles across.

### *Upper Plate Sequence*

The upper plate sequence includes the bulk of the exposed metamorphic section in the Chandalar Mining district (figure 7). It forms the core of the northwest-trending ridgeline that separates the north-flowing Big Squaw Creek drainage basin from the southwest-flowing Tobin and Big Creek drainage basins. It includes several mappable units: 1) dark gray quartz muscovite schist (pCPzs); 2) the 'Mikado Phyllite' (pCPzph); 3) a phyllitic schist unit (pCPzphs); and 4) a quartzite-quartzose schist unit (pCPzqs). Contacts appear to be gradational between all four units. The upper plate sequence may be equivalent to the Dqm unit of Brosge and Reiser (1964). The lowest unit of the upper plate sequence is the dominant quartz-muscovite schist (pCPzs) unit interbedded with the minor 'Mikado Phyllite' (pCPzph) unit. The phyllitic schist (pCPzphs) unit, which gradationally overlies the interbedded pCPzs and pCPzph units, occupies the summit of the northwest-trending ridgeline. The pelitic schist and phyllite units are capped by the quartzite-quartzose schist (pCPzqs) unit, which forms prominent ridges, and outcrops due to a high quartz content. The highest member of the upper plate sequence is in thrust contact with the lower plate sequence black schist (pcPzbs) unit along the lower slopes of Glacier Valley in the Lake-Graves Creek basin.

Duke (1975) believes that there are felsic exhalative horizons in the metamorphic section in the Chandalar district, and he even suggests their possible relation to sulfide mineralization in the area. To the west, the Coldfoot subterrane contains the Ambler sequence, a belt of metavolcanic rocks that host significant volcanogenic massive sulfide (VMS) deposits.

The appearance of albite+chlorite+biotite+white mica+quartz in equilibrium in all units of the upper plate sequence indicates greenschist facies metamorphic conditions. Because the upper plate sequence lacks the greenstone bodies of the lower plate sequence, retrograde garnets were not identified.

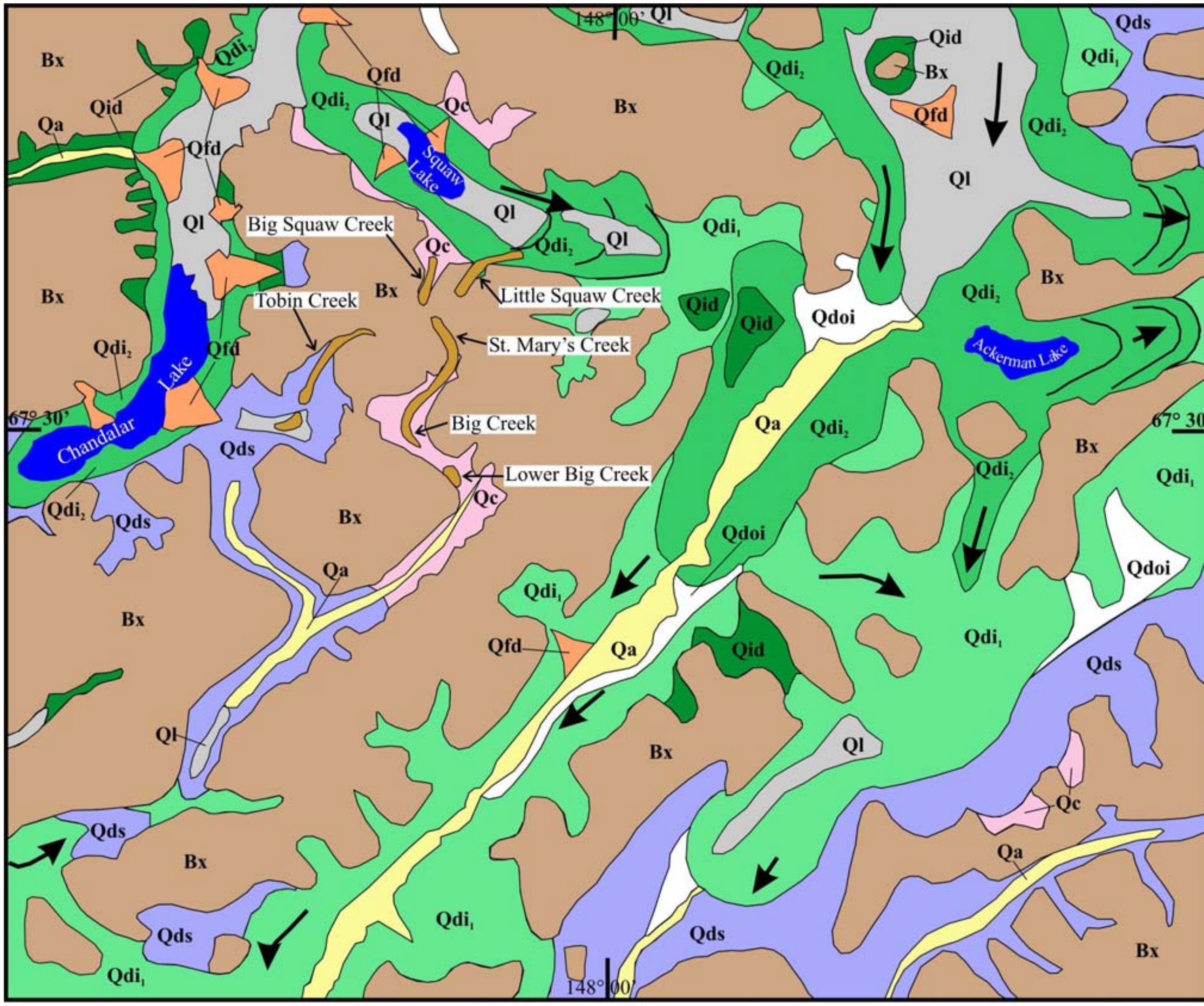
### *Intrusive Rocks of the Chandalar District*

No post-metamorphic igneous rocks have been described in published reports of the Chandalar Mining district (Brosge and Reiser, 1964, Dillon, 1989; Mertie, 1925; Chipp, 1970). The nearest plutonic rocks are found in the Baby Creek batholith, which crops out east of Twin Lakes, about 15 miles west of Tobin Creek. Intrusive rocks in the Baby

Creek batholith, although generally non-foliated, have undergone at least one regional dynamo-thermal metamorphic event and are considered to be Devonian in age, based on U/Pb isotopic age dating (Dillon and others, 1980, 1996). Fitch (1997) described an outcrop of medium-grained phaneritic, 'unfoliated biotite quartz monzonite' at an elevation of approximately 2,300 feet on the north-facing slope separating Little Squaw Creek from Big Squaw Creek (figure 7). Chipp (1970) describes spotted phyllite localities in both upper and lower plate sequences summarized above. Although he ascribes these textures to normal regional metamorphic processes, they could also be the manifestation of contact metamorphism by a buried intrusion.

### ***Quaternary History of the Chandalar District***

Understanding the Quaternary history of the Chandalar Mining district has a direct bearing on the origins, formation, and preservation of productive placer gold deposits as well as surface geochemistry dispersal factors deployed in the search of hard rock gold deposits. A Quaternary geologic map at 1:250,000 scale, modified from Hamilton (1978), is presented in figure 10. Although knowledge of the Quaternary history of the Chandalar Mining district has been refined by modern radiocarbon dates acquired by the U.S. Geological Survey (Hamilton, 1978), some of the most useful descriptions of relevant glacial processes have been provided by Mertie (1925). Glacial drift of the Middle Pleistocene Sagavanirktok River Glaciation and Late Pleistocene, probably the Late-Wisconsin, Itkillik Glaciation occupies valley floors and lower hill slopes throughout most of the Chandalar Mining district. Glaciers from the older Sagavanirktok Glaciation (Qds, figure 10) traversed at high elevations down trunk valleys and probably covered lower slopes in the mining district at or below the 3,500 feet elevation. Drift of the Sagavanirktok River Glaciation has been mapped in the south-facing valleys of Tobin Creek and lower Big Creek (Brosge and Reiser, 1964; Hamilton, 1978). The younger Itkillik Glacial advances (Qdi1, 2, figure 10) deposited unmodified drift in all valley bottoms. Glaciers during both glacial periods exhibited diffluent and transfluent flow patterns as they advanced in a southerly direction down the Middle and North Forks of the Chandalar River and in an east-southeast direction from Lake Creek to Graves Creek (figure 10).




**LEGEND**

**Qa-** Undifferentiated quaternary alluvium of several ages.
**Qc-** Undifferentiated colluvial deposits.
**Qfd-** Fan delta deposits deposited on pro-glacial lake deposits.
**Ql-** Lacustrine (lake) deposits undifferentiated.
**Qdoi-** Undifferentiated glacial outwash deposits.
**Qid-** Undifferentiated Itkillik drift.
**Qdi$_2$-** Youngest drift, Itkillik glaciation.
**Qdi$_1$-** Oldest drift, Itkillik glaciation.
**Qds-** Drift of Sagavanirktuk glaciation.
**Bx-** Undifferentiated bedrock and bedrock derived colluvium.

Indicates direction of Pleistocene glacier flow.

Approximate location of auriferous heavy mineral placer deposits.

Figure 10. Surficial geologic map of the Chandalar mining district at about 1:250,000 scale, illustrating the distribution of heavy mineral placer gold deposits and multiple glaciogenic episodes, modified from Hamilton (1978).

During the Itkillik glacial maximum (Qdi1, figure 10), an extensive lacustrine system inundated the entire valley of the North Fork of the Chandalar River from a point about 3 miles southwest of Chandalar Lake northward to Thru Creek, a distance of nearly 45 miles. This was made possible by the extensive east-southeast oriented valley fill moraines of the West Fork of the Chandalar River, which provided an effective barrier to southerly stream flow in the lower North Fork (Hamilton, 1978). The 8-mile-long Chandalar Lake is the last remnant of this formerly extensive lake system.

Placer gold deposits found in the area first began to form prior to the Sagavanirktok River Glaciation (Mertie, 1925; Hamilton, 1978). Prior to glaciation in Middle Pleistocene time, Little Squaw, Tobin, and Big Creeks had much the same stream courses as they do at present. Little Squaw Creek flowed eastward through the present Lake-Graves Creek Valley. Tobin and Big Creeks flowed west and southwest to the North Fork, the same trunk valley that exists today. Placer gold in the Chandalar Mining district was liberated from lode sources during several erosional and concentration processes. First, it was eroded from hard rock quartz vein sources such as the Mikado, Eneveloe, Summit, Little Squaw, Star, and St. Mary's deposits and deposited along slopes below the mineralization and in the stream basins. During the extensive Sagavanirktok Glaciation, some of this placer gold may have been transported as glacial till from hard-rock source areas.

Periods of deglaciation occurred with the most prominent example being an interglacial period between the Sagavanirktok and Itkillik glacial maximums. These deglaciation events caused periods of rapid downcutting in response to new base levels in valley floors. When the North Fork glacier retreated, it left a great mass of moraine that extended up to Little Squaw Creek almost to the upper limit of the glacier (Mertie, 1925). After deglaciation, the glacial drift acted as a new base level over which Little Squaw Creek flowed into the Lake-Grave Creek valley. When the glacial till was further eroded, Little Squaw Creek cut a new post-glacial channel through the glacial deposits to its lower course (Mertie, 1925). This adjustment also took place during an interglacial period between the Itkillik 1 and Itkillik 2 glaciations, and then after the end of the final Itkillik glacial maximum. The downcutting and fluvial adjustment episodes left perched and newly cut auriferous channel gravels above bedrock surfaces, which has been observed during exploration of the placer deposits on Little Squaw and Big Squaw Creeks. Placer gold deposits of the Chandalar Mining district formed in similar fashion to that observed in vigorous, placer systems in the Valdez Creek Mining district of south-central Alaska (Reger and Bundtzen, 1990) the Koyukuk-Nolan Creek area near Coldfoot (Mertie, 1925), and Bolotny-Ravkosky district in northeast Russia (Tchapko, 1995). In these examples, the heavy mineral placer pay streaks were not eroded by post-glacial readjustments and, instead, they were preserved as perched gravel channels sometimes buried under glacial drift.

# VIII Structural Analysis of the Chandalar Mining District

### ***Thrust Faults***

The dominant structural feature in the Chandalar Mining district is a low-angle decollement that separates two metamorphic panels designated the lower plate and upper plate sequences (Chipp, 1970; figure 7). The homoclinally dipping, metamorphic section also features minor but complex northeast-verging folds. After the upper plate sequence was thrust over the lower plate sequence, a series of orthogonal northeast- and northwest-trending, high angle faults cut the metamorphic rock section. These high angle structures have localized the important low sulfide gold-quartz deposits that have been developed and mined in the Chandalar Mining district.

Chipp (1970) provides the following lines of evidence for the thrust faulting in the district:

*1) the lower plate sequence (pCPzbs and pCPzg) is in contact with the highest unit of the upper plate sequence (pCPzqs) in the northern part of the map area;*
*2) there is a distinctive angular discordance between the lower plate sequence and upper plate sequence in many areas;*
*3) small fold plunges and crenulations in the lower and upper plate sequences are discordant with the orientation of the thrust fault;*
*4) the upper plate sequence does not contain mappable concentrations of greenstone and amphibolite (pCPzg), where these lithologies are abundant in the lower plate sequence; and*
*5) textural deformation (S surface development and shearing) is more pronounced in upper plate sequence rocks as compared to rocks in the lower plate sequence.*

The synclinal shape of the thrust (decollement) surface is inferred on the basis of mapped field relations and the discovery of the lower plate sequence on the north and south sides of the 'Chandalar Hills'.

Duke (1975) also believes that a major decollement surface separates two schist panels in the Chandalar district, but he presents a different structural analysis than Chipp (1970). Duke (1975) invokes a model of orogenic uplift along the southern Brooks Range mountain front, which provides the mechanism of gravity-slide displacement of schist panels in a northerly direction on planes dipping 10-30 degrees north. In the model proposed by Duke (1975), the northward-directed thrust faults dip in a homocline (figures 8, 9) and are not repeated in a synclinal trough as suggested by Chipp (1970).

### *Folding*

According to Chipp (1970), north-northeast-trending folds are largely confined to the lower plate sequence. These folds are mainly open folds with amplitudes ranging from 50 to 300 feet. Small, sub-isoclinal fold sets that trend northwest-west with amplitudes ranging from inches to a few tens of feet are generally found in the upper plate sequence. These northwest to west-trending sub-isoclinal folds in the upper plate sequence are not obviously related to larger folds. Late stage, N70E-trending crenulations overturned to the northwest are pervasive in the upper plate sequence and are probably related to the thrust faulting episode.

Fold deformation in the Chandalar district as presented by Duke (1975) differs significantly from that proposed by Chipp (1970). Instead of a regular fold deformation pattern, Duke (1975) depicts a chaotic structural pattern of complex poly-deformed folding broken up by post folding, high angle faults of several ages (figure 9).

### *High Angle Faults*

Northward thrusting summarized above has given rise to the two prominent fault planes, which are approximately perpendicular to each other (figure 9, this report). The most prominent high angle faults trend N50-60W and dip steeply-to-vertically. Most of the known lode gold mineral occurrences are hosted along these northwest-striking, high angle shear zones. For example the Mikado Fault, which hosts the Mikado gold deposit, down-drops the Mikado Phyllite more than 500 feet on its southwest side. The N55W striking Summit fault, displaced the pCPzphs unit at least 1,500 feet in a left lateral sense.

The northwest-trending high angle faults have been cut by N65-70E high angle structures in an apparent conjugate set, which combined form an orthogonal stress field. This orthogonal fault pattern was recognized and analyzed by Albert and others (1978). It occurs in an elongate belt some 25-30 miles long and about 10 miles wide, which extends both east and west of the Chandalar district. These northeasterly-trending tear faults are steeply dipping and their strike lengths are comparatively long and straight. Duke (1975) suggests that these faults have resulted from fracturing of the detached sheet and slippage, due to unequal rates of movement over the low-dip, shear surfaces. Under this assumption, these high angle northeast-trending faults probably did not extend below the decollement surface mapped by Chipp (1970).

The northwest-trending faults were believed by both Chipp (1970) and Duke (1975) to have undergone a more complex tectonic history than the northeast high angle structures. They were initially formed by the northward directed thrusting and, secondly, by late tensional normal faulting that post-dated the thrusting episode. The northwest-trending faults may dip steeply or shallowly and are characterized by wide gouge zones with hydrothermal alteration and auriferous quartz-sulfide mineralization. If the northwest-trending high angle faults persisted after thrusting, the auriferous mineralization that infills some of the fault structures might penetrate below the decollement surface.

### *Timing of Structural Deformation*

The following chronology of events, which has been proposed by previous workers (Dillon and others, 1989; Goldfarb and others, 1997), likely explains the successive transitions from ductile to brittle deformation during regional, dynamo-thermal metamorphism, plutonism, and uplift observed in the Chandalar Mining district:

*1) Two distinct periods of regional metamorphism took place during Pre-Jurassic and Late Jurassic-Early Cretaceous times respectively. This is evidenced by two distinctive 'S' surfaces and isotopic ages of metamorphic minerals formed during those deformational events.*
*2) Thrust faulting and isoclinal folding formed during the second period of regional dynamo-thermal metamorphism. The decollement surface recognized in the Chandalar district probably formed at this time. Dillon and others (1989) judge that this thrust faulting/isoclinal folding event took place during Late Jurassic-Early Cretaceous time.*
*3) NW-trending high angle faults were initially formed by the northward directed thrusting and, secondly, by late tensional normal faulting that post-dated the thrusting episode. The NW-high angle faults probably formed during the last waning stages of retrogressive regional metamorphism.*
*4) N65-70E high angle structures cut the NW-trending high angle structures in an apparent conjugate set. These northeasterly trending tear faults are steeply dipping and their strike lengths are comparatively long and straight. For the most part, they post-date and disrupt the auriferous high angle vein faults that contain most of the gold resources in the Chandalar Mining district.*

The specific timing of the events postulated above is poorly constrained by $^{40}K/^{40}Ar$ dating summarized by Dillon and others (1989). Hydrothermal mineralization in both the NE and NW faults sets in the Chandalar Mining district should be dated to place constraints on the timing auriferous quartz vein formation.

## IX Mineral Deposits

### *Definitions*

For the purpose of this report, definitions of 'ore reserve' classifications are based on U.S. Bureau of Mines and the U.S. Geological Survey definitions of 'ore' classes (USGS Circular 831, 1980). The term 'reserve' implies a body of mineralized rock that is economically viable to extract. The reader is advised that no feasibility studies have been completed for any of the estimates given in the following discussion. Therefore the term 'resource' will be applied to the estimates of placer and lode mineralization referred to in this report. Additionally, these estimates do not include mining dilution, and, for lode deposits, are based on a minimum mining width of three feet and a 12-cubic-foot per ton for the ores of the quartz-rich ores of the Chandalar mining district. Placer resources are measured as bank cubic yards. Furthermore, it should be noted that the U.S. Securities and Exchange Commission allows the use only of the proven 'ore reserves' term, defined as that 'ore' that can be economically extracted, and that all other classifications of 'ore', whether classed as 'reserve' or as 'resource', must be regarded as 'mineralized material'. The classification definitions are as follows:

1. <u>Proven:</u> Proven tonnage is computed from dimensions revealed in outcrops, trenches, pits, shafts, and other mine workings and in drill holes for which grade is computed from the results of detailed sampling. The sites for inspection, sampling, and measurement are so closely spaced and the geological character is so well defined that the size, shape, and mineral content are well established. The computed tonnage and grade are judged to be accurate and that no such limit is judged to differ from the computed tonnage and grade within stated limits that may not be more than 20 percent.
2. <u>Probable:</u> Probable tonnage and grade are computed partly from specific data and partly from projection for a reasonable distance, based on local geological evidence. The sites available for inspection, measurement, and sampling are too widely or otherwise inappropriately spaced to outline the 'ore' completely or to establish its grade throughout.

3. Possible: Possible tonnage and grade are estimates based on broad knowledge of the deposit's geologic character of the deposit but for which there are few, if any, samples or measurements. The estimates are based on assumed continuity or repetition for which there is geologic evidence which may include comparison with similar deposit types. Concealed deposits may be included if there is specific geologic evidence for their presence. Estimates should include a statement of the special limits within which the mineralization may lie.

Gold resources stated in this report are measured as troy ounce (ounce) and stated as ounce per short ton (oz/ton) for lode deposits or ounce per bank cubic yard (oz/cubic yard) for placer deposits.

### *LodeDeposits of the Chandalar District; General Discussion*

Gold occurs in definable systems of veins and lenses of quartz within or adjacent to northwest-trending shear zones. Highly mineralized quartz-sulfide veins and lenses within shear zone systems discovered to-date contain on average about 1.0 oz/ton gold or more. They are generally less than 150 feet long, 3-to-10 feet wide, with vertical extents averaging about 200 feet. Individual prospects have been discovered at various points along major shear zones, which have strike lengths up to about four miles. Mineralization has been found to occur at elevations between 3,100 and 5,000 feet. There has been no subsurface exploration below the 3,100-foot outcrop elevation along the valley floor.

Quartz veins are hosted in Devonian phyllite, quartzite, and schist with no apparent association with intrusive rocks. Some degree of lithologic control of mineralization has been suggested by previous workers, including Duke (1975) and Chipp (1970), who believed gold mineralization may be preferentially hosted in carbonaceous phyllite and gray to black schist wall rocks adjacent to the veins. Ashworth (1983) suggested a genetic connection between gold and greenstone. However, inadequate work has been done to comment further.

Two distinct types of veins have been explored. The largest lode found to-date that represents the first type is the Mikado, where gold mineralization occurs in the hanging wall of the Mikado shear zone (Bolin, 1984). Within these systems are discontinuous but discrete gold-bearing lenses, veins, and stringer zones, with associated alteration and gouge also having gold values. Alteration in gouge zones includes various clay minerals, predominantly kaolinite, black-to-green chlorite, granulated quartz, lesser albite, alunite, and carbonate. Mill records indicate graphite is associated with some of the mineralization. There is evidence of multiple stages of mineralization of gold, arsenopyrite, pyrite, and accessory galena and sphalerite. Quartz veins with similar mineral assemblages, but without significant gold, are also found in the district and occur in the same vein system as mineralized quartz. Recurrent movement along the shears has brecciated and displaced the structures (Bolin, 1984).

The second type of vein system with gold mineralization, described by Bolin (1984) and earlier investigators (Duke, 1975b), is found in the east-west-trending fractures in proximity of the major shear zones; the Little Squaw and Summit Lodes are of this type. These deposits occur in subparallel splay faults or fractures near the major shear zones. There is little evidence of movement on the host fractures and no significant gouge development. There are sharply defined footwall and hanging wall contacts with minor wall rock alteration, and veins have more continuity than the shear-hosted type. Deposition of the veins is possibly related to segments of tension fractures or drag folding on the shear zones. High grade auriferous mineralization is often concentrated in cherty, fine-grained ribbon banded zones along either contact, but tends to favor wall rock of carbonaceous phyllite. The veins generally will also include bands of massive lower-grade, coarser-grain quartz.

Evidence suggests the tonnage potential of the Mikado-type is greater than for the second type, given that numerous highly mineralized pods and lenses occur within a larger and wider, more continuous shear zone presumably having greater vertical extent. The 4-mile-long Mikado structure exhibits mineralized lenses along more than 7,500 feet of strike length. The much narrower, fracture-hosted type that are typically closed, pinched, or healed off within a relatively short distance appear to individually have much smaller reserve potential. However, several subparallel mineralized fractures may be found in close proximity, as suggested by several short drill holes at the Little Squaw Lode. Additional noncontiguous lenses may also be found to repeat along strike and dip on the individual system, such as the Chandalar Lode located about 1,200 feet west of the Eneveloe deposit. There is as yet insufficient exploration to determine the likelihood that both types of quartz-sulfide-gold vein deposits may occur along strike or dip within the same shear/fracture zone.

Most of the mineralized veins in the southern portion of the district, including the Mikado, Eneveloe, Jupiter, Venus, Star, and Summit lodes, dip north, whereas the mineralized veins in the northern portion of the district, including the Grubstake, Jackpot, and Little Squaw lodes, dip steeply south.

Both deposit types, quartz veins and shear zone-hosted, contain a relatively high gold to silver ratio, generally averaging 4 to 1 or more. Gold mineralization within both types of systems is erratically distributed with discrete grains of coarse-grained, free gold occurring as flakes and wires up to a few millimeters in size. The reader is cautioned to consider the difficulty this poses to accurate sampling and grade-tonnage calculations.

## *Primary Lode Deposits and Prospects*

### *Mikado Lode*

Maddren (1913) was the first to describe discovery of gold on the Mikado shear zone (figure 2), which by then had been exposed by six trenches along 3,000 feet of strike length and a 104-foot shaft from which assays averaged 5.42 oz/ton of gold (figures 11-16). Exploration and attempts to develop the deposit continued sporadically over the years, and by 1968 a proven and a probable reserve of 15,000 tons each, both grading 2.49 oz/ton of gold, were estimated.

Erratically distributed gold values occur in discontinuous lenses within the shear zone, which generally is 40-to-60 feet wide. Gold mineralization to some degree is now inferred by surface trenches and outcrop to extend laterally about 7,500 feet, beginning at elevation of 3,900 feet on upper Tobin Creek (Duke, 1975b), trending southeast over St. Mary's Pass at about 5,000-foot elevation, and down to lower St. Mary's Creek, at an elevation of 3,400 feet. A 1994 placer mine cut followed the southeast-trending zone of oxidized quartz veins and gouge in the bed of St. Mary’s Creek (Ackels, 1994). Generally, the Mikado shear zone strikes N60W and dips steeply northeast at 65-70 degrees. It has been estimated that there are about 1,300 feet of normal vertical displacement on the footwall along the Mikado shear (figure 12).

Geologic features of the Mikado Lode differ from other deposits in the district. The Mikado vein(s) have been intensely sheared and contain abundant gouge, some of which is auriferous, and quartz breccia within a hanging wall and footwall of chlorite and graphite-bearing gouge zones (figures 15-16). Wall rock adjoining both the hanging wall and the footwall consist of quartz sericite chlorite schist and minor carbonaceous quartzite variably altered to chlorite-bearing graphite gouge (Swanson and Block, 1975).

Boadway (1932, 1933), Swanson (1975), Duke (1975b), and Bolin (1984) describe several episodes of vein formation and faulting. Following initial development of the Mikado shear zone, quartz veins containing carbonate and pyrite formed in the fault zone. Some quartz-carbonate veins have low-grade gold values, while others are barren of precious metals. Later, normal faulting and intense shearing disrupted the veins, possibly setting the stage for auriferous quartz deposition with disseminated- and veinlet-sulfides. Post-mineralization offset faulting resulted in an east-west-trending joint system and minor non-mineralized movement on normal faults of earlier veinlets. Additional non-auriferous quartz and arsenopyrite were introduced at this time. Veins vary from inches to 15.0 feet thick, but the majority exhibit widths of less than 1.0 foot and lengths of several tens of feet. The discontinuous nature of the Mikado vein is believed to be the result of en echelon shearing planes.

Gold of the Mikado vein is fine-grained and occurs with disseminated sulfides in shear zones and with quartz and sulfide minerals in thin (less than 1 mm) veinlets. Other areas within the shear zone are lacking any significant gold values. Several investigators have noted that the presence of galena and sphalerite are indicators of gold mineralization. Swanson and Ashworth (1981) mention the present of chalcopyrite. At several sites, brecciated quartz and chlorite-bearing gouge are more highly mineralized than almost barren quartz veins nearby. Crosscuts on the 100-foot level demonstrate examples of this, where gouge and breccia adjacent to the hanging wall veins grade 0.49-to-5.37 oz/ton of gold. The main shear zone at Mikado does not appear to carry significant gold values across the full width of the zone, but rather as highly mineralized lenses and short veins.

Detailed mapping at the Mikado was done by Boadway (1933). When the workings were extended in 1960, mine mapping at 1 in=100 feet scale, coupled with systematic sampling, was compiled by Birch (1964). Internal reports and mine maps between 1960 and 1964 provided a basis for reserve calculations totaling about 25,000 ounces gold at a grade of 2.2 oz/ton of gold, and for development and production over the next 20 years (Birch,1964, misc. maps, sections) (Table 1).

Systematic channel sampling at the Mikado Mine was updated by Callahan Mining Company (Duke, 1975a,b; Swanson and McGregor, 1975). Reserves were re-estimated for ore blocks within the present mine, but a portion of these blocks have been mined (figure 14, 15, 16). Most reserve estimates are based on mineralization containing about 1.0 oz/ton of gold. Table 1 gives totals for remaining reserves as of 2003, as well as past production. The mine assay data are too voluminous to reproduce in this report, but can be reviewed in company files.

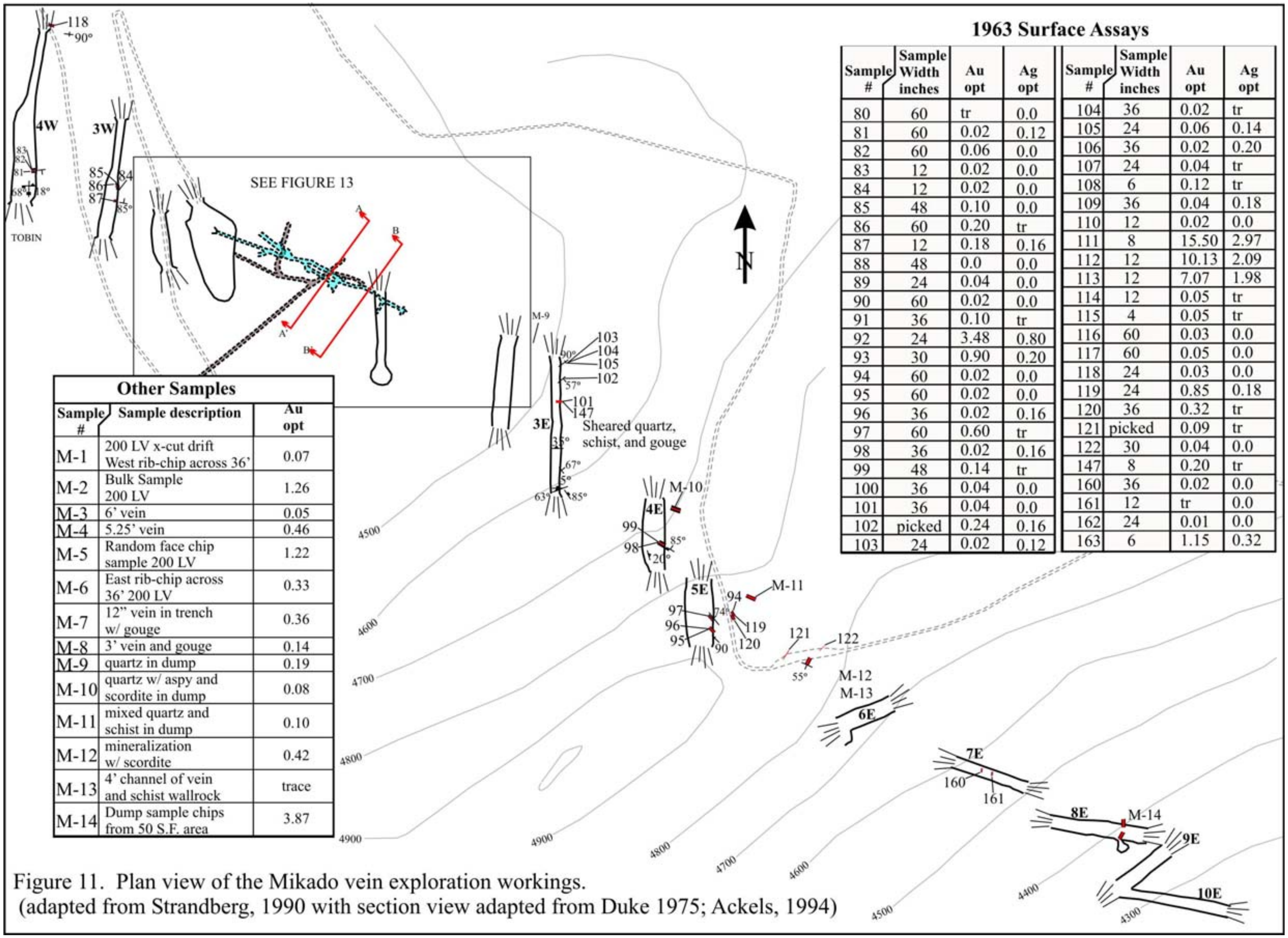
Channel sample assays by Callahan Mining Company provide an opportunity to determine silver content relative to gold. Two sample groups were assayed for both metals. Systematic channel sampling of the mineralized 100-foot level (n=78) indicates the Au:Ag ratio is 4.4:1 (144.8 ppm Au; 32.9 ppm Ag). Chip and channel samples of the Mikado trench (n=46) gave a Au:Ag ratio of 3.7:1 (31 ppm Au to 8.4 ppm Ag). Assay determinations for these calculations were completed by Union Assay Lab, Salt Lake City.

The Chandalar Development Corporation (CDC) conducted percussion drill exploration from the mine workings during their development work, and in this way identified mineralization in the previously suspected north shear zone about 30 feet north and subparallel to the main shear. The north shear zone was exposed near the north end of the Noranda 200 foot level cross-cut and assayed 1.26-to-1.4 oz/ton of gold (see assay table on figure 11, samples 1, 2, 5, 6; Hoffman, 1981). Additional percussion drilling in the area of the north shear intercepted only lower grade material, however, percussion drilling on the 100-foot level later indicated the north shear zone extended vertically.

Table 1. Estimates of lode gold resources and historic lode gold production by mine.

| DEPOSIT NAME | PAST PRODUCTION | | | | RESOURCES–as of 2003 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | PROVEN | | | PROBABLE | | | POSSIBLE | | |
| Operators | Tons | Oz/ton | Actual oz Au [1] | Recovered gold (oz) [2] | Tons | Oz/ton | Oz Au | Tons | Oz/ton | Oz Au | Tons | Oz/ton | Oz Au |
| MIKADO | | | | | 110 | 1.10 | 110 | 5,200 | 1.05 | 5,460 | --- | --- | --- |
| Birch | 891 | 1.64 | 1,456 | 685 | | | | | | | | | |
| Callahan | 487 | 0.85 | 413 | 185 | | | | | | | | | |
| CDC | 9,040- | 0.93 | 9,712 | 6,822 | | | | | | | | | |
| SUMMIT | 1,401 | 1.29 | 1,808 | 1,347 | --- | --- | --- | 1,375 | 3.52 | 4,840 | 3,615 | 2.13 | 7,700 |
| LITTLE SQUAW | --- | --- | --- | --- | --- | --- | --- | 1,986 | 1.55 | 3,078 | --- | --- | --- |
| ENEVELOE | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 5,356 | 1.00 | 5,356 |

[1] **G**old values as determined by mill head assays, which does not factor in mill losses; data from 1979-83 from Millmen (1983)
[2] gold recovered from mill and concentrates; i.e., actual reported production




## 1963 Surface Assays

| Sample # | Sample Width inches | Au opt | Ag opt |
|---|---|---|---|
| 80 | 60 | tr | 0.0 |
| 81 | 60 | 0.02 | 0.12 |
| 82 | 60 | 0.06 | 0.0 |
| 83 | 12 | 0.02 | 0.0 |
| 84 | 12 | 0.02 | 0.0 |
| 85 | 48 | 0.10 | 0.0 |
| 86 | 60 | 0.20 | tr |
| 87 | 12 | 0.18 | 0.16 |
| 88 | 48 | 0.0 | 0.0 |
| 89 | 24 | 0.04 | 0.0 |
| 90 | 60 | 0.02 | 0.0 |
| 91 | 36 | 0.10 | tr |
| 92 | 24 | 3.48 | 0.80 |
| 93 | 30 | 0.90 | 0.20 |
| 94 | 60 | 0.02 | 0.0 |
| 95 | 60 | 0.02 | 0.0 |
| 96 | 36 | 0.02 | 0.16 |
| 97 | 60 | 0.60 | tr |
| 98 | 36 | 0.02 | 0.16 |
| 99 | 48 | 0.14 | tr |
| 100 | 36 | 0.04 | 0.0 |
| 101 | 36 | 0.04 | 0.0 |
| 102 | picked | 0.24 | 0.16 |
| 103 | 24 | 0.02 | 0.12 |

| Sample # | Sample Width inches | Au opt | Ag opt |
|---|---|---|---|
| 104 | 36 | 0.02 | tr |
| 105 | 24 | 0.06 | 0.14 |
| 106 | 36 | 0.02 | 0.20 |
| 107 | 24 | 0.04 | tr |
| 108 | 6 | 0.12 | tr |
| 109 | 36 | 0.04 | 0.18 |
| 110 | 12 | 0.02 | 0.0 |
| 111 | 8 | 15.50 | 2.97 |
| 112 | 12 | 10.13 | 2.09 |
| 113 | 12 | 7.07 | 1.98 |
| 114 | 12 | 0.05 | tr |
| 115 | 4 | 0.05 | tr |
| 116 | 60 | 0.03 | 0.0 |
| 117 | 60 | 0.05 | 0.0 |
| 118 | 24 | 0.03 | 0.0 |
| 119 | 24 | 0.85 | 0.18 |
| 120 | 36 | 0.32 | tr |
| 121 | picked | 0.09 | tr |
| 122 | 30 | 0.04 | 0.0 |
| 147 | 8 | 0.20 | tr |
| 160 | 36 | 0.02 | 0.0 |
| 161 | 12 | tr | 0.0 |
| 162 | 24 | 0.01 | 0.0 |
| 163 | 6 | 1.15 | 0.32 |

## Other Samples

| Sample # | Sample description | Au opt |
|---|---|---|
| M-1 | 200 LV x-cut drift West rib-chip across 36' | 0.07 |
| M-2 | Bulk Sample 200 LV | 1.26 |
| M-3 | 6' vein | 0.05 |
| M-4 | 5.25' vein | 0.46 |
| M-5 | Random face chip sample 200 LV | 1.22 |
| M-6 | East rib-chip across 36' 200 LV | 0.33 |
| M-7 | 12" vein in trench w/ gouge | 0.36 |
| M-8 | 3' vein and gouge | 0.14 |
| M-9 | quartz in dump | 0.19 |
| M-10 | quartz w/ aspy and scordite in dump | 0.08 |
| M-11 | mixed quartz and schist in dump | 0.10 |
| M-12 | mineralization w/ scordite | 0.42 |
| M-13 | 4' channel of vein and schist wallrock | trace |
| M-14 | Dump sample chips from 50 S.F. area | 3.87 |

Figure 11. Plan view of the Mikado vein exploration workings.
(adapted from Strandberg, 1990 with section view adapted from Duke 1975; Ackels, 1994)

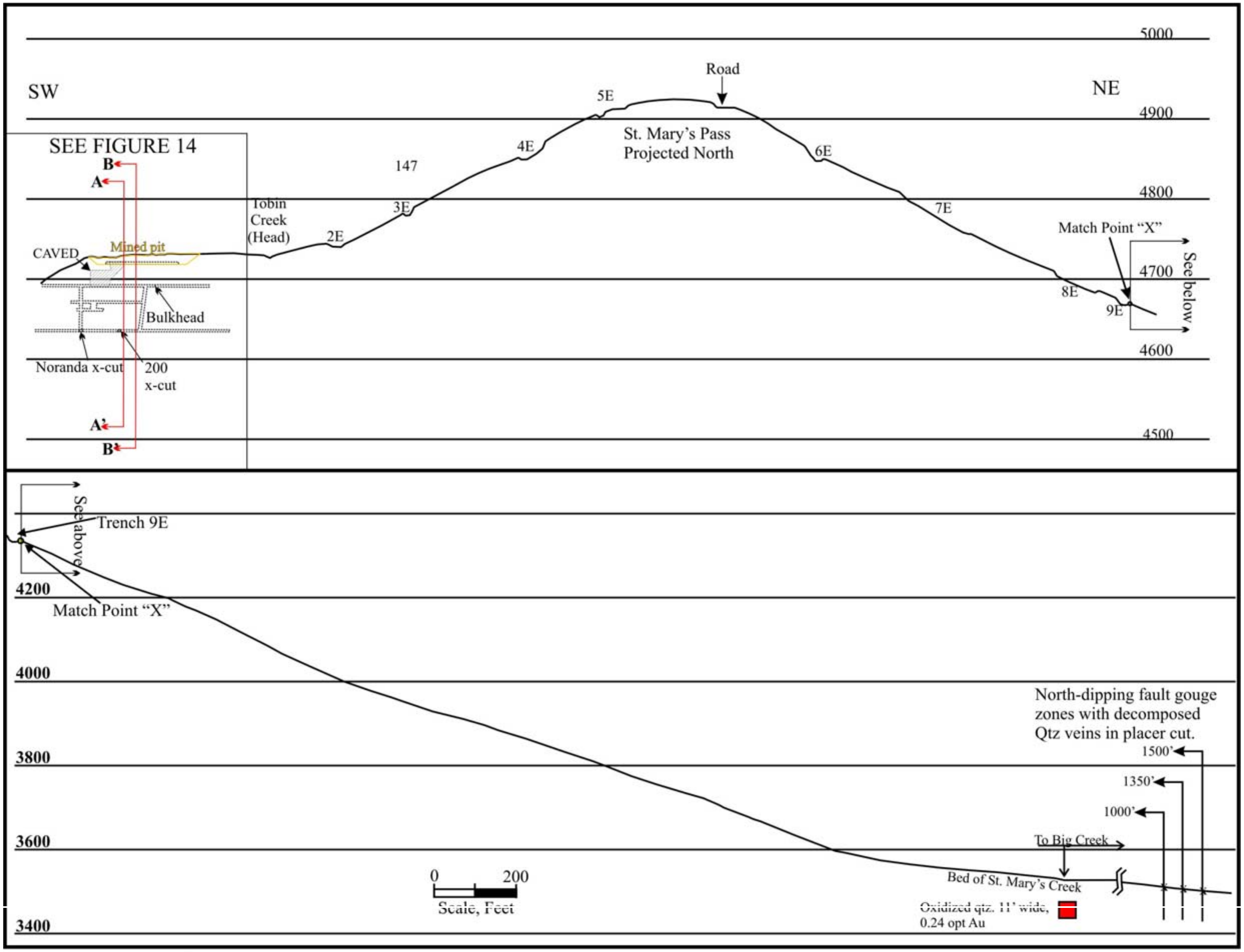



Figure 12. Longitudinal section of the Mikado shear. (adapted from Strandberg, 1990)

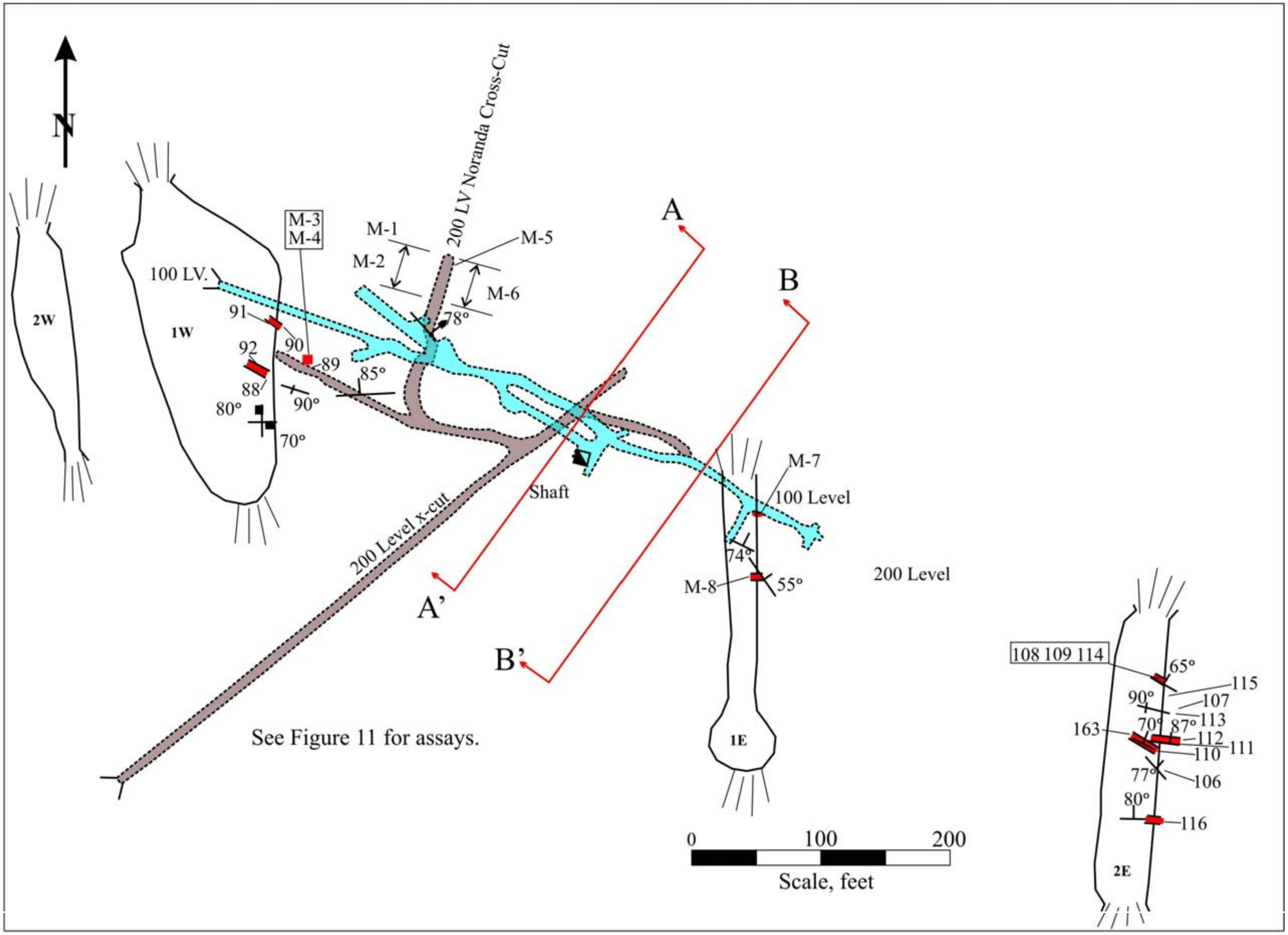



Figure 13. Mikado mine plan view.

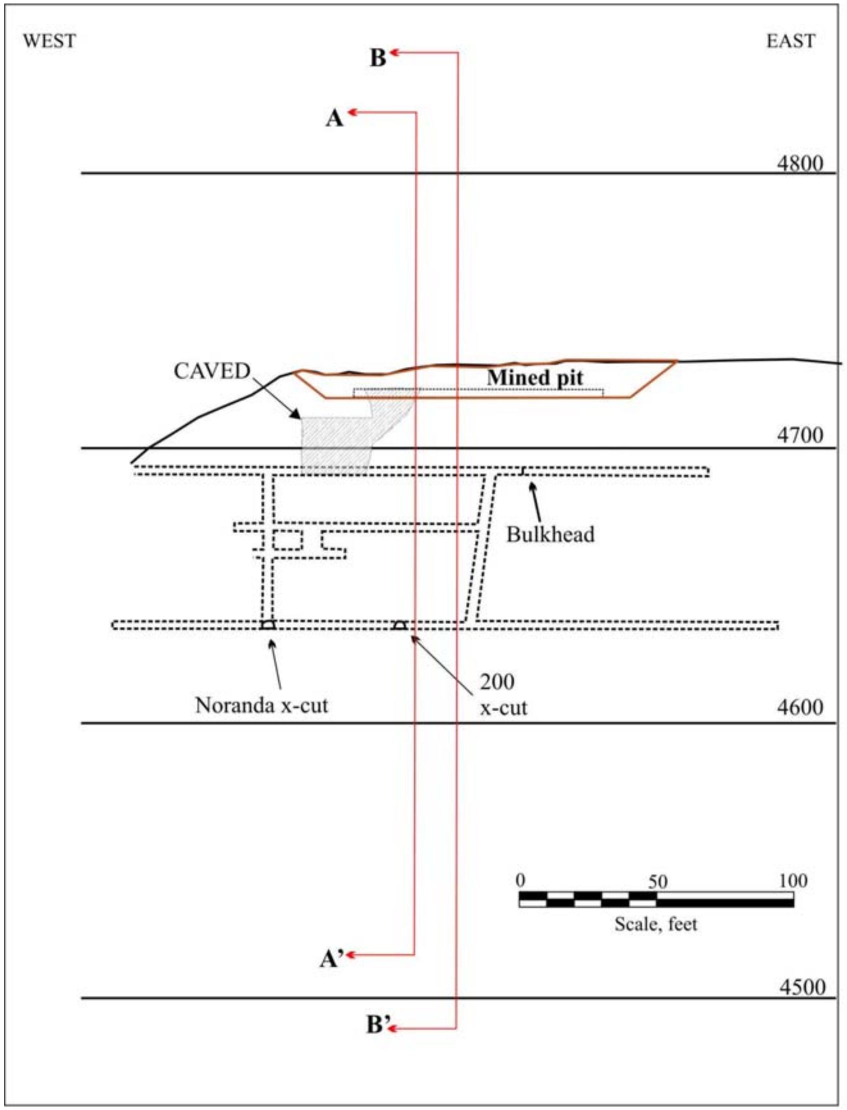



Figure 14. Mikado mine longitudinal section and photo of the 100 level portal.

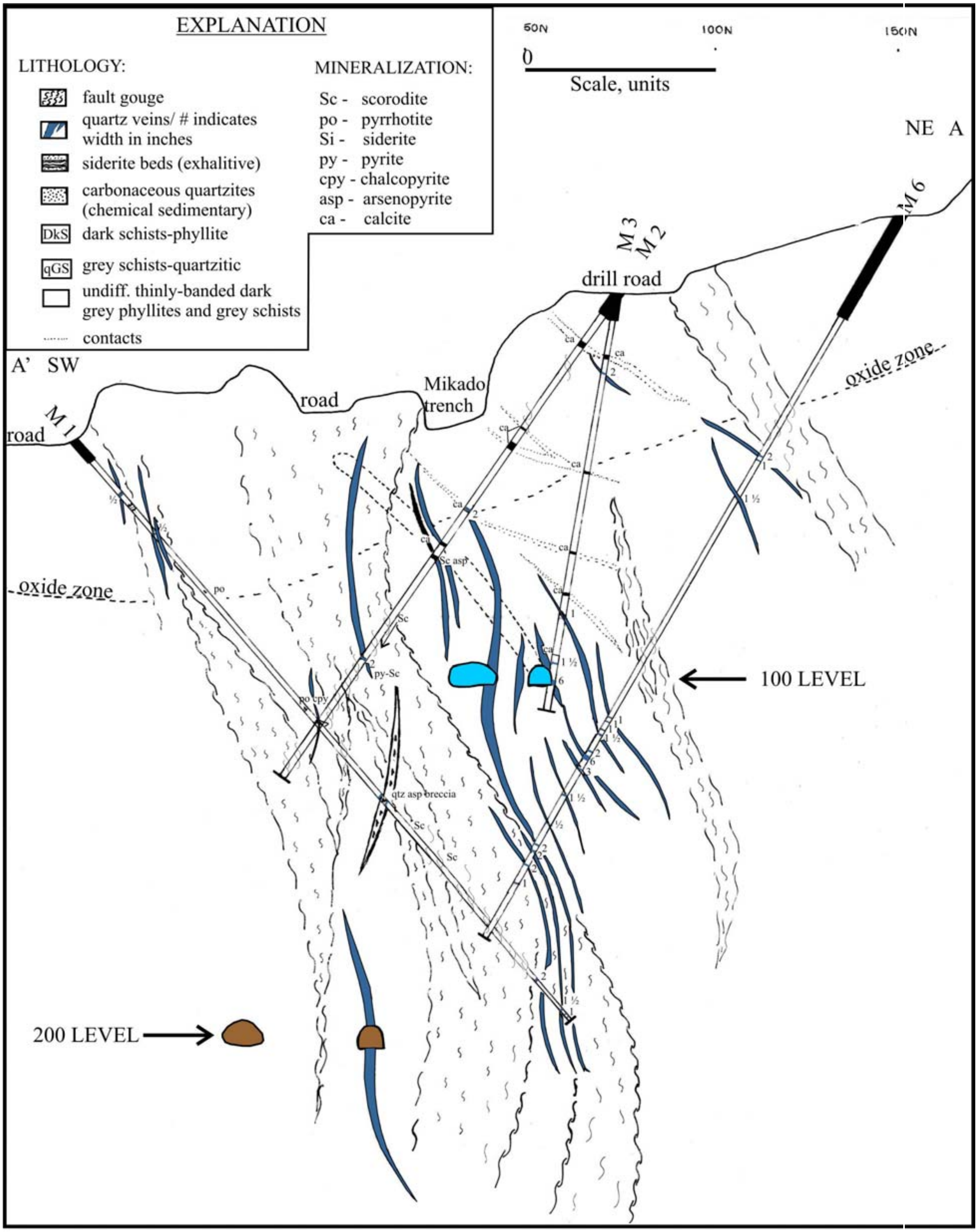



Figure 15. Geologic sectional views of Callahan Mining Co. Mikado drill holes M-1, -2, -3, and -6. Adapted from Duke, 1975.

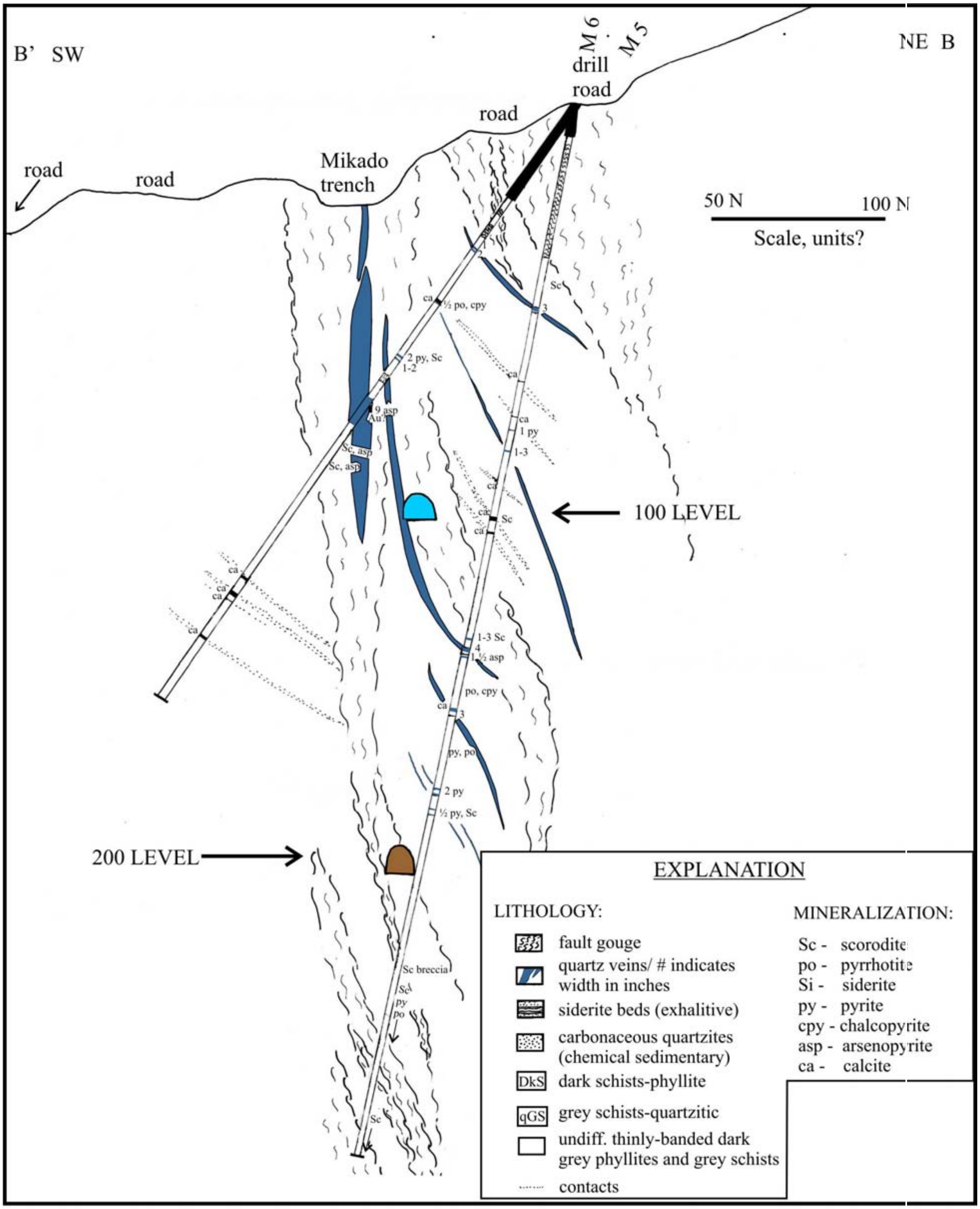



Figure 16. Geologic sectional views of Callahan Mining Co. Mikado drill holes M-4 and -5. Adapted from Duke, 1975.

Two five-foot drill intercepts from the 100-foot level assayed 0.46 and 0.58 oz/ton of gold and are interpreted to represent the north shear. Also, this north shear is likely the same zone seen in the 200-foot level, section 300E (figures 12, 14) by Callahan. Subsequent cross-cuts indicate the 200-foot level north shear vein is likely a false footwall that resulted from a fault movement displacement that offset the main stage mineralization.

Limited diamond drill programs were conducted by both Callahan Mining (Duke, 1975) and CDC (Swanson and Ashworth, 1981). Drilling was beset by severe problems with core recovery from frozen, clayey gouge fault zones and quartz breccia. Frozen gouge tended to dislodge and stick the rods or to disintegrate during drilling. The CDC drill program included 6 holes (1,220 feet total) on the Mikado Lode and was believed to be AQ size core diameter. No drill assay tabulations have been found in the files; they are believed to have been lost in a camp office fire, when an overheated oil stove, assisted by 3,000 blasting caps, leveled the site.

Callahan Mining Company drilled 5 holes that were done primarily for stratigraphic mapping and exploring the quartz vein shear zone below the 200-foot level. Callahan Mining also reported poor recovery. Drill sections depicting geology and interpretation of drill holes are given in figures 15 and 16 and show the lens-shaped, discontinuous character of the quartz veining in the Mikado shear-zone system. No assay data are available for the Callahan drill project. Apparently, analyses were completed by an undescribed atomic absorption procedure rather than by an accepted assay technique. Although a few intercepts could be considered anomalous, most results were close to or less than detection limit (0.020 ppm gold).

In 1981, a stope on the 100-foot level inadvertently broke through to the surface and initiated thawing and subsequent cave-in (figure 14). The cave blocked the 100-foot level and in-flowing water iced up the 200-foot level, preventing further operations underground. Limited mining was done later from an open pit over the high-grade section in the caved area. Mine production in 1982 suffered from unspecified dilution. The underground workings remain blocked at present.

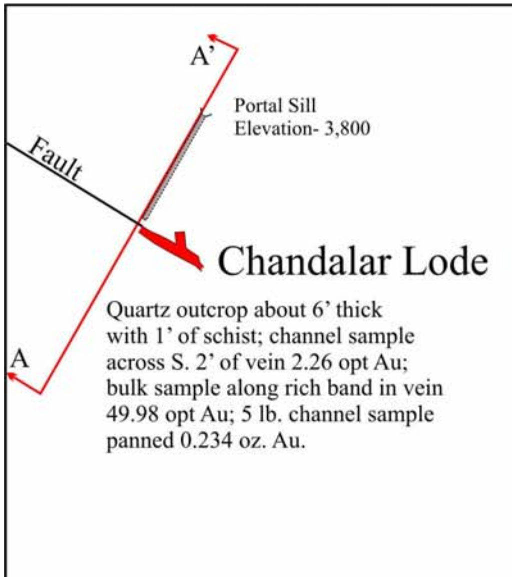
The Mikado shear feature is in a 4-mile-long, northwest-southeast trending fault that occurs in a 300-to-400 foot wide zone of shearing and granulation. It has not been well explored beyond the work on higher grade zones mentioned above. To the southeast beyond St. Mary's Creek and across Big Creek, the Mikado shear aligns with claims on Pedro Creek where quartz veins were reportedly prospected in the early years, but no other information on this early work was found in company files.

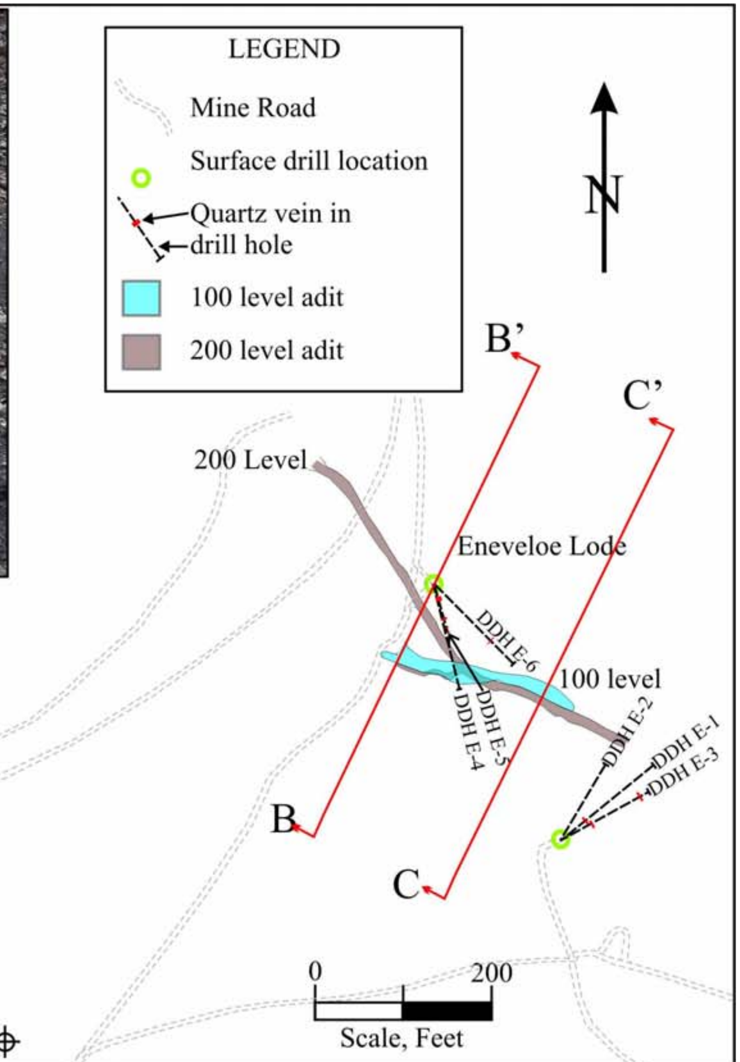
*Chandalar-Eneveloe Lode*

The Chandalar-Eneveloe prospect (figure 2) was originally reported as a quartz outcrop 16-to-20 feet wide, where hand samples assayed 0.33-to-0.87 oz/ton of gold (Marsh, 1911). Grab samples with more than 1.0 ounce/ton gold were collected from the dump and elsewhere along a series of outcrops, as well as from the outcrop of the Chandalar lode to the northwest. The Eneveloe is located along a fault and shear zone trending N65-80W that dips steeply north (figure 17). The structure forms a slight topographic low. The lower level adit was driven to intersect the west end of the Eneveloe vein on which a drift was subsequently driven for 500 feet. A high grade lens, exposed for 70 feet on the lower level, yielded assays of 0.5-to-10.0 oz/ton of gold. The upper 100-foot level adit was driven into a massive quartz outcrop in 1982. It shows the vertical extension of high-grade (plus one ounce gold/ton mineralization) found in the lower level. The adit encountered finely ground quartz with plus 2.0 oz/ton of gold on the north side of the massive quartz vein.

The CDC drilled a total of 6 diamond drill holes totaling 1,113 feet, but recovery was a problem and only a few assays were possible (figures 17, 18). For holes #1 and #2, there was no sample return. Only poor return was achieved for #3, but veins were cut at 65-foot and 158-foot intercepts.

There are no assays available for hole #6; they were likely lost in the camp fire. Nevertheless, drilling, coupled with the 1982 upper level adit records, suggests the presence of parallel mineralized structures occurring in highly sheared phyllite A smaller, but reportedly high-grade vein, sometimes called the Bonanza vein in past prospector records, appears to parallel the Eneveloe vein a few feet away.




| DDH | Incl. | Orient. | Descr. | ID |
|---|---|---|---|---|
| E-1 | 45° | N 50°E | no sample | 210 |
| E-2 | 60° | N 30°E | no sample | 225 |
| E-3 | 45° | N 60°E | poor return<br>veins @ 65'/158' | 175 |
| E-4 | 45° | S 15°E | veins 35-45'/85-95'/110-115' | 185 |
| E-5 | 60° | S 15°E | vein @ 140', 0.50 opt | 123 |
| E-6 | 45° | S 45°E | vein @ 140', no assay | 195 |

Figure 17. Chandalar-Eneveloe plan view of exploration workings, with photo of the Eneveloe adit 200 level portal. Map adapted from Strandberg (1990), with drilling data from CDC.

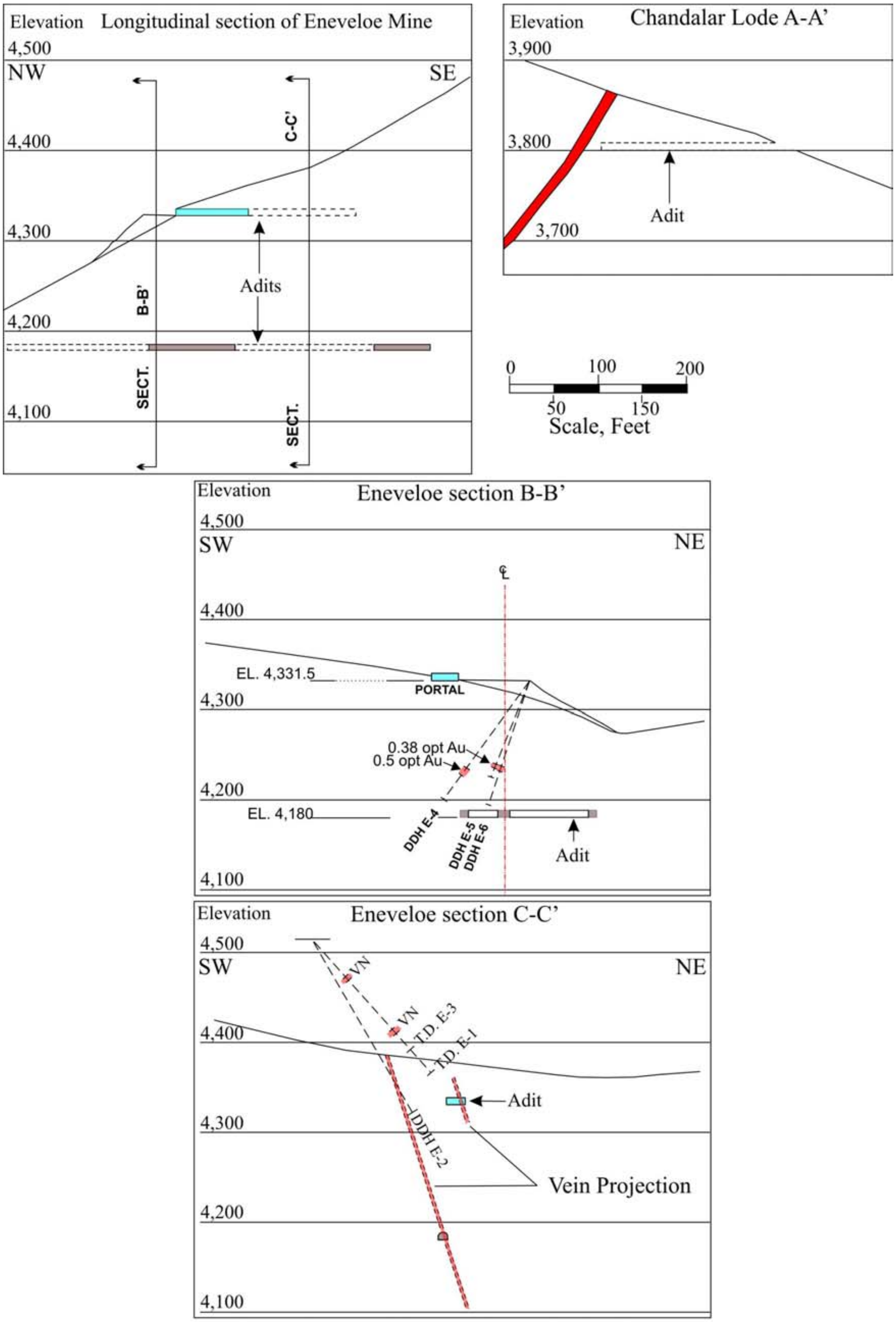



Figure 18. Chandalar-Eneveloe longitudinal section and cross-section A-A' and B-B'. Sections adapted from Strandberg, 1990.

A soil sampling effort was undertaken in the Eneveloe saddle area. Areas of soil anomalies were small and discontinuous. Follow-up percussion drilling indicated smaller lenses and veins. Swanson (1975) and Bolin (1984) suggested that it may be possible to define blind ore shoots 100-to-200 feet below the surface. The character of mineralization found in the 200-foot level has similarities to the shear zone hosted Mikado-type deposit (Bolin, 1984).

*Summit Lode*

The Summit prospect, including the Rex Discovery, (figure 2) were found along the divide between Big and Little Squaw Creeks. By 1913, a 54-foot-deep shaft had been sunk on the Summit Discovery and a short drift driven along a 1.5-to-2.5 feet wide quartz vein. The principal vein was exposed in a series of trenches for 950 feet along a strike of N70W, dipping steeply north (McKee, 1939). The Summit Lode is believed to be the Schultz Lode as described by Boadway (1933). Sample assays of the Summit vein range from 0.04 oz/ton of gold to 2.58 oz/ton of gold. Higher grade mineralization with sample assays to 10.57 oz/ton of gold was found west of the original workings. In 1981, CDC extended the 100-foot level and drove the 200-foot level drift. Development work on the 100-foot level produced 142 tons at a grade of 4.82 oz/ton of gold; however, the vein pinched out about 105 feet from the portal. Lower grade gold values were found in quartz lenses at 178-to-198 feet and from 220-to-233 feet as measured from the portal. Detailed channel sampling was also performed. Plan and longitudinal views of the Summit Lode are given on figures 19 and 20.

Gold mineralization is localized along the Summit fault, where the hanging wall is projected to have moved down and to the west relative to the footwall. The gold-bearing vein lies along the footwall side of the fault. Structure measured in the CDC workings indicated a strike of approximately N70-80W dipping 75-80 degrees north, where schistose quartzite beds are encountered south of the fault (Swanson and Ashworth, 1981). Wall rock to the south of the vein is silicified and iron-stained dark gray quartz muscovite schist, and to the north of the vein is a medium gray, quartz muscovite chlorite schist. The fault is marked by one to six inches of gray to black phyllitic gouge.

The gold-bearing quartz was deposited in two mineralizing episodes following the faulting; the first formed the massive quartz hanging wall vein containing few sulfides and low-grade gold, the second formed the irregular pinching and swelling footwall vein. The footwall vein is scorodite-stained and banded with arsenopyrite, stibnite, sphalerite, galena, and visible gold. Assays across the footwall vein ranged as high as 90.92 oz/ton of gold from a two foot channel sample (Strandberg, 1990).

Six short diamond drill holes, totaling 756 feet, were drilled at the Summit mine (Garverich and Hoffman, 1982). Of three holes north of the 100-foot level adit, two holes did not reach their target and were inconclusive. The third drill hole intersected a low grade vein on projection of the Summit fault and a second vein believed to be the vein being followed on the 200-foot level, which assayed 0.06 oz/ton of gold. No cuttings were retrieved. Core recovery for the three holes was poor and core barrel blocking was suspected.

The remaining three holes were drilled from the 200-foot level. Hole 82-7 intercepted two zones: 5.0 feet of 1.0 oz/ton of gold at 100 feet, and 2.0 feet of 0.34 oz/ton of gold at 73 feet. These assays were from cuttings; the core assayed only 0.04 oz/ton of gold. Cuttings from drill hole 82-6 reported 15 feet of 0.10 oz/ton of gold and 10 feet of 0.14 oz/ton of gold. The third hole lost circulation and no sample was recovered. Drilling suggests the vein on the 100-foot level and the vein on the 200-foot level are two separate veins.

| Sample Number | Width feet | Au opt |
|---|---|---|
| a | 1.6 | 0.51 |
| b | 3.8 | 1.57 |
| c | 4.0 | 0.95 |
| d | 4.0 | 0.21 |
| e | 3.7 | 1.00 |
| f | 3.8 | 0.49 |
| g | 3.6 | 8.93 |
| h | 3.9 | 0.43 |

| C.D.C. Trench Sample Results grabs of vein quartz, 1980 | | |
|---|---|---|
| Trench Number | Au opt | Ag opt |
| C.D.C. 1 | 0.24 | 0.03 |
| C.D.C. 2 | 0.13 | 0.79 |
| C.D.C. 3 | 0.046 | 0.13 |
| C.D.C. 4 | 0.21 | 0.04 |
| C.D.C. 5 | 0.91 | 0.15 |
| C.D.C. 6 | 0.64 | 0.24 |

| C.W.M. Trench Sample Results | | |
|---|---|---|
| Trench Number | Width feet | Au opt |
| C.W.M. 1 | 5.33 | 2.32 |
| C.W.M. 2 | 3.33 | 0.42 |
| C.W.M. 3 | 1.5 | 0.94 |
| | 2.6 | 0.08 |
| | 2.1 | 0.14 |
| C.W.M. S-1 | 2.8 | 4.37 |
| | GRAB | 9.04 |
| C.W.M. S-2 | 3.75 | 0.19 |
| | GRAB | 2.58 |
| C.W.M. 4 | 2.5 | 0.24 |
| | 1.5 | 0.12 |
| | 3.75 | tr |
| C.W.M. 5 | 1.9 | 0.05 |
| C.W.M. 6 | NO SAMPLE | |

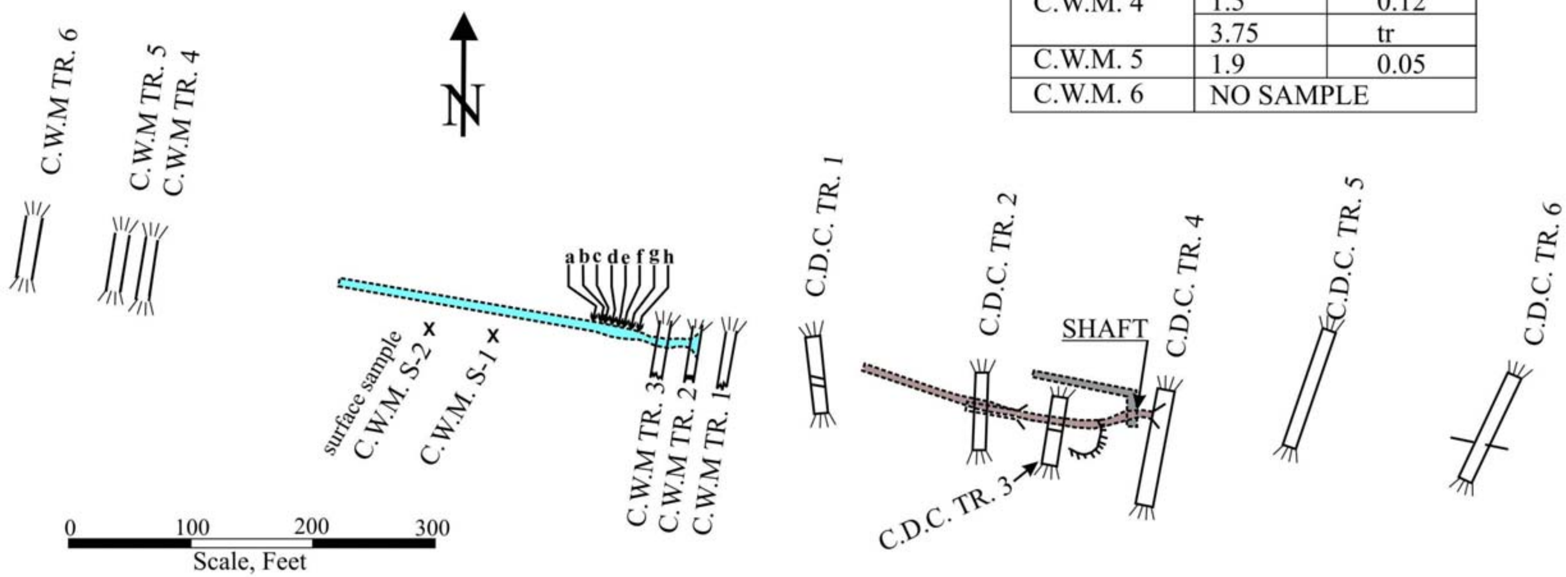



Figure 19. Summit mine plan view of exploration workings. Adapted from Strandberg, 1990.

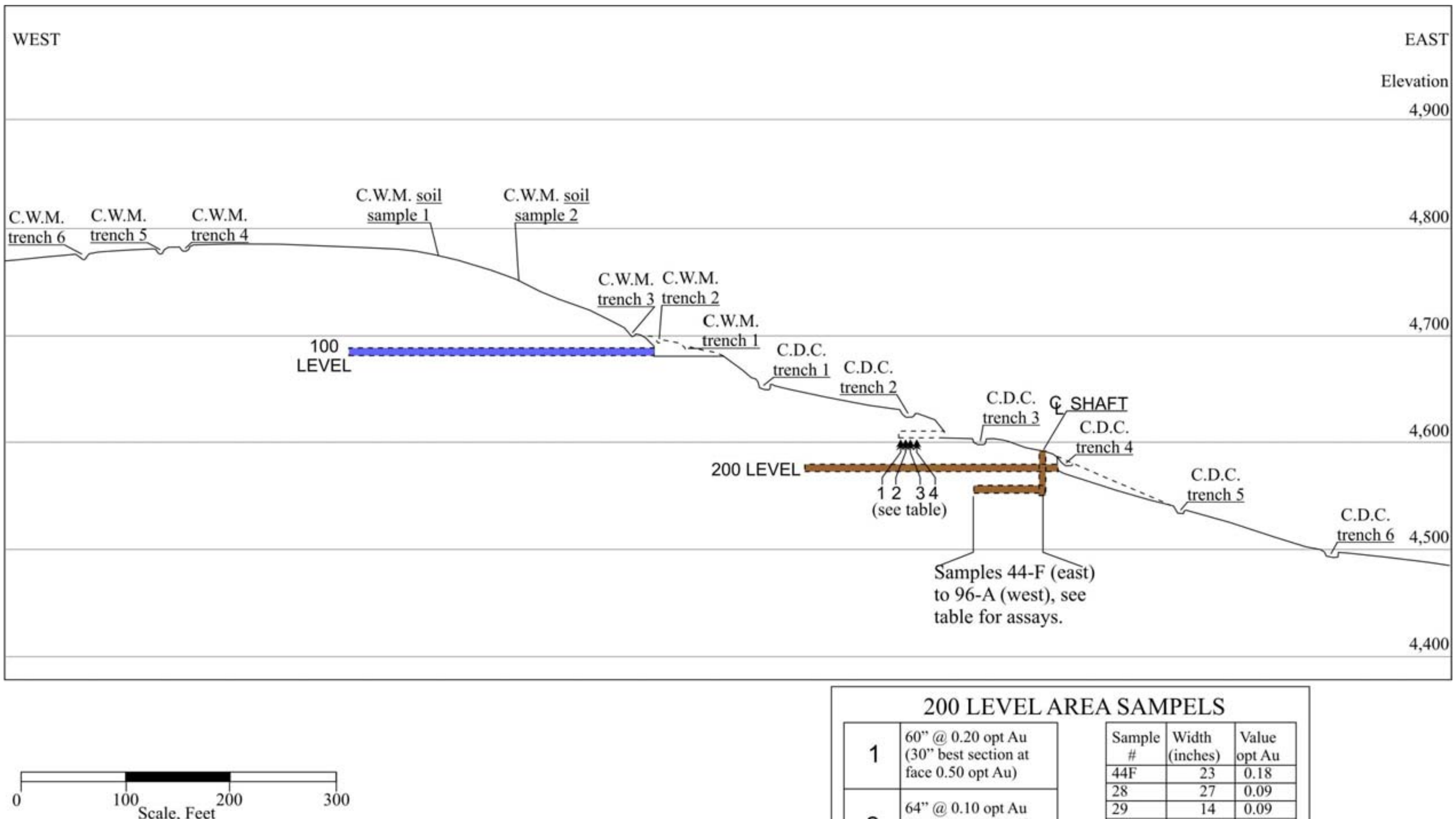



Figure 20. Summit mine longitudinal section. Adapted from Strandberg, 1990.

## 200 LEVEL AREA SAMPELS

| | |
|---|---|
| 1 | 60" @ 0.20 opt Au (30" best section at face 0.50 opt Au) |
| 2 | 64" @ 0.10 opt Au (21" best section @ 0.21 opt Au) |
| 3 | 86" @ 0.06 opt Au (21" best section @ 0.14 opt Au) |
| 4 | 30" @ 0.05 opt Au |

| Sample # | Width (inches) | Value opt Au |
|---|---|---|
| 44F | 23 | 0.18 |
| 28 | 27 | 0.09 |
| 29 | 14 | 0.09 |
| 48-A | 13 | 0.12 |
| 49-A | 13 | 0.12 |
| 50-A | 10 | 0.14 |
| 90-A | 13 | 0.10 |
| 91-A | 10 | 0.12 |
| 92-A | 10 | 0.14 |
| 93-A | 12 | 0.13 |
| 94-A | 14 | 0.28 |
| 95-A | 17 | 0.04 |
| 96-A | 38 | 0.14 |

*Little Squaw Lode*

By 1909, the Little Squaw quartz lode had been discovered and explored by surface cross-cuts, shallow shafts, and a 64-foot long adit that intersected the vein (Marsh, 1911). Over the next 75 years, the workings were gradually enlarged and a small reserve of about 10,000 tons grading 1.70 oz/ton of gold was estimated prior to a brief period of mining in 1982.

Quartz vein mineralization and subparallel, sheeted quartz stringers occur in a banded, iron-stained sequence of gray quartz-muscovite-chlorite phyllite, carbonaceous phyllite and quartzite, and carbonates, including a buff-to-red, siderite-bearing, exhalative(?) unit. The vein system can be projected to strike into a unit of carbonate sandstone; although an obvious exploration target, this has not yet been examined (Duke, 1975). Greenstone dikes cut the stratigraphy to either side of the vein system (McKee, 1939).

At present, the Little Squaw lode has been explored underground for about 200 feet along a vein strike of N75-85E with a 60-75 degree south dip (Swanson and Ashworth, 1981). Additionally, a 200-foot level was driven 240 feet to a point below the end of the 100-foot level, and several cross-cuts explored the footwall and hanging wall. There is a 78-foot raise to the surface from the 100-foot level, and a winze below connects to the 200-foot level (figures 21-24).

Quartz mineralization is localized along the steeply south dipping Little Squaw fault. North of the fault is gray muscovite-chlorite schist and phyllite that forms the footwall to the vein. To the south of the fault is a light gray muscovite schist that forms the hanging wall. The fault is mapped with a normal down movement on the hanging wall. The vein cuts schistosity that strikes N5W and dips gently to the east (Boadway, 1933). The principal vein exposed in the 100-foot level adit was lost while extending the adit to 200 feet from the portal, due to intersection of a N45W high angle fault. As traced on the surface, the quartz vein system comprising the Little Squaw Lode occurs as discontinuous segments repeatedly offset to the southeast in an en echelon array by north-northwest shear zones. Displacements are on the order of a few tens of feet (figures 24-25).

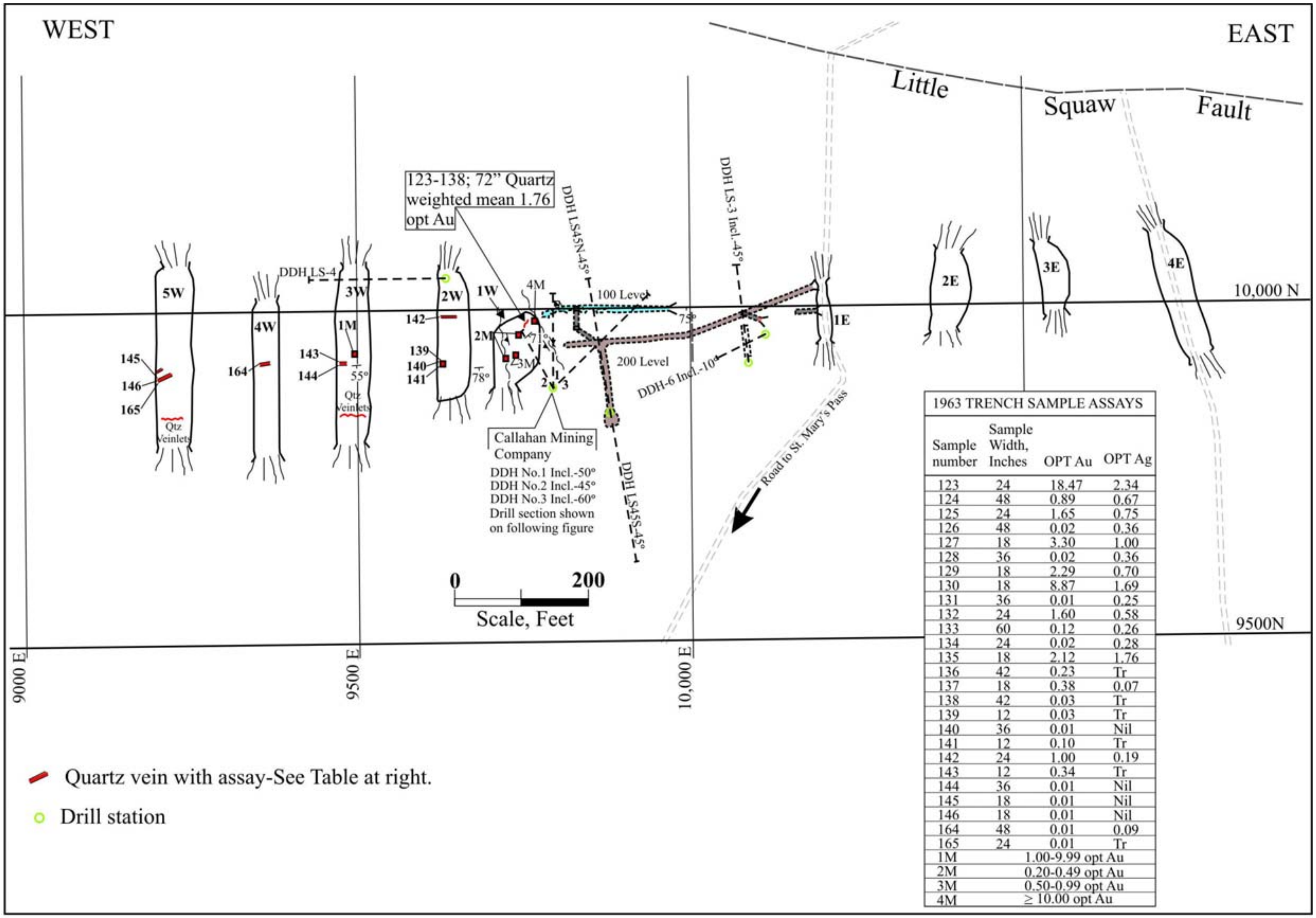
Over the years it has been suggested that the Little Squaw vein system extends along the Little Squaw shear zone, to include either the Crystal prospect (location #1; figure 2) or the Pioneer prospect (location #3, figure 2) to the east, and to the Big Squaw prospect (location #2; figure 2) to the west. This does not imply continuity of mineralization, but rather that mineralization occurs as discontinuous lenses or veins over a strike length of about 2.5 miles.

Gold values in the Little Squaw vein are mostly concentrated in a one-foot band along the 100-foot level footwall, where the auriferous quartz has a ribbon appearance and contains disseminated and massive seams of pyrite and arsenopyrite, and accessory galena and sphalerite (Swanson and Ashworth, 1981). Scorodite and iron-staining is common and occurs also as bands within the vein up to 15-inches wide. Most of the coarse gold and wire gold found in the Chandalar district comes from the banded footwall zone of the vein, where it is found in graphite-scorodite vugs and graphite smears and narrow lenses. The principal zone or lens of high grade vein mineralization extends about 65 feet in from the portal on the 100-foot level and to a depth of 30 feet, with grades up to 1.64 oz/ton of gold, based on systematic channel samples.

Based on surface sampling and trenching, the higher grade lens at the Little Squaw vein extends to the surface. Surface exploration has shown the vein system can be traced westerly for 500-to-600 feet beyond the southerly offset encountered underground. The average gold content, however, is considerably less than the grades indicated above, based on available data (Birch, 1960,1961, 1963; Duke, 1975b; Swanson and Ashworth, 1980). The principal vein, as exposed in trenches, pinches and swells from 2-to-8 feet in width and but generally averages about 4 feet in width. Quartz veins and veinlets at the Little Squaw Lode are coherent veins with sharply defined contacts that break clean from the wall rock, generally with little or no gouge material. Wall rock alteration is minimal. There is evidence of several stages of silica deposition both with and without gold values. Massive, coarse-grained, quartz veins are generally earlier and contain little or no gold. It is believed the mineralized footwall band is a later event within the vein and that this mineralized band precipitated as fine-grained ribbon-banded quartz following recurrent movement on the Little Squaw fault.

Exploration by Callahan Mining Company (Duke, 1975b) included mine mapping and a limited diamond drill program of 3 holes totaling 726 feet. The drilling by Callahan was reported to have been reasonably successful. It was done primarily for stratigraphic mapping and exploring the quartz vein fracture system below the 100-foot level. More exploration work was conducted by Chandalar Development Corporation, who drilled four more holes totaling 1,099 feet; a fifth hole had no sample return (Swanson and Ashworth, 1981). Drill intercepts by CDC (believed to be AQ size) are partially based on analyses of drill sludge, presumably due to poor core recovery. Core is stored on site at the Mikado Mine compressor house on Tobin Creek.

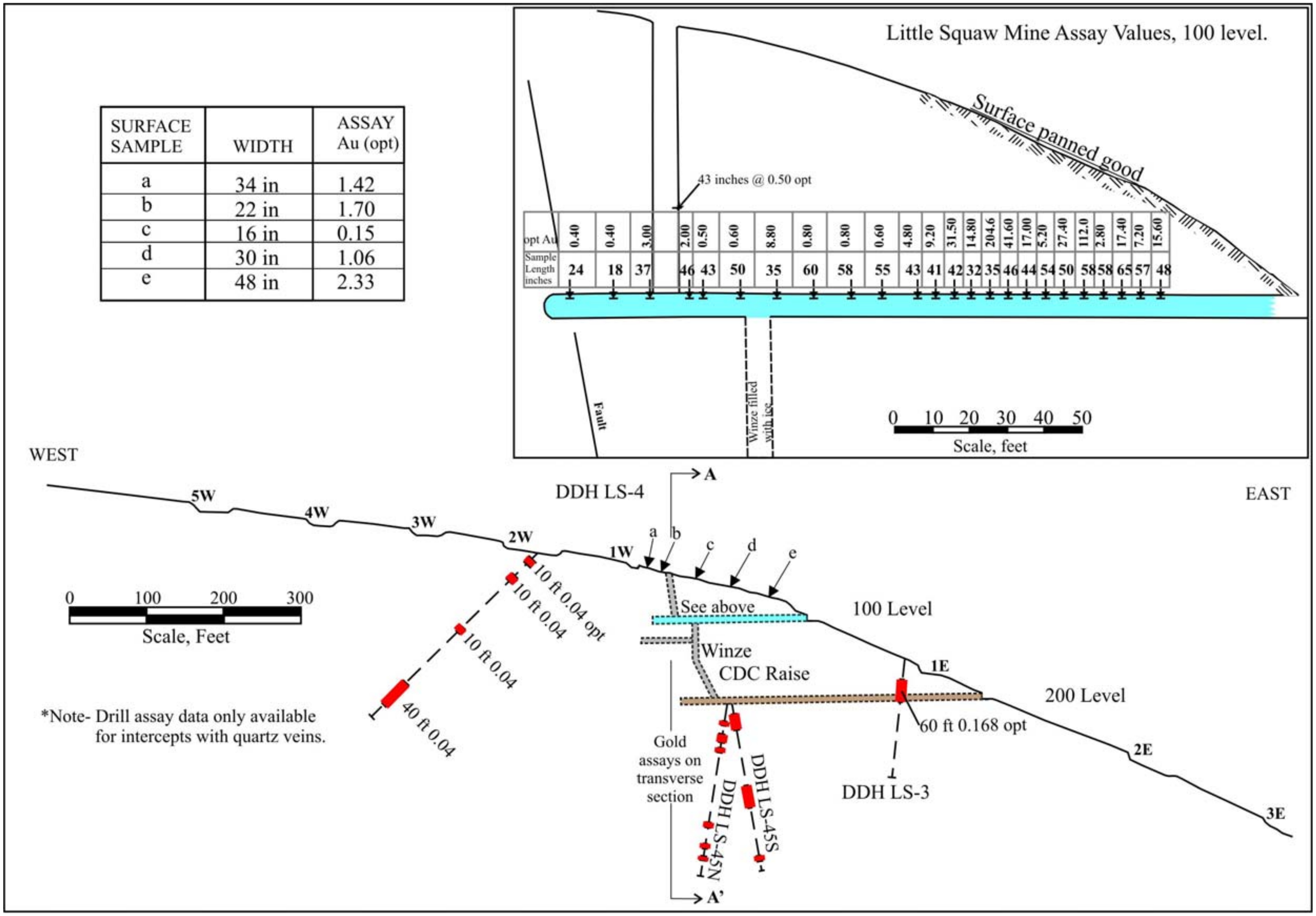
Drilling found no additional tonnage of high grade mineralization; however, low grade intercepts were reported by CDC (figure 22). Drill sections depicting geology and interpretation for holes LS-1, LS-2, and LS-3 by Callahan are given on figure 23; they show the sheeted and discontinuous character of the quartz and fracture/shear-zone system. No assay data are available for the Callahan drill project, however. Analyses were done, but using an undescribed atomic absorption procedure, and results were all close to or less than detection limit (0.020 ppm gold). Callahan drill hole LS-3 intersected the approximate area cut by CDC Hole LS 45N that encountered several wide zones of lower grade gold mineralization.




1963 TRENCH SAMPLE ASSAYS

| Sample number | Sample Width, Inches | OPT Au | OPT Ag |
|---|---|---|---|
| 123 | 24 | 18.47 | 2.34 |
| 124 | 48 | 0.89 | 0.67 |
| 125 | 24 | 1.65 | 0.75 |
| 126 | 48 | 0.02 | 0.36 |
| 127 | 18 | 3.30 | 1.00 |
| 128 | 36 | 0.02 | 0.36 |
| 129 | 18 | 2.29 | 0.70 |
| 130 | 18 | 8.87 | 1.69 |
| 131 | 36 | 0.01 | 0.25 |
| 132 | 24 | 1.60 | 0.58 |
| 133 | 60 | 0.12 | 0.26 |
| 134 | 24 | 0.02 | 0.28 |
| 135 | 18 | 2.12 | 1.76 |
| 136 | 42 | 0.23 | Tr |
| 137 | 18 | 0.38 | 0.07 |
| 138 | 42 | 0.03 | Tr |
| 139 | 12 | 0.03 | Tr |
| 140 | 36 | 0.01 | Nil |
| 141 | 12 | 0.10 | Tr |
| 142 | 24 | 1.00 | 0.19 |
| 143 | 12 | 0.34 | Tr |
| 144 | 36 | 0.01 | Nil |
| 145 | 18 | 0.01 | Nil |
| 146 | 18 | 0.01 | Nil |
| 164 | 48 | 0.01 | 0.09 |
| 165 | 24 | 0.01 | Tr |
| 1M | 1.00-9.99 opt Au | | |
| 2M | 0.20-0.49 opt Au | | |
| 3M | 0.50-0.99 opt Au | | |
| 4M | ≥ 10.00 opt Au | | |

Figure 21. Little Squaw vein plan view of exploration workings. Adapted from Strandberg, 1990.




| SURFACE SAMPLE | WIDTH | ASSAY Au (opt) |
|---|---|---|
| a | 34 in | 1.42 |
| b | 22 in | 1.70 |
| c | 16 in | 0.15 |
| d | 30 in | 1.06 |
| e | 48 in | 2.33 |

Figure 22. Little Squaw Vein longitudinal section viewed north.

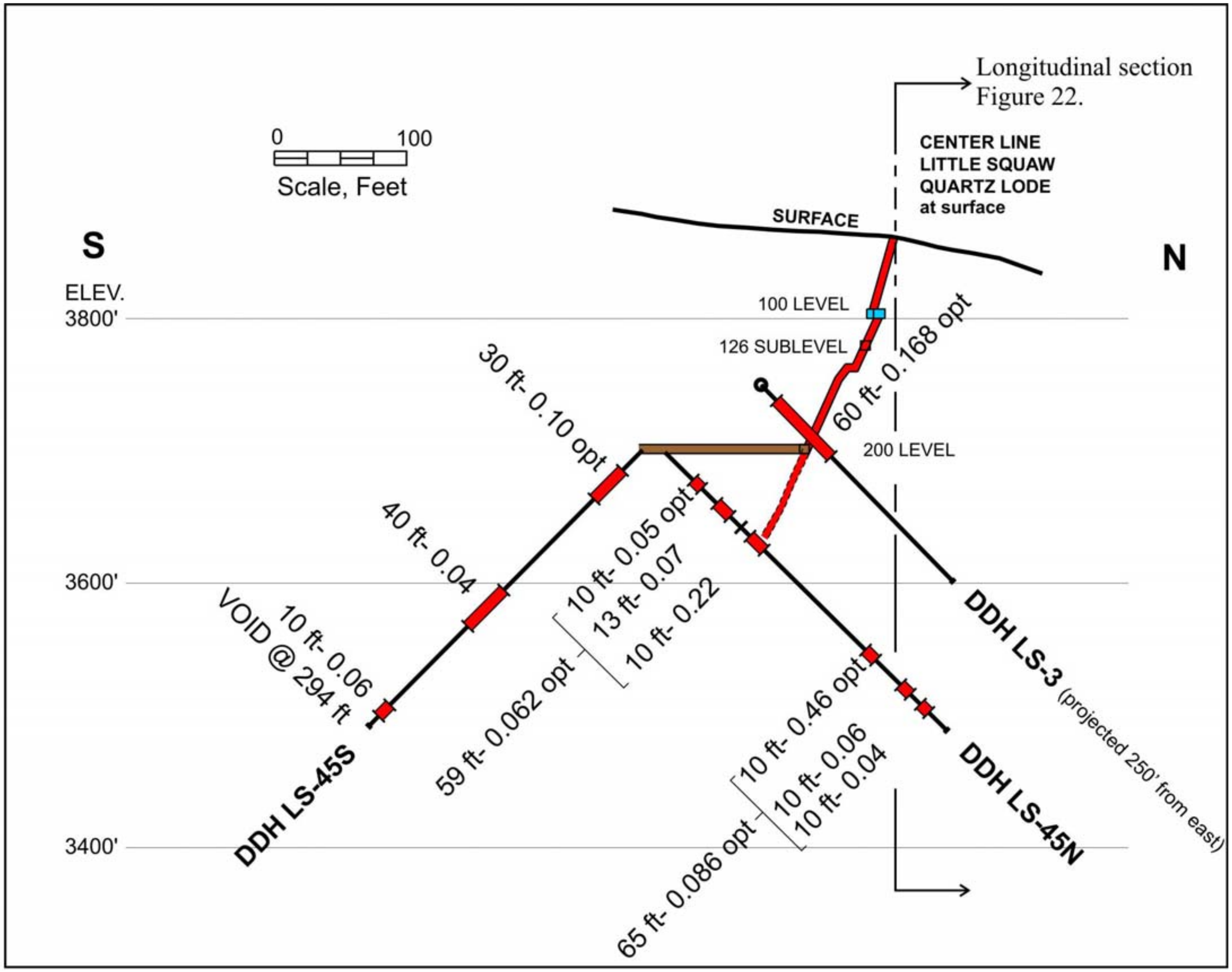



Figure 23. Little Squaw vein longitudinal section through winze, looking west.

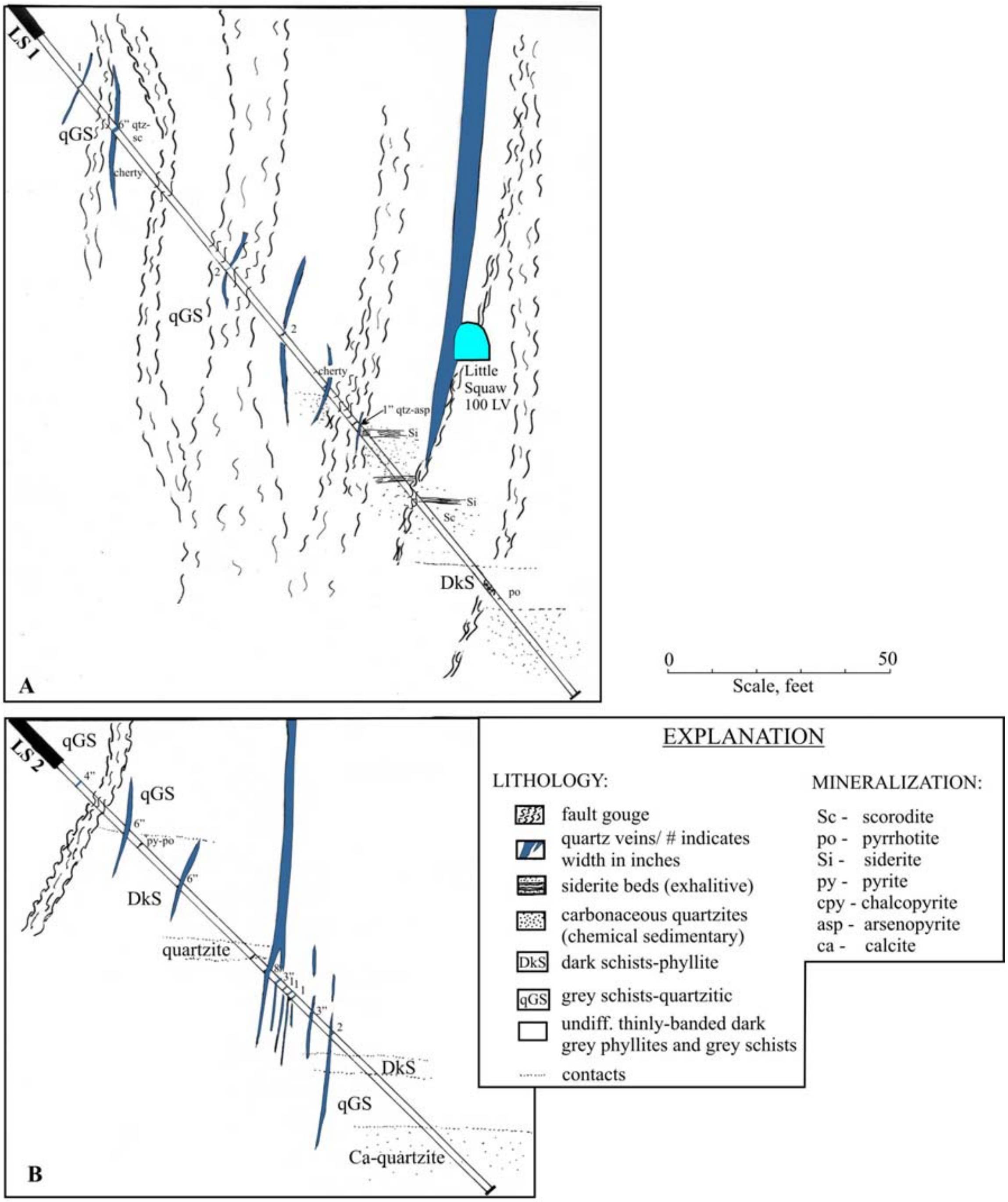



Figure 24. Geologic sectional views of Callahan Mining Co. Little Squaw vein drill holes LS-1 and -2. Both sections adapted from Duke, 1975. Note: Holes drilled for geologic information only, no assays performed.

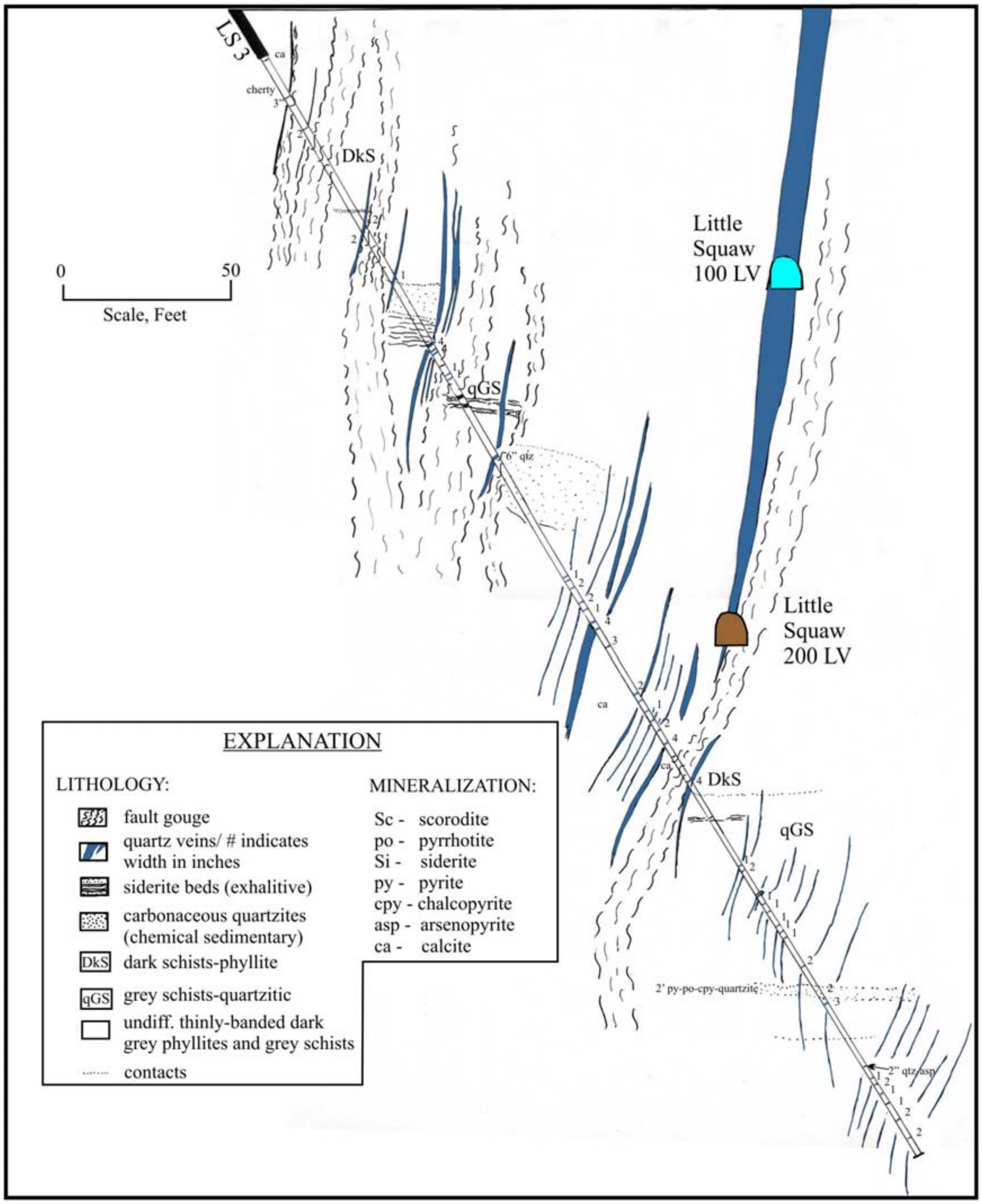



Figure 25. Geologic sectional views of Callahan Mining Co. Little Squaw vein drill hole LS-3. Adapted from Duke, 1975. Note: Holes drilled for geologic information only, no assays performed.

### *Other Lode Gold Prospects of the Chandalar Mining District*

Following discovery of high-grade gold placers on Little Squaw and Big Creeks, prospectors soon began to locate claims on the quartz veins that appeared to be the source of the placer gold. LSGMC files document many early $20^{th}$ century claim locations for which there are records of discovery. For many of these early prospects, the description and specific locations are vague. The objective of early $20^{th}$ century Chandalar district prospectors was to discover vein quartz prospects containing at least 1.0 oz/ton of gold because anything less would have been considered at the time to be uneconomic. Description of about 10-to-15 or more such prospects were found where at least 1.0 oz/ton of gold assays were reported. Some of these prospects occur along strike of a single vein system and are listed collectively under one prospect name. Over the years, claims were consolidated under several corporate entities, and these companies leased development and mining rights to a series of mining companies. The attention of previous lease holders was narrowly focused on the four principal lodes described in the previous section. This was largely a factor of limited assets and the respective lessee's need to quickly move into production or fail. Most failed. To quote the 1982 effort by CDC, "...the sole geologist was also part-time driller, operator, and truck driver, and that left little time for the pursuit of theory" (Garverich and Hoffman, 1982).

The following summary of prospect descriptions is based on the only information available. Some of the reports are quite old and their credibility is uncertain, some descriptions also include information from unverified prospector reports.

*Crystal Vein*

The Crystal vein (location #1; figure 2) occurs near the ridge crest between Little Squaw and Little McLellan Creeks. A prospect shaft and short crosscut is located about 100 feet vertically below the ridge top, and float rock can be traced for 1,500 feet downslope to Little Squaw Creek. The vein is described as 6.5-to-9 feet wide and carrying iron-sulfide and free gold in hard quartz (Marsh, 1909). The vein is composed of several distinct bands, one of which exhibits a ribboned texture. Grab samples assayed 10.0-to-43.2 oz/ton of gold, whereas the massive quartz zone is reported to assay 0.5-to-

1.0 oz/ton of gold (Marsh, 1909). A 'streak' also occurs on the steep east side of the ridge, described as the hanging wall of soft, decomposed pyrite and free gold.

*Big Squaw Claim*

The Big Squaw Claim (location #2; figure 2*)* lies on the east slope of Big Squaw Creek, and its description appears to correlate with location of the present Cosine Claim. The names of the two claims may have been reversed. The vein, said to be 8 feet in width, was examined by Marsh (1909), who reported that the Big Squaw vein outcrops near the creek and strikes uphill for a distance of 300 feet before being covered by slide rock. Murphy (1928) said he drove a short adit about 150 feet above the creek on a 4-to-7-foot wide mineralized vein, but assays were low. The Big Squaw vein cuts the schist, but it is also in contact with 'intrusive' rock. Marsh (1909) suggested the vein to be an extension of the Little Squaw lode. Carter (1917) reported tracing the Little Squaw structure from the Little Squaw Claim, across both claims, to the Big Squaw Creek vein system. Marsh (1909) refers to a sample, but no record of an assay was found. This may be the assay listed by Strandberg (1990) of 0.43 oz/ton of gold across a 12-foot length of the vein. Anderson (1946) refers to early reports of high-grade float found in the Cosine Claim area.

*Pioneer Prospect*

Float and outcrop samples from the Pioneer prospect (location #3; figure 2) contain up to 7.54 oz/ton of gold (Strandberg, 1994). Float in trench samples contains sulfides and fine gold; the float trends N65W (Anderson, 1946). Three float samples assayed an average 1.45 oz/ton of gold in 1946. The vein was later found in outcrop in the ridge saddle about 1,000 feet from Crystal Peak. Two samples assayed 2.89 and 7.54 oz/ton of gold. A dozer trench in 1981 more fully exposed the structure as an irregular pinching and swelling vein between a gray schist on the north and carbonaceous schist on the south. Grab samples of quartz with free gold from the Pioneer vein contained up to 10.3 oz/ton of gold, but most channel samples, which contained from 0.02-to-2.52 oz/ton of gold, had an unweighted average of 0.218 oz/ton of gold (Swanson and Ashworth, 1981). The Little Johnny prospect is located on the first claim to the north, and the Matchless prospect on the second claim to the north, but only trace gold with lead sulfide is reported from these claims (Anderson, 1946).

*Drumlummon Prospect*

A vein with free gold, averaging 8 feet wide, striking N75W and dipping 50S, is exposed for about 150 feet at the Drumlummon prospect (location #4; figure 2). Only low assay values were reported (Anderson, 1946). Neither vein wall was exposed. Similar results were found in 1982 sampling (Hoffman, 1982). A 5-foot thick vein outcropping 1,000 feet southeast along strike is reported to assay about 0.14 oz/ton of gold. There is a second, 2-foot thick vein about 300 feet north of the Drumlummon prospect. A prospect referred to as Golden Vale, located S30W of Drumlummon, is also reported to have gold-bearing float. Other prospects in the area include the Outlaw, consisting of an east-west-trending vein; the Big Mick, consisting of a 6-foot thick, barren quartz vein; Little Johnny, described as a 10-foot wide quartz outcrop with small amounts of galena and trace gold, and the Matchless vein, an 8-feet thick mineralized zone with disseminated galena.

*Grubstake Vein*

The Grubstake vein (location #5; figure 2) is reported to extend across the divide between Little and Big Squaw Creek valleys. A 20-foot long tunnel exposed a 20-inch wide vein with free gold, some coarse-sized gold grains up to 0.375 inches in diameter. The Grubstake vein strikes N75E from the right limit of Gold Gulch about 100 feet in elevation below the mountain top. There are other vein outcrops lower on slope and to the north that contain pyrite and arsenopyrite. Extending east across the ridge are additional outcrops of the structure. At the Trail tunnel, which was driven west on the south-dipping vein, a 30-inch vein width assayed 0.02 oz/ton of gold. Two samples of scorodite-stained quartz from the dump on the middle claim contained 0.10 oz/ton and 0.32 oz/ton of gold (Swanson and Ashworth, 1981).

*Grubstake East Prospect*

A quartz vein, estimated to be 2.5-feet thick, assayed 0.02 oz/ton of gold (location #6; figure 2). There is an unclear report of another vein outcrop in area. The Grubstake East appears to be on the same fault/vein system as the main Grubstake Prospect

*Prospector East Prospect*

The Prospector East is also described as the Prospector prospect, which is located one-third mile north of the Grubstake vein in the saddle between Gold Gulch and Little Squaw Creek (location #7; figure 2). A quartz galena vein, about 3-feet thick, strikes N75W and contains trace to 18.3 oz/ton of silver.

*Indicate-Tonapah Lode*

The Indicate-Tonopah lode is also known as the American Eagle or Newton prospect (location #8; figure 2). Trenches and channel samples from the slopes above Big Creek show only trace to 0.04 oz/ton of gold (unknown source, 1962). Reed (1930) described a 40-foot deep placer shaft on Big Creek that exposed a wide quartz vein in bedrock. A two-stamp mill was brought in for the 1909 season, but it had only 30 percent recovery. Ore grade was said to be too low for mining at that time, and no gold assay values were given. There are also reports of specimen-grade gold in quartz taken from this vein. Anderson (1946) and Strandberg (1994) mention an old report of a 20-foot wide, east-west-trending structure that contains free gold, pyrite, and arsenopyrite.

McGee (1939) described another 15-foot deep shaft that encountered a quartz vein with free gold about 50 feet east of Big Creek, apparently in the same area. He reported vein quartz representative of the dump to assay $11.20 or 0.32 oz/ton of gold at $35/oz. Early century trenching on the Indicate-Tonopah failed to locate additional significantly mineralized veins; however, the veins are very poorly exposed under slide rock. Re-sampling of trenches in 1982 yielded several values including 1.7 and 6.0 oz/ton of gold in grab samples (Garverich and Hoffman, 1982).

*Chandalar Vein*

Strandberg (1994) includes his description of the Chandalar vein with the Eneveloe vein (location #9; figure 2). Anderson (1946) described a 2-foot chip sample across a portion of the 6-foot wide structure that returned 2.26 oz/ton of gold, and that a bulk sample along a mineralized quartz band reported 49.98 oz/ton of gold. In 1981, the old trench was uncovered and an extension of the vein striking S85W was exposed. Grab samples contained 0.02-to-2.00 oz/ton of gold (Swanson and Ashworth, 1981). In 1982, a 3.3-foot channel sample from additional dozer trenching contained 0.66 oz/ton of gold (Garverich and Hoffman, 1982). The vein can be traced for at least 300 feet on the surface.

*Jupiter Vein*

Samples collected from Jupiter claim trenches (location #10; figure 2) assayed up to 0.36 oz/ton of gold (Strandberg, 1994). On the Jupiter Claim, there is a 20-foot long adit that exposes a hanging wall side of a S65W-trending quartz vein that dips 70 degrees north and contains sulfides and scorodite. Quartz banding was noted. Channel samples were taken but no assay data were found (McKee, 1939; Anderson, 1946). A 7-foot wide vein described by Marsh (1911) assayed 0.39 oz/ton of gold. Marsh (1911) indicated that a 13-foot long adit exposed a 40-inch thick vein. Reportedly, placer gold was mined below the Jupiter claim, which exposed the vein in the creek bed. However, no bedrock samples were collected in the placer cut. A dozer trench was opened on the Jupiter claim in 1981, and a series of channel samples were taken approximately every 10 feet for 160 feet of strike along a 3-foot wide quartz vein. An unweighted average assay was 0.08 oz/ton of gold (Swanson and Ashworth, 1981). The vein was extensively fractured and heavily stained by scorodite. On the adjoining Jupiter Fraction claim, a 1-foot thick vein was also trenched in 1981. Channel samples of this vein ranged from trace to 1.66 oz/ton of gold (Strandberg, 1994).

*Bonanza Vein*

The Bonanza vein (location #11; figure 2) is a possible side vein of the Eneveloe Vein. According to Boadway (1933), it occurs 4,000 feet south of the Little Squaw Vein.

Seven-to-ten-foot widths of vein quartz are reported over a strike length of about 2,000 feet. One sample of dump material assayed about 0.09 oz/ton gold. According to Boadway (1933), high grade float was found in Robbins Gulch below the Eneveloe vein.

*Pallasgren Claim*

The northwest corner of the original Pallasgren claim (location #12; figure 2), which may include the Northern Light claim, is S57E and 800 feet from U.S. Landmark #1999. The Pallasgren prospect is near the head of Nugget Gulch, on the divide between Lake and Little McLellan Creeks. Two samples of quartz veins 6-to-8-feet wide with the footwall not exposed were reported by McKee (1939) to contain 0.12 oz/ton of gold over 34 inches and 0.32 oz/ton of gold over 8 inches. On the hanging wall side there is 8 inches of banded quartz said to be well mineralized with black sulfides. A trench exposes a vein striking east-west, about 140 feet west of the main Pallasgren showing. This vein dips south, has a width of 10-to-15 feet, and is oxidized and highly fractured. This may be the 6-to-12 feet thick vein reported by Guise (1935) to assay 2.26 oz/ton of gold. A 26-inch thick, parallel vein is exposed in a trench 240 feet to the north. To the west, in the bed of Nugget Creek, there is quartz float with free gold that McGee (1939) believed is evidence for at least two more parallel veins underlying the side hill.

*St. Mary's Prospect*

Oxidized quartz veins in fault gouge striking northwest and dipping north were found in bedrock on St. Mary's Creek in each of three mine cuts spaced 200-to-300 feet apart (Ackels, 1994). St. Mary's Creek below the vein exposure (location #13; figure 2) produced high-grade placer gold which accounts for much of the historic 20,000 ounces of placer gold production from Big Creek.

*Star Claim Group*

The Star claim group (location #14; figure 2) contains a quartz vein that can be intermittently traced across 3 lengths of claims on the west slope of Big Creek: the Evening Star, Morning Star, and Star Fraction (Marsh, 1909). The vein across the entire distance of the 3 claims averages 8-to-10 feet wide, but no assays were given by Marsh

(1909). The Star vein is said to strike east-west and have a vertical to steep north dip. Guise (1935) reported assays ranging from 0.04-to-1.24 oz/ton of gold for samples of vein from the three claims; however, specific locations were not given. In 1981, new trenches on the Star No. 1 and 2 Claims were excavated, exposing a vein striking N45W, but of unknown dip. Channel and grab samples ranged from trace to 0.74 oz/ton of gold. Guise (1935) reported grab sample assays of 0.89 oz/ton of gold from the Star No. 1 claim and 1.24 oz/ton of gold on the Star No. 2 claim.

*Star No. 3 Claim*

At the Star No. 3 claim, an E-W-striking quartz vein, about 5-feet thick and dipping south, was exposed by trenching and short test holes (location #15; figure 2). A chip sample across 3.5 feet contained 0.24 oz/ton of gold (Strandberg, 1994). Poorly mineralized quartz outcrops are reported 500 feet to the west.

*Duplex-Triplex Vein*

The Duplex-Triplex vein (#16, figure 2; location uncertain) is cited (Marsh 1909; Murphy, 1925). A prospect trench was excavated on a quartz outcrop.

*Wildcat Prospect*

A prospect trench was excavated on a quartz outcrop; there are no further details concerning this quartz vein occurrence (location #17; figure 2).

*Jackpot Prospect*

A 20-foot long adit at the Jackpot prospect exposes a 1.5-foot-wide vein striking N80E and dipping 80 degrees south (location #18; figure 2). Two channel samples contained 0.08 and 0.33 oz/ton of gold (Anderson, 1946). Some free gold in quartz was reported.

*Woodchuck Claim*

A 3-foot wide vein can be traced for 100 feet; however, no assays are given (Reed, 1930). A 6-foot wide vein with free gold on the Woodchuck Claim (location #19; figure

2) is also mentioned by Marsh (1911). The Woodchuck vein can be traced for a claim length (Strandberg, 1990, 1994). A shaft has been sunk on one outcrop. Two samples collected by CDC in 1981 contained 0.04 and 0.06 oz/ton of gold respectively.

*Little Kiska Occurrence*

Stibnite-bearing, quartz mineralization was reported on a hillside between Mikado and the Star claim groups by Adney (1945) and referred to as the Little Kiska occurrence. The location of the Kiska occurrence is uncertain (location uncertain on figure 2).

*Pedro Prospect*

The Pedro prospect (#21, figure 2; location uncertain) is located on Pedro Creek Claims no. 1 and 2 above Discovery, which trend southeast across Big Creek near the mouth of St. Mary's Creek. No other information was found in LSGMC data files.

*Grubstake West Claim Group*

The Grubstake West claim (location #22; figure 2) is located in an unnamed gully of Big Squaw Creek. No specific description of the Grubstake West claim was found.

### ***Placer Deposits of the Chandalar District; General Discussion***

Placer deposits of the Chandalar Mining district are characterized by high grade concentrations of native gold that occur in the vicinity of known quartz lodes. From 1905-to-1999, approximately 76,000 ounces of gold have been produced from four third-order streams in the Chandalar Mining district: Little Squaw and Big Squaw Creeks drain north; Tobin and Big Creeks flow south and southwest. Placers of the Chandalar district occur in fairly steep, second- and third-order streams that contain an abundance of locally derived sub-angular to sub-rounded clasts of schist, quartz, and greenstone dike rock. The mountain ridgeline that separates the placer stream basins averages about 5,000 feet in elevation, and there has been significant downcutting of a former highland lying south of Squaw Lake; that process continues at present. Placer gold grains are sub-angular to sub-rounded in shape, and lode sources for placers in St. Mary's Creek and Big Creek are in the immediate vicinity (McKee, 1939).

Placer gold deposits in the narrow, incised upper creek valleys occur in pay streaks under 10-to-35 feet of overburden. At distances of two-to-five miles below the heads of the valleys, placer gold exploration has found depth to bedrock to exceed 170 feet with pay streaks on bedrock surfaces and several in 'false bedrock' intervals above bedrock surfaces. Placer gold in deep placer gravel, such as on lower Little Squaw and likely Big Squaw Creeks, occurs at several fluvial horizons separated by barren, poorly sorted glaciofluvial deposits containing clay-sized silt to boulder-size material. The clay-rich material serves locally as a false bedrock on which fluvial gold has concentrated during interglacial periods. Pay streaks on bedrock are said to have been followed downstream with prospect shafts and found to leave bedrock and continue out over the glacial deposits.

Repeated Quaternary glacial advances have periodically in-filled and scoured the lowlands to the north around Squaw Lake and in-filled the lower valleys of Big and Little Squaw Creeks. The presence of the multi-level placer deposition, with gold also concentrated on bedrock, indicates the general lack of glacial scour within the Chandalar Mining district, even in auriferous deposits of Big and Little Squaw Creeks on the north side, where several periods of Late Pleistocene, transcurrent ice flow occurred (figure 10). The Little and Big Squaw Creek placer deposits likely were developed during downcutting and readjustments caused by changing base levels in the trunk glacial valley to the north. The rapid erosion and downcutting of the north-facing hill slopes concentrated relatively rich gold placers derived from upslope lode sources, which were subsequently preserved under outwash and drift in Big and Little Squaw Creek valleys and perhaps elsewhere in the district. This periodic but rapid placer gold deposition on both bedrock and false bedrock surfaces is typical of gold districts in glaciofluvial settings such as the Valdez Creek district in south-central Alaska (Reger and Bundtzen (1990), the Bolotny-Ravkosky district in northeast Russia (Tchapko, 1995) and other similar glaciogenic settings in Alaska and British Columbia, Canada (Knight and McTaggert, 1989; McLeod and Morison, 1996).

Overall, average values for Chandalar placer gold indicate gold fineness is 848 with silver fineness at 148. Concentrates also contain arsenopyrite, pyrite, hematite, limonite, and minor galena and scheelite; magnetite is rare on Little Squaw Creek (Mertie, 1923), but magnetite concentrations are reported on Big Creek (Daughtry, 1973). Mertie found monazite and rutile occurring in concentrates from Big Creek, and cites differences in the characteristics of deeper pre-glacial gold as coarser and more water worn than post-glacial gold. On Little Squaw Creek, he observed gold nuggets up to 10.6 ounces in weight in the older sediments, whereas gold nuggets from more recent sediments did not exceed 0.6 ounces in weight.

Productive placers of the district have been worked by shallow, hand-dug open cuts in the upper creek valleys, followed in later years by mechanized sluice operations, and by drift mining frozen ground to depths of 165 feet. The original discovery of gold at Chandalar was on Little Squaw Creek in 1905, but shallow auriferous gravel reserves were found to be of limited extent. By 1907, miners were beginning drift mining operations on the principal gold-bearing creeks, and were focused on deposits in lower Little Squaw Creek valley. The early drift miners recovered 0.98 ounces/per cubic yard gold, based on compiled records for 1916 through 1923 (Fitch, 1997). Some recorded cleanups at the Mello Camp ranged up to 4.85 ounces/cubic yard of gold (Dunlap, 1925). Rich clean-ups were also reported at locations on Big and Tobin Creeks during these early years. Drift mining peaked in the 1920s, but continued until WWII.

Previous mining has probably exhausted most of the shallow deposits and frozen placer ground that could be drift mined. During the late 1980s and 1990s, a bulldozer/sluice operation operated on Tobin and Big Creeks under a lease from LSGMC to Gold Dust Mines, Inc. This open-cut placer mine annually produced several hundred to as much as 1,700 ounces of gold per season. Placer resources occur in deep gravel lying in active water tables below present stream beds, where the thawed conditions precluded drift mining. The best known deep placer gold deposit is located on lower Little Squaw Creek, and similar deposits may occur on lower Big Squaw Creek.

## ***Primary Placer Deposits***

*Little Squaw Creek*

Placer deposits on Little Squaw Creek account for half of the placer gold produced from the district. Shallow deposits in the upper valley, amenable to open-cut hand mining, were soon developed but mostly played out by about 1916; there are few substantive reports on this activity or on gold production from these operations. Most production came from drift mines operating on the Mello Bench, also known as the Little Squaw Bench deposit in the 1920s, specifically from Claim Nos. 2 and 3 Above Discovery. Mertie (1925) reported the richest drift mining on Little Squaw Creek occurred on a false clay-rich bedrock surface. Gold values fell off both upstream and downstream of this area. There has been no explanation for the higher gold values in this segment of the valley.

Trace quantities of placer gold are known to extend down Little Squaw Creek as far as Little Squaw Lake. A shaft near the lake was sunk to a depth of 150 feet without encountering bedrock; however, traces of gold were found throughout the entire length of the shaft. About a mile upstream of the mouth of the creek, unmined auriferous gravel occurs at three horizons in the Carlson-Buckley Shaft (Thompson, 1925; figure 26, this study), located on the left limit of Little Squaw Creek on the No. 1 Below Claim. The shaft was sunk in 1925 and reportedly encountered a gold-bearing horizon of 0.12 oz/cubic yard of gold over a 9 foot thickness at 70 foot depth, 0.24 oz/cubic yard of gold over a 5 foot thickness at 140 foot depth, and 0.58 oz/cubic yard of gold over a 9 foot thickness on bedrock at 164 foot depth. The shaft was in frozen ground, but near the thaw margin underlying the creek. A 300-ounce-gold pilot mining test in the 1920s returned a mine-grade of 0.32 oz/cubic yard of gold. Herbert (1980) reviewed the information for the Carlson-Buckley Shaft placer deposit, and he noted a possible resource extending from about 500 feet downstream of the Carlson-Buckley Shaft to about 2,000 feet upstream from the shaft along the left limit. Herbert (1980) concluded that there was an attractive target for development of a more than 1.0 million bank cubic yard placer deposit and recommended a systematic drill program. Although productive placer ground immediately west and south of the Carlson-Buckley Shaft was known, the early miners were unable to develop the left limit bench because it was thawed.

In 1997, Daglow Exploration, Inc. obtained a lease from LSGMC and conducted placer exploration in the district. A 12-hole drilling program was undertaken by Daglow in the vicinity of the Carlson-Buckley Shaft (Fitch, 1997), and two drill lines crossed the pay streak with 6-inch diameter reverse circulation (RC) holes spaced approximately 100 feet apart (figure 26). Drill depth capacity of the rig was limited to about 95 feet. The western end of the drill lines, located over the Mello Bench, encountered only old workings. The eastern holes on both lines reported placer gold grades over intervals shown on figure 26. Based on drill data and local geologic observations, Fitch (1997) determined a possible resource extending about 1,800 feet upstream along the left limit of the creek to Line 44 and thence upstream to Line 49. .

Limited portions of this placer gold resource were further deemed probable and proven. Fitch (1997) estimated that about 194,000 ounces of proven, probable, and possible gold resources are present in Little Squaw Creek (table 2).

Review of information prepared for Daglow by Fitch (1997) estimated ‘possible’ resources within Blocks 3 and 4 are in the area of past drift mining; therefore, some of this ‘possible’ resource may have been mined out. In addition, the estimates prepared by Fitch (1997) are also reliant on early reports from several sources concerning the average gold contents of the pay section near the Carlson-Buckley Shaft. However, we judge that the average gold content reported in the earlier reports are reliable because they are consistent with reported production at the time. Because of the wide spacing of the drill lines, Fitch strongly recommended further in-fill drilling, and we would agree with that recommendation. Holes 10, 11, and 12 on drill line #44did not reach bedrock, where the highest gold concentrations found in the Carson-Buckley shaft occurred. Exploration below the Carlson-Buckley shaft may extend the resource downstream; however, the increasingly lower bedrock surface may require pumping groundwater out of water-saturated sections above bedrock.

Table 2. Estimates of placer gold resources and historic placer gold production by creek.

| PAST PRODUCTION | | | | RESOURCES – as of 2003 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | PROVEN | | | PROBABLE | | | POSSIBLE | | |
| CREEK NAME | Cubic Yard | Ounce/ cubic yard | Ounces gold | Cubic Yard | Ounce/ cubic yard | Ounces gold | Cubic Yard | Ounce/ cubic yard | Ounces gold | Cubic yard | Ounce/ cubic yard | Ounces gold |
| BIG CREEK, INCL. ST. MARY'S CREEK | | | | 39,875 | .016 | 634 | 50,000 | .028 | 1,375 | 12,030 | 0.013 | 32,755 |
| hand mng | 34,667 | 0.209 | 7,257 | | | | | | | | | |
| mech | 300,000 | 0.026 | 7,954 | | | | | | | | | |
| mech 1993- | --- | --- | 2,541 | | | | | | | | | |
| drift | --- | --- | 7,588 | | | | | | | | | |
| LITTLE SQUAW CREEK | 30,466 | 0.960 | 29,237 | 51,281 | 0.047 | 2,410 | 217,955 | .049 | 10,606 | 1,991,596 | 0.091 | 180,900 |
| TOBIN CREEK | | | | --- | --- | --- | --- | --- | --- | 2,352,000 | 0.028 | 66,569 |
| pre-1945 | 2,268 | 0.441 | 1,000 | | | | | | | | | |
| 1966-70 | 14,000 | 0.536 | 7,500 | | | | | | | | | |
| mech 1979-99 | 600,000 | 0.021 | 12,559 | | | | | | | | | |
| BIG SQUAW CREEK | --- | --- | --- | --- | --- | --- | --- | --- | --- | 1,522,221 | 0.060 | 91,333 |

[1] **G**old values as determined by mill head assays, which does not factor in mill losses; data from 1979-83 from Millmen (1983)
[2] gold recovered from mill and concentrates; i.e., actual reported production

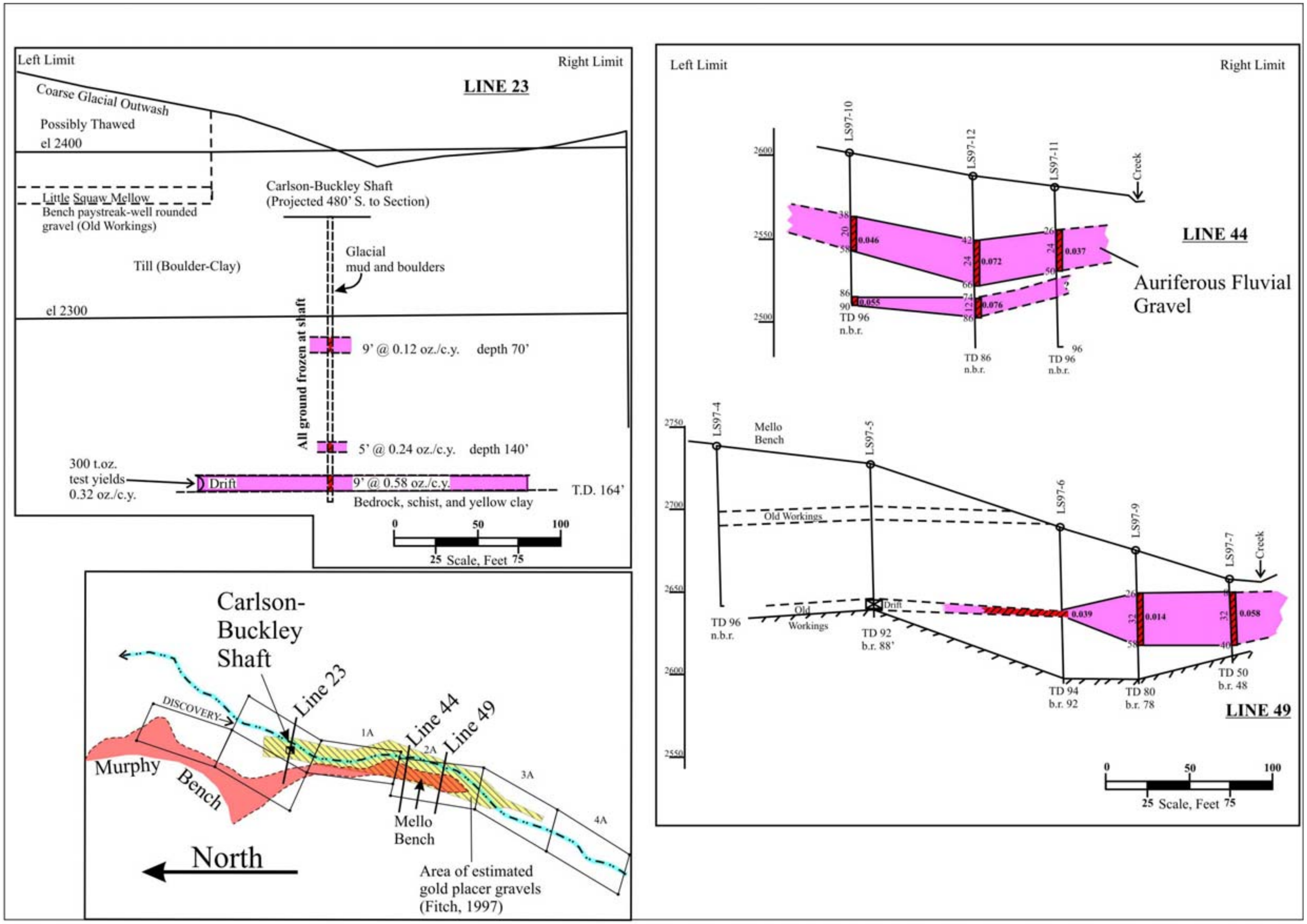



Figure 26. Little Squaw Creek placer, plan and cross sections of lines 23 (Carlson-Buckley shaft), 44, and 49 (drill holes).

*Big Creek*

Big Creek is not known to contain glacially derived sediments, and all gravel is apparently of local origin. Depth of creek sediments ranges from less than 20 feet to about 35 feet about 10 miles downstream from the mouth of St. Mary’s Creek. The original discovery claim was located near the very head of the creek; however, most production came from farther downstream near the confluence of St. Mary’s Creek and Big Creek.

Hesse (1924) examined the drainage and documented high grade drift operations averaging $1.34-to-$2.22 per bedrock foot (brf) on the Nos. 4 and 5 Below Discovery claims in the vicinity of Pedro Creek and the confluence of St. Mary’s Creek. Economic placer gold-bearing material was later found and mined on St. Mary’s Creek. Reed (1929) visited operations that year and reported a mine grade of 0.87 oz/cubic yard of gold from difficult drifting in partially thawed ground on the No.1 Below Discovery claim. The placer gravels between claim Nos. 2 to 5 Below Discovery averaged about 0.1 oz/cubic yard of gold, and the gold content in gravels at 5 Below ranged from 0.16 to 0.2 oz/cubic yard of gold. There were several reports of gold-bearing quartz veins up to 25 feet thick in the vicinity of the confluence of Big Creek and St. Mary’s Creek, which could be an easterly extension of the Mikado vein fault/vein zone (see St Mary’s #13 and Indicate-Tonopah #8 prospects, figure 2, this study). Processed gravel on St. Mary's Creek contained up to 0.48 oz. gold per square foot of bedrock.

A drilling project was initiated on Big Creek beginning in 1940 using a 4-inch Kirk-Hillman airplane drill. This drill program blocked out additional reserves containing about 7,000 ounces of gold in ground that averaged about 0.04 oz/cubic yard of gold (Adney, 1945; Wolff, 1949; Herbert, 1980). Adney (1945) indicated that blocks of unmined ground were encountered in the drill program.

Resources for Big Creek were tabulated by E.O. Strandberg Jr. (1990), independent Professional Mining Engineer, using available reports and on-site examinations. Strandberg estimated remaining proven, probable, and possible resources as 35,305 ounces of gold in 2.4 million cubic yards or an average grade of 0.0154 oz/cubic yard of gold. Most of this lies downstream of the confluence of St. Mary’s Creek on ground not controlled by LSGMC. Proven and probable resources on LSGMC claims total about

1,500 ounces of gold. Although lower Big Creek is not held by LSGMC, it should be noted that the drainage crosses additional east-west-trending shear structures recognizable on air photos. These structures might contribute additional placer gold to the stream drainage. There has been very little exploration of the placer gold resource potential, but coarse placer gold was found as far downstream as the #19 Below Discovery claim.

*Big Squaw Creek*

Gold was discovered in 1909 and shaft prospecting on the Nos. 1 Above and 1 Below Discovery claims soon commenced (Marsh, 1909). There is little production information for Big Squaw Creek during the early half of the 20th century. Mertie (1925) reported this drainage to have a similar geologic history as Little Squaw Creek and noted the presence of stibnite and pyrite with intergrown gold in placer concentrates.

When Reed (1930) visited the valley, there was no mining in progress. He noted that on lower Big Squaw Creek several abandoned partially completed shafts had encountered thawed ground and flooded out. McKee (1939) reported a high grade cut being worked on Big Squaw Creek below the Jupiter lode claim. In 1997, Daglow Exploration drilled three holes to a maximum depth capability of 96 feet on lower Big Squaw Creek near the airstrip. These holes encountered traces of gold, but did not reach bedrock (Fitch, 1997).

Herbert (1980) and Strandberg (1994) noted a possible ancestral channel of Big Squaw Creek south of and about parallel to the Little Squaw airstrip. Strandberg (1994) described the feature as probably thawed and therefore unexplored. Strandberg (1994) suggested that a target bench deposit 5,000 feet in length and 200-feet wide may contain 750,000-to-1,000,000 cubic yards of auriferous gravel. He further speculated that this bench may merge with the Little Squaw (Mello) and Murphy bench system. Strandberg (1994) calculated a possible resource of 91,333 ounces of gold. at an average grade of 0.06 oz/cubic yard of gold within the 1.5 million cubic yard 'Big Squaw Bench', but provided few details concerning the data used to calculate this gold resource.

*Tobin Creek*

Shafts sunk in the upper reaches of Tobin Creek, above Woodchuck Creek, found only traces of gold (Reed, 1930). There were reports of good results from prospects on upper Woodchuck Creek, possibly due to nearby gold-bearing Mikado quartz lodes. In 1939 ground running $5/bedrock foot was reported about a mile below the Mikado Mine on Tobin Creek. A rich pay streak was later found along the left limit of Tobin Creek beginning above the confluence of Woodchuck Creek, and extending down valley past the present airstrip. Anderson (1956, 1960) reported $8.00/bedrock foot in the upper end and $3.00/bedrock foot about 1,500 feet down valley. In some shafts, 'pay' was reported to occur in the entire gravel section.

Beginning in 1932 and continuing to about 1966, the Tobin Creek pay streak was explored by shafts, and limited open-cut mining produced about 1,000 ounces of placer gold. Between 1966 and 1970, Chandalar Gold Mining Company and Canalaska Placer Inc. produced 7,500 ounces at a grade of 0.535 oz/cubic yard of gold. Since then, Tobin Creek has been surface-mined intermittently until 1994 with mechanized equipment that processed pay at a lower mine grade, yielding an estimated 12,559 ounces of placer gold. The authors believe that most of the major pay streak on Tobin Creek has been mined out.

Based on old reports, sampled exposures, and limited drilling conducted in 1980, Strandberg (1990) calculated that Tobin Creek contained a 'possible' resource of 70,800 ounces of gold in 2.5 million cubic yards of gravel at a grade of 0.0283 oz/cubic yard of gold. He believed that the Tobin Creek airfield, which had never been drilled, may contain a placer gold resource. There are reports of lower grade gold in several shafts on lower Tobin Creek and elsewhere in remaining side pay, but too little information is available to make reliable placer gold resource estimates.

## ***Other Placer Prospects***

On Trilby Creek, a tributary to the Middle Fork of the Chandalar River about six miles west of the district, coarse gold was reported on bedrock outcroppings in the streambed. Miners are said to have recovered $6.00 or $7.00/day in gold (at $20.67/oz) in the early days.

Dictator Creek, a right limit tributary to the Middle Fork, was prospected and a shaft was sunk in 1930, but flooded before reaching bedrock (Reed, 1930). Placer mining is reported to have occurred in 1928 and 1933 (Cobb, 1976). Prospects are also known on Agitator and Rock Creeks, a northern tributary to Slate Creek, Our Creek (near Bend Mountain), Bridge Creek (a left limit tributary to the North Fork), and on lower Big and Little McLellan Creeks. All reports of placer gold showings are more than 80 years old and no accounts of follow-up investigations could be found.

## X Milling Processes and Metallurgical Studies

The quartz-hosted gold ores in the Chandalar Mining district have long been classified by many investigators as containing about 70-90 percent free-milling gold, with the balance intergrown with sulfide minerals, which comprise about 10-to-15 percent of the high grade mineralized veins.

The first effort to mill gold ore from the Chandalar mines occurred in 1909 at the quartz showing on the Indicate-Tonopah claims. Later a 15 ton-per-day (tpd) stamp mill was installed at the Summit Lode in the 1930s. The stamp mill proved to be inadequate to achieve reasonable recovery. Later tests performed at the Alaska Agricultural College and School of Mines in Fairbanks demonstrated that the quartz ores required finer grinding followed by amalgamation (Boadway, 1933). Tests on a minus 60 mesh grind of the Mikado ore achieved 76 percent recovery. Additional tests from the Mikado attained 89 percent, and up to 90 percent was recovered from the Little Squaw vein. A grinding, gravity separation, amalgamation mill was then proposed by Boadway (1933) to be located on the Spring Creek mill site and fed by a 2-mile-long aerial tram. This infrastructure was never built.

There followed a series of bench scale metallurgical tests of mineralized samples from the district, beginning in the 1950s, that ultimately led to construction of a 100 ton-per-day mill at Tobin Creek in 1970. Table 3 is a chronology of post-WWII activities related to milling processes and metallurgical studies in the Chandalar Mining district.

All of the above samples were briefly described, but the degree of oxidation, both in situ and oxidation occurring during shipment to stateside laboratories, is unknown. Samples submitted were no more than several hundred pounds. There has been no bulk sampling of lodes in the Chandalar district, and most attention was paid to only the Mikado Lode. Recommended flow sheets all included an initial first step of grinding to minus 60 mesh or finer and a gravity separation circuit (including jigs, Deister tables, and spirals), followed by amalgamation, cyanide, and retort recovery. This generally recovered about 75 percent or more of the head assay.

***Table 3. Post-WWII activity summary for milling and metallurgical studies, Chandalar District***

| *Year* | *Private Operator/Institution* | *Summary of Activity* |
|---|---|---|
| 1954 | Denver Equipment Company | Study of Summit Lode ores. Recommended an agitation cyanide leach circuit (0.50 percent NaCN) without flotation (Toussaint, 1954). |
| 1961 | University of Alaska SME | Hoch (1961) reported results of mill tests on Mikado ore, including gold sizing and amalgamation tests. |
| 1961 | Gallagher Company | Straight cyanidation was performed on Mikado ores with a grind of 52 percent at 325 mesh; extracted 98.7 percent of gold in 24 hours; leaving 0.04 percent oz/ton in tails; recommended gravity circuit and cyanide leach (Liss, 1961). |
| 1962 | American Cyanamid Company | Jankovich (1962) Recommended a 60 percent -200 mesh grind followed by amalgamation of tails. |
| 1963 | Day Mines Company | Ziegler (1963) reported that flotation might work on ores from the Mikado and Little Squaw lodes, but graphite could pose a dilution problem. |
| 1973 | Harrison Western Corporation | Designed mill on the basis of ore test by Denver Equipment Company in 1954 |
| 1976 | Mountain States Research and Development, Inc. | McAllister (1976) tested Mikado ores at Tobin Creek mill and achieved gold recoveries of 85.6 percent with amalgamation and 92.0 percent with cyaniding of tails after amalgamation; and 98.0 percent with cyaniding of table tails after steps above. |

The amalgamation tails (sulfides) were then treated by either floatation and/or cyanidation. Flotation of a sulfide concentrate posed the problem of either shipping a heavy product from the remote location and finding a smelter willing to accept the high arsenic concentrate, or cyaniding the sulfide product and producing a bullion product on site. The various proposed circuits achieved recoveries exceeding 90 percent on materials containing at least 1.0 oz/ton of gold. With a total cyanide leach of the mill feed, recoveries could be raised to as high as 98 percent. Some problems were encountered with sulfides fouling the cyanide dissolution and with floatation reagents being carried over into cyanidation or amalgamation treatment. The only mineralogical work found in LSGMC files was completed by American Cyanide Co. (tables 3, 4). Some tests also encountered graphite, which possibly could pose a recovery problem (Zeigler, 1963).

***Table 4 Mineralogy of metallurgical sample from the Mikado Mill, Chandalar district, from Jankovich (1961)[1]***

| Sulfide Minerals | Gangue Minerals |
|---|---|
| Pyrite | Quartz |
| Arsenopyrite | Chlorite |
| Chalcopyrite | Talc |
| Sphalerite | Phlogopite |
| Pb-Sb-Bi-Fe sulfide[2] | Sericite |
| Magnetite | Ankerite |
| Galena | Fe-Mg carbonates |
| | Limonite |
| | Barite |
| | Tourmaline |

[1] Free gold, readily observed, ranged from approximately 300 microns down to 10 microns in size and probably below.
[2] Unidentified sulfide occurs as elongated columns and needles that cleave lengthwise into fine splinters.

Figure 27. Photograph of the Tobin Creek 100 ton per day mill.

The Tobin Creek 100 ton-per-day mill was designed to handle the high grade (multi-ounce) auriferous feed from all of the known lode deposits and ultimately at least some production was milled from each of the four better known lodes (Hoffman, 1980, 1981, 1982). The mill was equipped with a jaw crusher to ball mill grinding circuit, followed by gravity separation (figure 27). Initially a Denver jig followed by Deister tables were installed, but tabling problems continually led to poor recovery: 1) table sliming occurred with subsequent fine gold losses, 2) surges of gold in the table feed, due to the highly variable nature of the gold content in the mine run, resulted in lack of separation control and additional gold loss, and 3) the table concentrates contained a high percentage of arsenopyrite, which was not possible to amalgamate even after an attempt to roast the material. The gravity concentrate was amalgamated and the gold recovered in a retort. Later, in 1981, the tables were replaced with a jig followed by a bank of six Denver 18S flotation cells.

Flotation concentrates were treated in a cyanidation circuit, and pregnant solutions were precipitated in a carbon tower; however, mill recovery was still only 77.9 percent for the year and 69.8 percent for 1982, though that would have been higher except for gold lost in the leach tails impoundment. These tails were saved for future processing. At least part of the problem continued to be the occasional high-grade surges of sulfides and gold when rich charges of mine run material were processed through the mill. Mill tailings contained 0.115 oz/ton of gold for 1981 and were pumped to a nearby tailings pond.

Other problems persisted with the mill flow sheet, including the sticky nature of the gouge contained in the Mikado ore, which clogged feeders and bins, and differing characteristics of ore from the other quartz lodes (Hoffman,1981). In addition to the Mikado, in 1981 the Summit and the Little Squaw veins were mined, and in 1982, the Eneveloe was also mined. Material delivered to the mill from different sources had variable degrees of oxidation, which interfered with the flotation cells. Additionally, flotation reagents, such as Aerofloat 25, were difficult to clean from the flotation concentrate and resulted in frothing in the cyanide leach tank, which floated sulfide and gold grains. A flow chart of the mill circuits as they were modified in 1981-1982 and as they remain at present is given in Strandberg (1990).

In summary, previous beneficiation tests indicated acceptable recoveries can be achieved using standard gravity and cyanidation processes, perhaps incorporating flotation. In practice, however, the Tobin Creek mill failed to attain similar recoveries for reasons cited. Additional pilot plant-scale testing of bulk samples to investigate blending of ores and scrubbing and de-sliming procedures of gouge-rich ore will be necessary.

## XI Environmental Issues at the Chandalar Mines

The Chandalar Mining district has been in development and production for nearly 100 years. All of the activities have been small scale, placer gold mining and limited development and production of high grade, low sulfide, gold-quartz ores. Available records indicate that a cumulative total of about 11,819 tons of low-sulfide, auriferous quartz ores have been processed intermittently at hard rock mills in the district from 1909-1983 (table 1). As early as 1909, a small stamp mill was hauled to Big Creek and eventually to the Spring Creek mill site. In the 1930s, a small 15 ton-per-day stamp mill was installed at the Summit mine. Because the stamp mills at both locations proved to be inadequate to liberate the gold, these initial activities were discontinued and never placed into full production. More than 95 percent of the ore milled in the district was processed in the Tobin Creek mill, which is described in a previous chapter of this report. A lined tailings pond at Tobin Creek was sealed in the early 1990s. Because much of the placer mining has been from underground drift mines, there is very little placer tailings present in the district. During the 1980s-1990s, surface placer mining has taken place, but has been permitted under regulations promulgated by the Alaska Department of Natural Resources (ADNR), with full compliance achieved (Jack Kerin, ADNR, oral commun., 2004).

Because some of the historic lode and placer mining activity predated the development of modern environmental guidelines, past mining practices have resulted in site conditions that might require environmental remediation.

During the 1980s, the Alaska Department of Environmental Conversation (ADEC) completed an assessment of the claims that were 'tentatively approved' for transfer to the State of Alaska from the Federal Government in the Chandalar district area, in accordance with the State land entitlement selections. The mitigation issues identified by ADEC were: 1) the need to remove about 3,000 pounds of old lead-acid batteries; 2) removal or reprocessing of about 200 cubic yards of fill found to be contaminated with low levels of mercury at the Tobin Creek mill site; and 3) removal of 'benign' ferrous scrap that has accumulated over several decades of mining activities (ADEC internal memo-- Teleconference with Odin Strandberg, 04/22/93). In addition there are approximately 50 barrels and two 6-foot concentrate tanks filled with gold-sulfide concentrate stored in the Tobin Creek mill that will have to be permanently stored. The Chandalar mining property is listed as a 'medium rank' contaminated site, mainly because of the mercury contamination identified at the Tobin Creek mill (ADEC website, 04/01/04). During the late 1980s and early 1990s, Little Squaw Gold Mining Company had formulated plans to mitigate these environmental concerns.

In 1990, LSGMC consultants traveled to the property and cleaned up the mill area. Ferrous scrap was removed from the mill building, and the flotation and cyanide bays were cleaned up. Trash from the spill banks and shop was cleaned out of Woodchuck Creek and dozed into a permitted pile along the left limit of the Creek. Junk was also hauled from the mill shop area to a solid waste disposal pit approved by ADEC in the Tobin Creek tailings and buried. A 3406 diesel generator was moved inside the Tobin Creek mill building, and components of the mill building were repaired. Later in 1990, Strandberg returned to the site and continued environmental mitigation efforts. Samples of the tailings ponds were collected by LSMC consultant Odin Strandberg and Ron McAllister of ADEC.

In January, 1991, results from the mill work pad area soil samples showed elevated mercury levels. The analyses, which were completed by Columbia Analytical Services and paid for by LSGMC, contained up to 103 ppm mercury (Strandberg letter to ADEC officer Ron McAllister, 01/23/91). A more comprehensive shallow auger drill sampling program was planned and completed by LSGMC in July, 1991. This latter effort also tested for arsenic, cadmium, lead, nickel, and zinc as well as mercury (figure 28). The 66 samples taken during 1991 contained 0.4-to-59.8 ppm mercury (average = 5.8 ppm); 13 of the 66 samples contained 11.6-to-59.8 ppm mercury. The samples that contained more than 10 ppm mercury were judged by ADEC to be in need of environmental mitigation. They define an elongated area that contains an estimated 200 cubic yards of unconsolidated materials. The drill samples also contained up to 1.6 percent arsenic, 854 ppm lead, 76 ppm nickel, and 325 ppm zinc. In general, the base metal values occurred in only a few samples and were not considered to be an environmental issue of concern by ADEC.

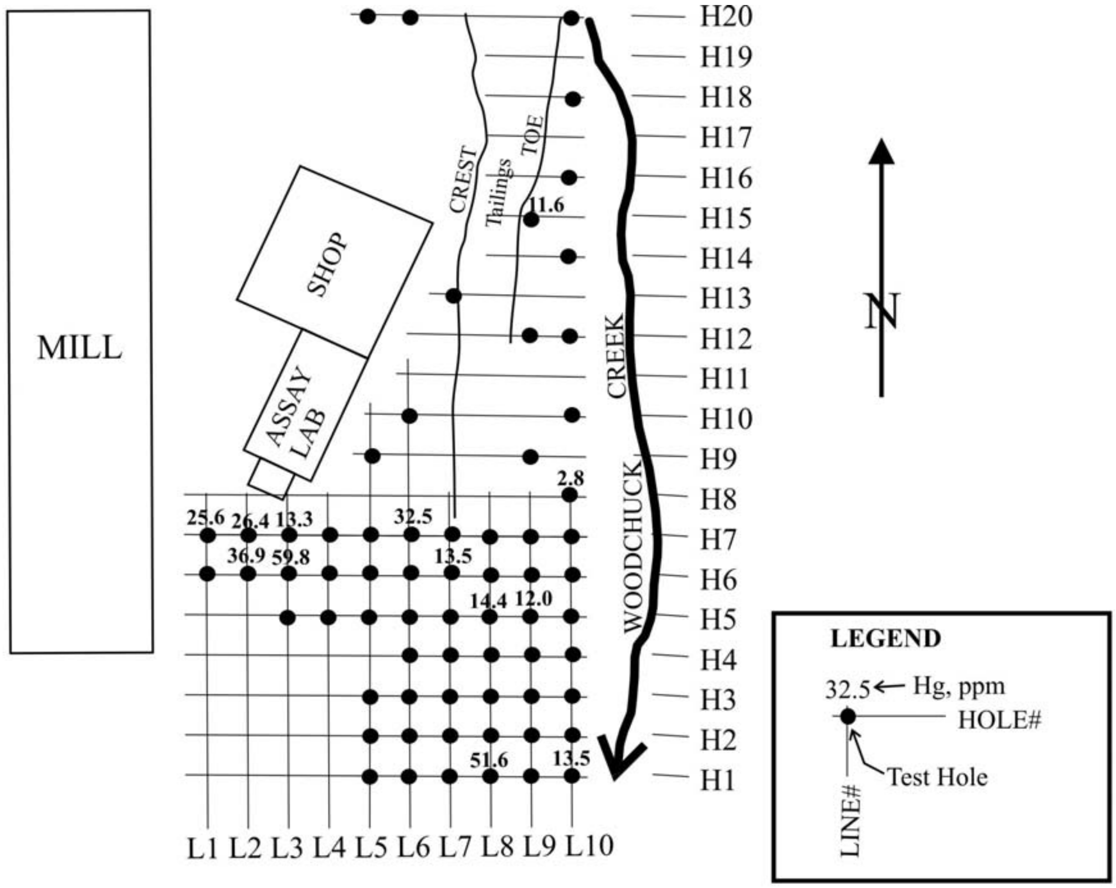



Figure 28. Sample location map showing mercury values (in ppm), Tobin Creek Mill facility, Chandalar Mining district, Alaska; analyticaldata by Columbia Analytical Services, Inc., samples collected by DEC and LSMC.

***Table 5 Base metals values found in mill tailings, Tobin Creek Mill, Chandalar District, Alaska; all values in ppm; analyses by Columbia Analytical Services, Inc.***

| **Sample #** | **L2H7** | **L6H7** | **L9H5** | **L9H9** |
|---|---|---|---|---|
| **Arsenic** | 16,000 | 4,120 | 1,230 | 1,970 |
| **Cadmium** | 2 | ND | ND | ND |
| **Lead** | 879 | 252 | 142 | 109 |
| **Nickel** | 58 | 39 | 40 | 40 |
| **Zinc** | 320 | 134 | 121 | 97 |

Although arsenic values ranging from 1,970-to-16,000 ppm were detected in four samples, ADEC judged that the source of the high arsenic levels was not an issue and did not recommend a mitigation plan for arsenic. Instead ADEC focused their attention on the mercury contamination at the Tobin Creek mill site (figure 28). In 1993, ADEC approved a plan submitted by LSMC to process the 200 cubic yards of contaminated soils through an IHC Jig plant owned by lessee Del Ackels of Gold Dust Mines, Inc. To the writers' knowledge, this planned solution was not implemented. In 2002, the ADEC and ADNR examined the Tobin mill site for potential cyanide concentrations and did not detect cyanide in any sulfide-bearing containers or surface materials at the site (Jack Kerin, pers. commun., 2004).

None of the environmental issues identified by the Alaska Department of Environmental Conservation or Alaska Department of Natural Resources on the Chandalar district properties are regarded as significant problems, and remediation actions recommended by these agencies will not be time consuming or expensive. The Chandalar hard rock mills processed limited amounts of high grade gold ores, and as a result, did not accumulate large amounts of contaminated materials. The most significant mitigation measures are probably: 1) removal or treatment of about 200 cubic yards of soils contaminated with mercury at the mill site; 2) removal of about 3,000 pounds of lead acid batteries—probably by air freight back hauls to Fairbanks; and 3) possibly some burial or removal of ferrous scrap in key areas of the properties. There is no information concerning the present condition of the underground workings or surface drill collars in the project area. No environmental issues have been identified with the placer deposits in the Chandalar Mining district (Jack Kerin, oral commun., 2004).

# XII Ore Deposit Model for Gold-Bearing, Low Sulfide-Quartz Veins, Chandalar District

### *Descriptive Summary of Chandalar District Veins*

The mineralogy, structure, and geological features of the auriferous quartz vein deposits have been described in some details by many workers and authors, including Mertie (1925), Chipp (1970), Ashworth (1983, 1984), Duke (1975), Rose and other, 1988), Bolin (1984), Garverrich and Hoffman (1982), Swanson (1975), and Brosge and Reiser (1970) and are summarized here on the basis of these published and unpublished observations. The lode gold deposits of the Chandalar Mining district have been qualitatively classified as low-sulfide, quartz-sulfide-gold epigenetic vein deposits. Known auriferous veins are mainly confined to a northwest-trending zone approximately four miles (4.0) wide and three (3.0) miles along strike between Tobin, and Big Creeks on the south, and Big Squaw and Little Squaw Creeks on the north. Almost all of the gold-bearing veins occur in or near N57-60W trending normal faults, with metallic mineralization largely confined to the hanging walls of the shears. White crystalline quartz is the dominant gangue mineral in all gold lodes. Quartz crystals project into small vugs that uncommonly contain sulfide species and limonite. Banding in quartz veins is caused by shearing, and quartz vugs are elongated parallel to vein walls. Inclusions of bedrock within the quartz veins are quite common, illustrating the aggressive, penetrative nature of vein formation, and are distinctly chloritic and often contain cubes of pyrite. Siderite occurs in several veins and is well represented in the Little Mikado vein. Of note is a sub-type of the quartz veins-something missing here. Bolin (1984) describes structurally controlled, auriferous zones confined to ‘siliceous carbonate beds’ in the Little Squaw Creek area. As such, they might constitute a significant new replacement (?) type of exploration target that has not been explored for in the Chandalar district.

The sulfide content of the auriferous veins is less than 5.0 percent with the principle sulfides being arsenopyrite, galena, sphalerite, and pyrite, in order of relative abundance (figure 29a). Massive arsenopyrite with the greenish-colored, oxidized product scorodite commonly occur in the Mikado and Summit systems (figure 29b). Minor amounts of stibnite and antimony-lead sulfo-salts also occur in the Mikado vein (figure 29c). Gold occurs as flakes and wires in quartz, and the Chandalar veins are known for specimen-quality, crystalline gold aggregates. Gold fineness varies in the different vein systems and ranges from 829-856 at the Little Squaw lode; 797-880 at the Summit Lode; and 740-800 at the Mikado Lode (Moiser and Lewis, 1986).

Brosge and Reiser (1970) concluded that arsenic in both wall rocks and soils was the best pathfinder for gold lodes in the Chandalar district. Elevated mercury, lead, antimony, and copper also occurs with the gold (table 6). Lode gold in the Wiseman-Nolan and Wild Lake areas of the central Brook Range Metallogenic belt also contain elevated arsenic, mercury, and copper, but these latter districts generally have higher gold fineness values averaging about 920 (Moiser and Lewis, 1986).

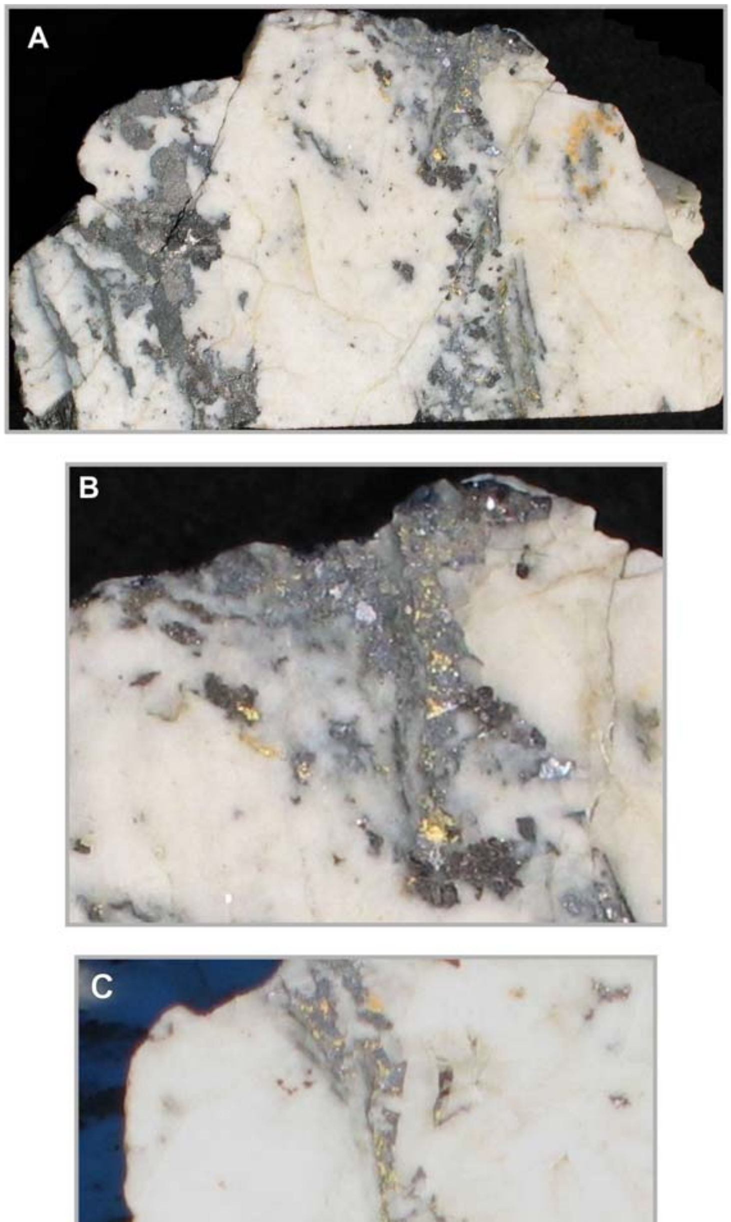



Figure 29 Textural features of Chandalar district ores: a) electrum with galena and stibnite at the Mikado Vein; b) gold in association with arsenopyrite at the Mikado Mine; c) gold with galena and stibnite at the Mikado Mine; photos from LSGMC files.

***Table 6 Selected Microprobe Gold Fineness Data from Lodes in the Chandalar District, from Moiser and Lewis (1986)***

| Sample #/Location | Gold | Silver | Copper | Mercury | Arsenic | Other (1) | Total | Au/Ag Ratio |
|---|---|---|---|---|---|---|---|---|
| 3037A/St. Mary's Creek | 87.966 | 11.224 | 0.020 | 0.204 | ND | 2.490 | 100.00 | 7.83 |
| 3056XC/Little Squaw Mine | 81.600 | 13.636 | 0.011 | 0.170 | 2.272 | 2.328 | 100.01 | 5.98 |
| 2564/ Little Squaw Mine | 86.296 | 13.392 | 0.018 | 0.063 | 0.089 | 0.192 | 100.05 | 6.44 |
| 2603/Summit | 85.696 | 11.627 | 0.017 | 0.081 | 0.697 | 1.738 | 99.85 | 7.36 |
| 3004/Mikado Open Pit | 67.326 | 25.240 | 0.003 | 0.060 | 0.084 | 7.317 (1) | 100.03 | 2.66 |
| 3005/Mikado Underground | 76.541 | 22.222 | 0.009 | 0.092 | ND | 0.986 | 99.850 | 3.44 |
| 3004y/Mikado | 78.441 | 19.516 | 0.055 | 0.093 | 0.557 | 1.368 | 100.03 | 4.01 |

(1) Contains up to 3.61 percent lead, 0.36 percent antimony, and 0.84 percent iron

### *Previous Studies of Mineral Deposits in the Chandalar District*

Proposed ore deposit models presented by previous investigators for the Chandalar district gold-sulfide-quartz veins differ in several important aspects. Dillon et al (1989) and Ashworth (1983, 1984) advocated epithermal conditions of formation for the auriferous gold-quartz-sulfide deposits of the Chandalar Mining district. They cite the following lines of evidence: 1) appearance of the relatively low temperature mineral stibnite in a co-genetic relationship with gold; 2) the elevated mercury in the gold bullion; 3) the relatively low fineness gold found in the lodes; and 4) the appearance of variable gas-to-liquid ratios resulting from boiling hydrothermal fluids; and 5) a postulated buried Devonian pluton, which is the hypothesized source for the gold-bearing fluids. Devonian plutons exposed along the southern Brooks Range host both base metal and precious metal skarn, porphyry and epigenetic deposits (Nokleberg and others, 1987). If this model is correct, it implies there is a significant limitation on the potential vertical extent and size limitation of the gold resources in the Chandalar Mining district. The original work by Ashworth (1983) on samples from the Little Squaw and Mikado veins indicated homogenation temperatures averaging 275 degrees C; inclusions contained 0.80 percent NaCl, and 0.18 mole fraction $CO_2$; and fluid trapping pressures at about 887 bars, or at about 6,000 feet depth. When Ashworth (1984) conducted fluid inclusion studies on the Eneveloe vein, she found higher NaCl values (3.0-4.0 percent) than were found in the

Little Squaw and Mikado samples, and estimated trapping pressures for the Eneveloe vein at 300-500 bars, or formation at about 3,000 feet depth. Hence the fluid inclusion data collected at the Mikado, Little Squaw, and Eneveloe veins indicates a minimum vertical range for the hydrothermal mineralization of about 1.0 km or 3,000 feet. Never-the-less, Ashworth (1983, 1984) and Dillon and others (1989) concluded that mineral exploration on the 'epithermal veins' be focused on determining the levels of boiling of the hydrothermal fluids in the gold-bearing quartz-sulfide fractures of the Chandalar district, and that exploration should occur along strike rather than at depth in the vein systems.

The contention that the Chandalar veins formed in epithermal conditions affected to some degree the planned exploration work during 1982-83. Because the veins were judged to be 'epithermal', coupled with encountering barren quartz at depth in the Little Squaw vein, led Garverich and Hoffman (1982) to declare "there is no ore in the district below the 132 foot level of the Mikado Mine". However, when high grade gold values, were subsequently found by drilling deeper levels of the Summit Lode, these authors changed their minds.

Bolin (1984) disagreed with the contention by Ashworth (1983, 1984) that the Chandalar veins were derived from epithermal sources and compared them to a "deep mesothermal or metamorphic class of deposits" (Lindgren, 1933). Bolin (1984) compared the Chandalar veins to the Cariboo district in British Columbia, Canada, where about 1.0 Moz of gold were produced from quartz veins and replacement deposits. He further offered the observation that "It is reasonable to interpret from the data that the gold mineralization (in the Chandalar district) is not terminated at any depth yet encountered".

### ***USGS Inclusion Studies on Chandalar Veins***

Rose and others (1988) conducted fluid inclusion and oxygen isotope studies to determine the physical and chemical nature of the fluids responsible for gold ore genesis in the Chandalar district. Fluid inclusions can imply important constraints on the pressure, composition, and composition of ore fluids, and oxygen isotopes can help identify the source of the ore fluids. Rose and others (1988) found the same variable gas-to-liquid ratios and temperature ranges (268-295 degrees C) in fluid inclusions as reported by Ashworth (1983). However, Rose and others (1988) interpreted these data as secondary inclusions by necking down (Roedder, 1984), of former primary inclusions, and saw no evidence of trapping of immiscible fluids or boiling conditions. In the Chandalar district, ore-stage sulfide-quartz veins are frequently banded, ribbon-type quartz that formed by repeated episodes of dilation, quartz precipitation, subsequent shearing along the high angle fault structures that host the veins. According to Rose and others (1988), this repeated shearing results in the formation of numerous necked, secondary inclusions observed in the quartz vein material being studied. The necked secondary inclusions in the absence of boiling conditions are features more typically observed in low sulfide mesothermal gold deposits worldwide (Berger, 1986; Panteleyev, 1990).

Primary and pseudo-secondary fluid inclusions in both quartz and sphalerite from the Little Squaw, Mikado, Eneveloe, and Summit deposits were chosen by Rose and others (1988) for micro-thermometric study. The inclusions generally contained three phases at room temperature: $CO_2$ vapor, $CO_2$ liquid, and water. The inclusions have consistent gas to liquid ($CO_2$-$H_2O$) ratios of 0.30-to-0.35. The limited range of clathrate melting temperatures (8.8-10.4 degrees C) and consistent gas-to-liquid ratios cited above likely indicate trapping conditions under similar pressures and temperatures. No evidence of boiling was recognized. Seven samples from the low sulfide, gold-quartz vein deposits, as well as, samples of 'metamorphic segregation' quartz at least 100 meters away from known auriferous veins were submitted to an oxygen isotope study. The auriferous and barren metamorphic quartz samples yielded the same isotopically heavy values of about +7.2-to+7.9 per mil $^{18}O$, which are consistent with analytical results found in other orogenic (mesothermal) gold-quartz districts of the North American Cordillera such as the Mother Lode in California, the Juneau Gold Belt, and the Nome Mining district (Gamble and others, 1985; Nesbitt and others, 1986; Ohmoto, 1986; and Goldfarb and others, 1997). Rose and others (1988) concluded that the Chandalar district gold-sulfide quartz lodes formed in mesothermal conditions, and were not related to epithermal processes.

### *Comparative Analyses of Epithermal and Mesothermal Mineral Deposit Models for Chandalar District Veins*

Table 7 compares the qualitative physical, geochemical, mineralogical, and isotopic features of the Chandalar district lodes with mesothermal and epithermal mineral deposit models that summarize data from deposits and districts worldwide. Fourteen geological, geochemical, isotopic, and morphological criteria were used for comparisons between the lodes of the Chandalar area with well-published worldwide examples. In general, the lode gold deposits of the Chandalar district compare favorably with orogenic (mesothermal) low sulfide, gold-quartz lode deposits worldwide. This deposit class compares favorably in ore morphology, rock type, tectonic setting, mineralogy, ore controls, texture, and alteration types, with the Chandalar district auriferous veins. Mesothermal deposits are structurally controlled systems that occur in shear zones, ribbon quartz sheets, and in massive silica flooding zones (figure 30 a-c). The radiogenic lead, sulfur, and oxygen isotope ratios support a mesothermal genetic model. $^{18}O$ values indicate a non-mantle origin for ore fluids, which probably precludes an epithermal origin for the hydrothermal fluids. Lead isotope data from the Mikado and Summit vein deposits were published by Gacetta and Church (1989) and discussed by Goldfarb and others (1997). These data show $^{206}Pb/^{204}Pb$ values ranging from 18.766-18.804; $^{207}Pb/^{204}Pb$ values ranging from 15.633-15.662; and $^{208}Pb/^{204}Pb$ values ranging from 38.820-38.938. The results are somewhat ambiguous in terms of mineral deposit classification, and plot in the field of "mixed deposits" defined by Newberry and others (1995), which contain both 'plutonic' related and 'metamorphic' related gold deposits. However, the $^{208}Pb/^{204}Pb$ ratios from the Summit and Mikado veins are similar to values found in the Alaska-Juneau deposit in southeast Alaska or the mesothermal gold veins of the Cape Nome Mining district in western Alaska. As summarized previously, the fluid inclusion information reported by Rose and others (1988) provides strong evidence for classifying the Chandalar district deposits as mesothermal lodes.

The Chandalar district does contain features that are not typical of mesothermal gold districts such as high mercury content in gold (up to 1.00 weight percent), the relatively

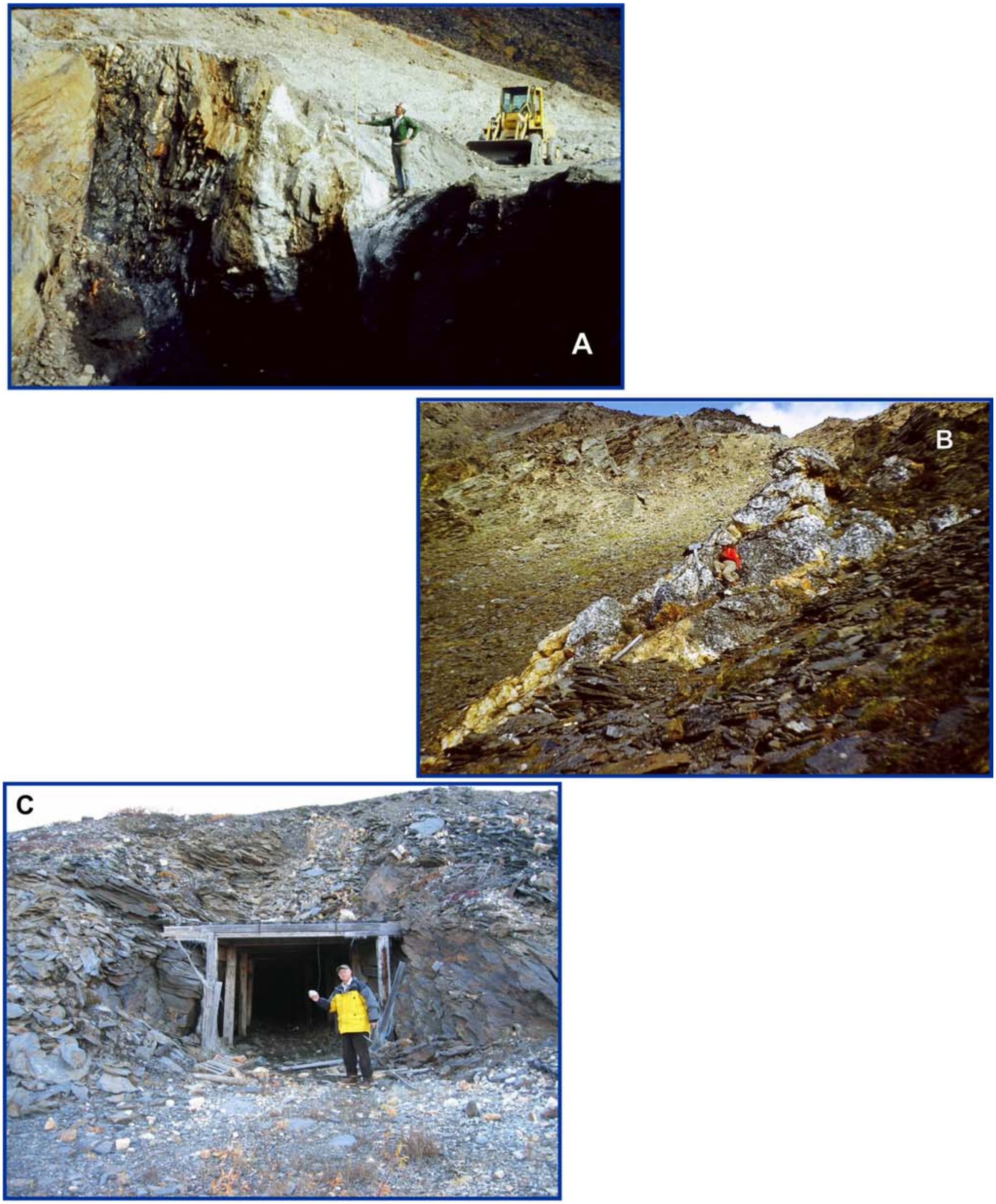



Figure 30. Structural features observed in Chandalar district gold lodes: a) ribbon quartz segregations at trench/open cut exposure , Mikado vein-photo courtesy of Mike Garverich, 1982; b) ribbon and sheeted structured quartz lodes at the Eneveloe vein, Chandalar; c) portal of Little Squaw gold-quartz vein showing discordant relationship with enclosing schist host rocks. Photos b and c from LSGMC files.

**Table 7 Comparisons between 1) orogenic, low sulfide, gold-quartz; 2) epithermal; and 3) plutonic-related mineral deposit models, and deposits in the Chandalar Mining district, Northern Alaska**

| *Criteria and Physical Aspects of Deposits and Districts* | *Orogenic (Mesothermal) Low Sulfide Deposits (Cox and Singer, 1986; Goldfarb and others, 1997; Laznicka, 1985)* | *Plutonic-Related Deposits (McCoy and others, 1997; Nokleberg and others, 1995; Bundtzen and Miller, 1997; Laznicka, 1985)* | *Generalized Epithermal Deposits (Cox and Singer, 1986; Panteleyev, 1990; Laznicka, 1985)* | *Chandalar District (this investigation)* |
|---|---|---|---|---|
| *Qualitative Description* | Gold in massive to persistent quartz veins mainly in regionally metamorphosed volcanic and sedimentary rocks | Gold occurs in apexes of Paleozoic-Mesozoic, reduced plutons and in spatially associated sedimentary and metamorphic rocks | Formed by hot ascending hydrothermal solutions usually related to volcanism, in near-surface T/P conditions | Gold in massive to persistent quartz veins and larger shear zones mainly in regionally metamorphosed flyschoid rocks |
| *Rock Type Hosts* | Greenstone belts, oceanic metasediments; regionally metamorphosed volcanic and flyschoid sediments; Alpine mafic/ultramafic rocks; granitic batholiths | Felsic, phaneritic composite intrusions, poly-metamorphic schist, carbonaceous sediments. | Frequently in volcanic terranes; including flows, tuffs, and sub-volcanic intrusions; veins are almost always the principle host of gold mineralization, | Regionally metamorphosed flyschoid sediments with minor mafic tuffs and amphibolite |
| *Age Range* | Archean to Tertiary | Generally Paleozoic and Mesozoic | Archean to Recent; many are Tertiary to Quaternary in age, and related to recent volcanic arcs. | Host is Devonian Hammond subterrane of Arctic Alaska terrane; latest dynamo-thermal metamorphism is believed to be mid-Cretaceous |
| *Tectonic Environments* | Continental margins mobile belts; accreted margins; veins are usually post-metamorphic and formed in faults and joints produced by regional compression. | Subduction related plutonic and volcano-plutonic complexes; related extensional, strike slip faulting | Extensional tectonic settings frequently related to back-arc magmatism (both volcanic and plutonic rocks) | Veins are post-metamorphic and formed in faults and joints produced by regional compression. |
| *Mineralogy* | Native gold, pyrite, arsenopyrite, galena, sphalerite, chalcopyrite, pyrrhotite; locally or uncommonly with tellurides, scheelite, bismuth, tetrahedrite, stibnite, and molybdenite. Quartz and uncommonly fluorite gangue. Generally <5.0 percent by volume are ore minerals | Gold--arsenical gold in high level deposits; arsenopyrite and stibnite the most common sulfides; bismuth, bismuth tellurides, and Bi-sulfosalts are characteristic with sometimes Bi/Au ratios important, molybdenite, Quartz gangue but fluorite also present | Electrum with highly variable fineness range; acanthite, (argentite), and numerous silver-antimony sulfosalts; cinnabar, stibnite, tetrahedrite, selenides, and tellurides. Silver >gold. Gangue mainly quartz, calcite, fluorite, barite, and pyrite. | Native gold (with some crystalline varieties), pyrite, arsenopyrite, galena, stibnite, sphalerite, chalcopyrite, pyrrhotite, tetrahedrite, and molybdenite. Sulfide ore mineral are <5.0 percent by volume. Gangue is quartz; minor carbonate and albite occur in several deposits. |
| *Textures, Structures* | Productive quartz is frequently | Anastomosing or planar quartz- | Ores occur along high angle | Grayish to bluish and often |

| | | | | |
|---|---|---|---|---|
| | grayish to bluish and often banded, ribbon-type variety; open space fillings usually destroyed by vein deformation | sulfide veins in quartz carbonate shear zones. | shear zones, and in volcanic breccias. Silica most commonly as amethystine quartz, opal, and chalcedony. | banded, ribbon-type quartz in the high grade gold zones; open space fillings usually destroyed by vein deformation |
| *Alteration* | 1) Quartz + siderite (or ankerite) + albite in phyllite and schist; 2) chromium mica + dolomite + talc in mafic-ultramafic rocks; 3) sericite + rutile + disseminated sulfides in granitic rocks | 1) feldspar + white mica or quartz + sericite in intrusions; sometimes tourmaline; 2) quartz + carbonate (siderite) in schist and metasediments. Wide zones of propylitic alteration in intrusions. | 1) Illite-sericite, adularia-sericite, and kaolinite-dickite for low sulfidation types; 2) alunite-jarosite-sericite-adularia for high sulfidation types. | Quartz + siderite (or ankerite) + albite in phyllite and schist of Hammond subterrane. |
| *Ore Controls* | Along regional high angle faults and shear zones; often in quartzite, and granitic rocks; frequent greenstone association in metamorphic rocks; vertical TP range is large (>2 kilobars) | High angle faults, cupola positions of intrusions; vertical TP range about 0.5-to-2.5 kilobars. | Often localized along structural conduits. Formerly deposition in volcanic caldera or collapsed caldera thought to be primary prerequisite; however, this is not the case. Can be hosted in plutonic and sedimentary terranes. Gold is often localized in zones of boiling and oxidation (see fluid inclusion summary); in general vertical range is 300-500 feet | Orthogonal shear zones trending north 50 west and north-northeast; low angle decollement surface may truncate ore zones at depth. TP conditions calculated to be from 300-900 kilobars (Ashworth (1983); Apparent vertical range in district is a minimum of 1,600 feet |
| *Detrital (Placer) Character* | Frequently produces coarse nugget gold from lodes; some of largest nuggets in world produced from orogenic (mesothermal) gold-quartz lodes | Frequently fine-grained (oat-meal sized) nugget gold, rarely large nuggets. | Does not produce placer gold accumulations in many world examples; when it does, it is extremely fine-grained with no nugget component | Frequently fine-grained (oat-meal sized) nugget gold, rarely large nuggets, but some nuggets to 10 ounces recovered in placers. |
| *Geochemical Signatures* | Arsenic is best pathfinder; also copper, lead, zinc, and silver | Arsenic and bismuth are good pathfinders. | Mercury, antimony and arsenic have highest correlation coefficients. | As is the leading pathfinder (Brosge and Reiser, 1970). Sb, although minor, is locally abundant. Pb and Zn in soils successfully used by Noranda as pathfinders to ore zones. |
| *Trace Element and gold fineness* | Middle to High fineness ranges; 850-950; gold can carry copper, bismuth, and rarely mercury. | Middle to High fineness ranges; 850-950; some intrusion-hosted is very high fineness (>980 at Fort Knox). | Generally low fineness gold/electrum ranging from <500 to >900; steep zoning within 100-200 meters vertically. Gold fineness usually increases significantly with depth. | Gold fineness: 829-856 for Little Squaw; 797-880 for the Summit; 740-800 for Mikado; all bullion contains elevated mercury, arsenic, and copper. Down slope placers have higher fineness values (Moiser and Lewis (1986) |

| | | | | |
|---|---|---|---|---|
| *Fluid Inclusion and Geothermometry Criteria* | Coevally-trapped, $CO_2$-$H_2O$ fluids with significant CO2 enrichment (up to 20.0 percent by weight); no evidence of boiling; trapping temperatures ranging from 225-375 degrees C; generally low salinity (< 4.0 percent) NaCl. | Arsenopyrite geothermometry suggests 400-480 degrees C for feldspathic alteration and 300-350 degrees C for sericite alteration; wide salinity range but averages 1-10 percent NaCl or mid-level amounts; Abundant $CO_2$ (7-22 percent); mineralized systems exhibit evidence of $H_2O$-$CO_2$ immiscibility | Relatively dilute, weak saline (<4.0 percent NaCl), low $CO_2$ fluids with trapping temperatures ranging from 150-300 degrees C—most commonly between 230-300 degrees C. Boiling or mixing of fluids as they ascend or migrate laterally appears to be an important cooling and gold-depositional mechanism—implies restricted areas of gold deposition | Fluid inclusions from the Little Squaw, Mikado, Eneveloe, and Summit deposits contained three phases at room temperature: $CO_2$ vapor, $CO_2$ liquid, and water, gas to liquid ($CO_2$-$H_2O$) ratios of 0.30-to-0.35, and limited range of clathrate melting temperatures (8.8-10.4 degrees C). Salinity is generally low (<5.0 percent). No evidence of boiling was recognized by Rose and others (1988). |
| *Isotopic Characteristics* | Radiogenic Pb as compared to epithermal and generalized epigenetic deposits; $^{206}Pb/^{204}Pb$ >19.00) $^{207}Pb/^{204}Pb$=15.52-15.68 $^{208}Pb/^{204}Pb$=38.50-38.80; $^{18}O$ (>5.0) are distinctly heavy del $^{34}S$ values are variable; generally negative-to-0.0. | Radiogenic Pb; $^{206}Pb/^{204}Pb$=19.00-19.45; $^{207}Pb/^{204}Pb$=15.58-15.70; $^{208}Pb/^{204}Pb$=39.00-39.20 $^{18}O$ is not heavy (0.0-2.0) and differs from orogenic deposits; del $^{34}S$ values 0.0-to-5.0 | Less radiogenic than orogenic or plutonic deposit types; $^{206}Pb/^{204}Pb$=18.75-19.03; $^{207}Pb/^{204}Pb$=15.54-15.65; $^{208}Pb/^{204}Pb$=38.14-38.65. $^{18}O$ are highly variable and range from 0.3 to 29.0 in SW Alaska mercury belt (Gray and others, 1997); | In general, not radiogenic but heavy lead ratio ($^{208}Pb/^{204}Pb$) most similar to orogenic deposits; $^{206}Pb/^{204}Pb$=18.766-18.804; $^{207}Pb/^{204}Pb$=15.633-15.662; $^{208}Pb/^{204}Pb$=38.820-38.939 $^{18}O$ is heavy—consistent with orogenic deposits. |
| *Deposit Examples* | Sukhoi-Log and Natalka (Russian Far East); Alaska Juneau, Treadwell, Cape Nome, Kensington, Jualin (Alaska); Mother Lode, Grass Valley (Lower 48); Giant Yellowknife, Goldfields of Nova Scotia, Polaris Taku (Canada); Bendigo, Reefton, Ballarat (New Zealand-Australia) | Fort Knox, Brewery Creek; Pogo(?), Donlin Creek, Ryan Lode, other Fairbanks District Veins; Willow Creek District; Keno Hill (Canada); Murantau (Central Asia) | Comstock Lode, McGlaughlin, and Borealis in USA; Apollo in Alaska; Karemken, Kupol, Aginskoye, Ametistovoe, Mutnovskoye, and Kubaka in Russia; Silbak-Premier, Equity Silver, Iskut River district in Canada. | See orogenic deposit types in this table |
| *Other Similar Deposit Types* | Chugach type of low sulfide Au-quartz deposit (Bliss, 1992) | Many intrusion hosted deposits and districts. | Large variety of epithermal models i.e., Hot Springs, Creede, Comstock, Sado, and both high and low sulfidation state sub-types. | See orogenic deposit types in this table |

low gold fineness values (740-880), the presence of significant stibnite, and the general absence of scheelite. Stibnite is found in all of the schist-hosted mesothermal vein deposits of northern Alaska, including numerous vein localities in the Nolan Creek-Wiseman area, (Goldfarb and others, 1997), the Wild Lake area (Dillon and others (1989), and in the Cape Nome Mining district (Gamble and others, 1985; Bundtzen and others, 1994). The mercury content in the gold of the Chandalar has been cited by Dillon and others (1989) to argue for an epithermal origin for the Chandalar gold lodes. However, elevated mercury also occurs in the gold of the Wiseman area and occurs in many mesothermal lodes in the *Tintina Gold Province* (McCoy and others, 1997; Bundtzen and Miller, 1997). It is generally believed that elevated mercury in the gold of these districts is sourced in the wall rocks of the districts, which were enriched in lithophile elements and metals.

Besides the isotopic and fluid inclusion data, an additional line of evidence supporting a mesothermal versus epithermal origin for the Chandalar district is the morphology of gold grains. Most epithermal districts on a worldwide basis do not form accumulations of coarse placer gold. In contrast, the streams in the Chandalar area contain coarse accumulations of placer gold with nuggets up to 10.6. ounces being found and exploited. Orogenic (mesothermal), low sulfide quartz gold lodes have produced most of the largest detrital gold nuggets in the world—including the famed *Welcome Stranger* in Australia and Alaska's largest placer gold nuggets in the Nome and Wiseman-Nolan districts. Minor scheelite is reported in placer concentrates of the Chandalar district, but not identified in area lodes. It's absence is not an important criteria for judging what T/P regime the lodes of the Chandalar district formed. Although scheelite is frequently found in Alaskan mesothermal gold deposits, it is conspicuously absent in lodes of the Juneau Gold Belt of Southeast Alaska (Goldfarb and others, 1997) and in many areas of the Kolyma district of eastern Russia (Goryachev, 1995)—both regions classified as orogenic, mesothermal lode gold provinces.

A missing line of evidence in the Chandalar district is the isotopic ages of the mineralized veins. Isotopic ages from hydrothermal vein minerals have been determined for the Cape Nome and Wiseman areas. Both areas contain schist-hosted, mesothermal gold-quartz veins. $^{40}Ar/^{39}Ar$ ages ranging from 100-115 Ma are consistent with the age of the retrogressive greenschist facies metamorphism and thrust faulting, which indicates gold vein formation closely coincided with the dewatering processes associated with metamorphism in both districts (Gamble and others, 1985; Bundtzen and others, 1994).

Epithermal deposits generally form in a relatively limited vertical range that varies from 250 to 500 feet (Panteleyev, 1990). The spatial occurrence of gold-quartz mineralization in the Chandalar district has been found at elevations ranging from 3,400 feet to 5,000 feet or over a vertical range of about 1,600 feet (figure 31). The lower limits to mineralization are in creek bottoms and the upper limit represents the highest pre-Quaternary surface of the uplands east of Chandalar Lake.

One of the more diagnostic characteristics of mesothermal deposits is the gold/silver ratio, which is higher in mesothermal mineralization than in other gold deposit types (Hodgson, 1993). Table 1 shows that the gold/silver ratio in the Chandalar district varies from 2.66 to 7.83 and averages about 5.75. Another data set of gold-silver assays (n=26) of the Little Squaw quartz vein yields a gold/silver ratio of 3.66:1. Figure 34 shows the field for the Chandalar deposits, as compared to several other gold deposit types. The Chandalar deposits lie within the field of mesothermal deposits as defined by Berger (1986a) and Bliss (1992).

The general absence of bismuth and Bi-sulfosalts, the low salinities and $CO_2$ content of fluid inclusions, and their homogenation temperatures, and the absence of intrusive rocks and associated thermal aureoles (hornfels) in the metamorphic host rocks are features that argue against a plutonic origin for the lodes of the Chandalar area. However, some low sulfide quartz gold deposits like the Pogo deposit east of Fairbanks share characteristics of both mesothermal 'metamorphic-related' and 'plutonic-related' mineralization (Rhys and others, 2003; Smith and others, 2000). Although the cumulative evidence suggests otherwise (table 7), the source of the gold in the Chandalar district could conceivably involve the presence of a deeply buried intrusion underneath the Chandalar upland area. Two significant features bear discussion. Bolin (1984) described a northeast-trending, magnetic high adjacent to the southeast side of the zone hosting most of the Chandalar gold vein deposits, and speculated that it could be the manifestation of a buried intrusion (figure 7). Fitch (1997) describes a small outcrop of medium grained, phaneritic, un-foliated biotite quartz monzonite on a north-facing slope that separates Little Squaw Creek from Big Squaw Creek. Chipp (1970) describes the existence of ‘spotted’ phyllite in the metamorphic rocks of the Chandalar area, particularly in the upper plate sequence. Although he attributes these textures to regional metamorphism, they might also indicate the presence of ‘static’ thermal metamorphism created by a buried intrusion.

Mesothermal low sulfide gold lodes of both plutonic and metamorphic origins are included in the orogenic deposits of the Russian Far East (Goryachev, 1995), and Cox and Singer (1986) do not preclude the existence of plutonic attributes to the origins of orogenic, low sulfide mesothermal deposits. Regardless, large vertical and lateral ranges for gold deposition exist in worldwide examples of both plutonic-hosted and metamorphic-generated mesothermal deposits.


Figure 31. Photo of upper Tobin Creek, showing infrastructure at the Mikado Mine and the approximate trace of the Mikado structural zone looking to the northwest.

***Resource Sizes of Orogenic Gold Deposits and Implications for the Chandalar District***

Cox and Singer (1986) reported tonnage and grade data from about 150 orogenic (mesothermal), low sulfide deposits from the United States, Canada, Australia, and New Zealand. Sizes in their data set range from 1,500 to 25.0 million tons and grades from 0.07 to 2.75 oz/ton of gold (figure 32). The 50 percentile ranking, which is considered by computer statistical methods to be the mean value for mineral deposit modeling, is 25,000 tons at an average grade of 0.51 oz/ton of gold (figure 11). The deposits described by Cox and Singer (1986) are individual vein-fault deposits and not the total extent of a district-wide vein-fault system such as exist in the Chandalar district. Cox and Singer (1986) grade and tonnage models do not include many very large, orogenic, (mesothermal) lode gold deposits in Central Asia that have been recently summarized in Goryachev (1995). These include the Sukhoi Log (1,100 tonnes; 34.2 Moz gold), Nezhdanin (475 tonnes; 14.7 Moz gold), Natalka (450 tonnes; 14.0 Moz) gold), Karalveem (40 tonnes; 1.24 Moz gold), or Utin (25 tonnes; 777,000 oz gold). Goldfarb and others (1997) also includes other large mesothermal gold deposits mainly from Australia and Canada (i.e., Golden Mile, Barberton, Giant Yellowknife) that were not included in the low sulfide gold-quartz deposit model of Cox and Singer (1986). These additional deposits, which are hosted in regionally metamorphosed flysch-hosted deposits of Paleozoic and Mesozoic age in zones of recognized strike-slip faulting, share many of the overall characteristics of similar deposits in Alaska including those in the Chandalar district (figure 33). Inclusion of these much larger gold deposits would significantly increase the size and grade tonnage parameters of orogenic low sulfide deposits from those reported by Cox and Singer (1986). Average grades of the very large, orogenic gold deposits range from 0.07 to 0.25 oz/ton of gold, and the values are generally carried over large widths of vein swarms and reactivated shear zones up to 700-feet wide. Although these deposits have a wide variety of structural regimes, Eremin (1995) believes that, in Russian orogenic (mesothermal) gold deposits, moderate strike-slip movement coupled with compression produces the largest gold resources whereas minor strike-slip movement with associated tensional features result in formation of smaller gold resources. Hence recognition of detailed structural features may be important criteria to collect in the Chandalar district during future exploration activities.

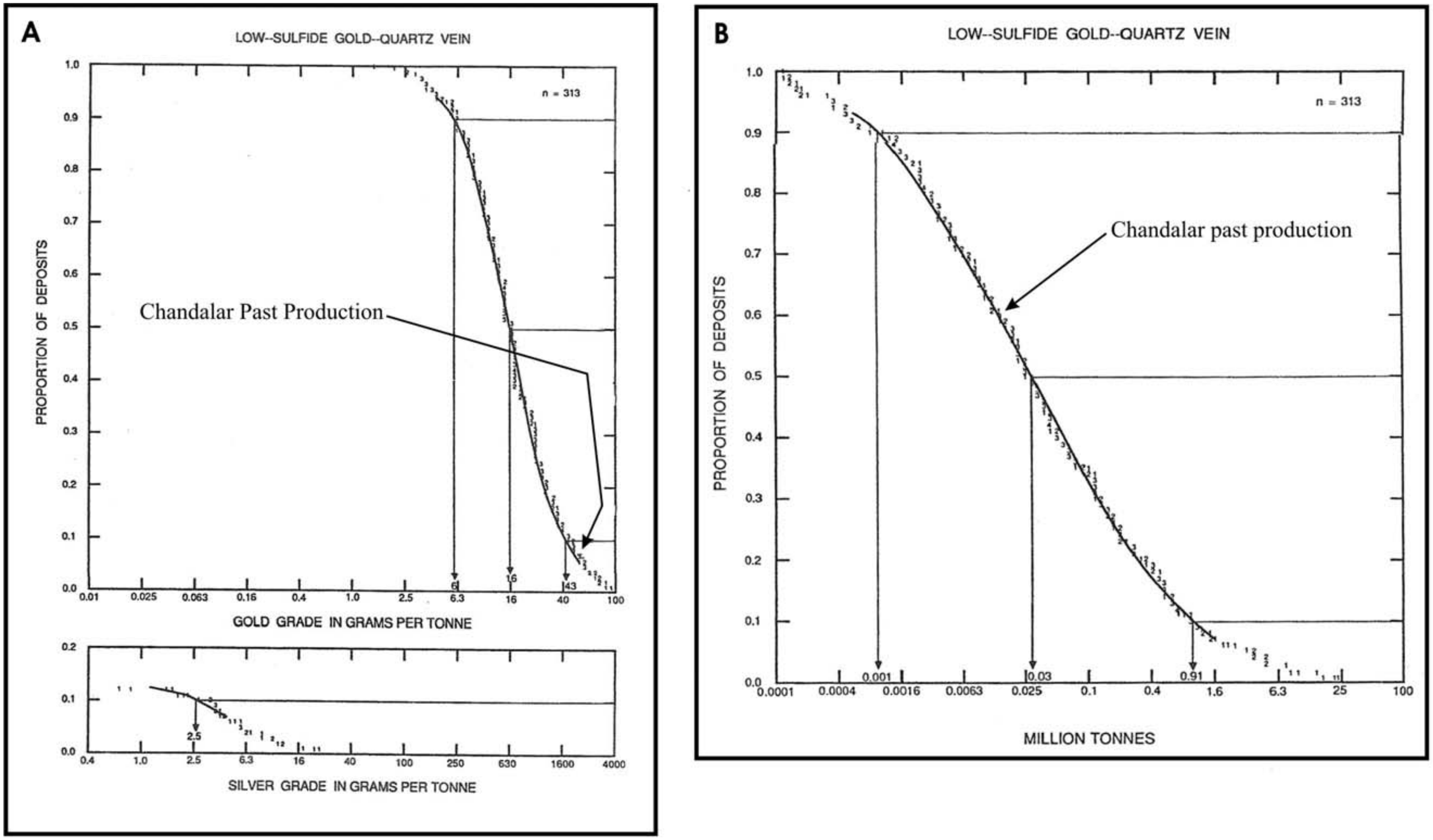



Figure 32. Gold resource estimates based on data from 150 Low Sulfide (Mesothermal) quartz-gold deposits; model 36a of Cox and Singer (1986); after Burger (1986). Grade is shown in A; tonnage in B. The 50 and 90 percentile values are given in each graph.

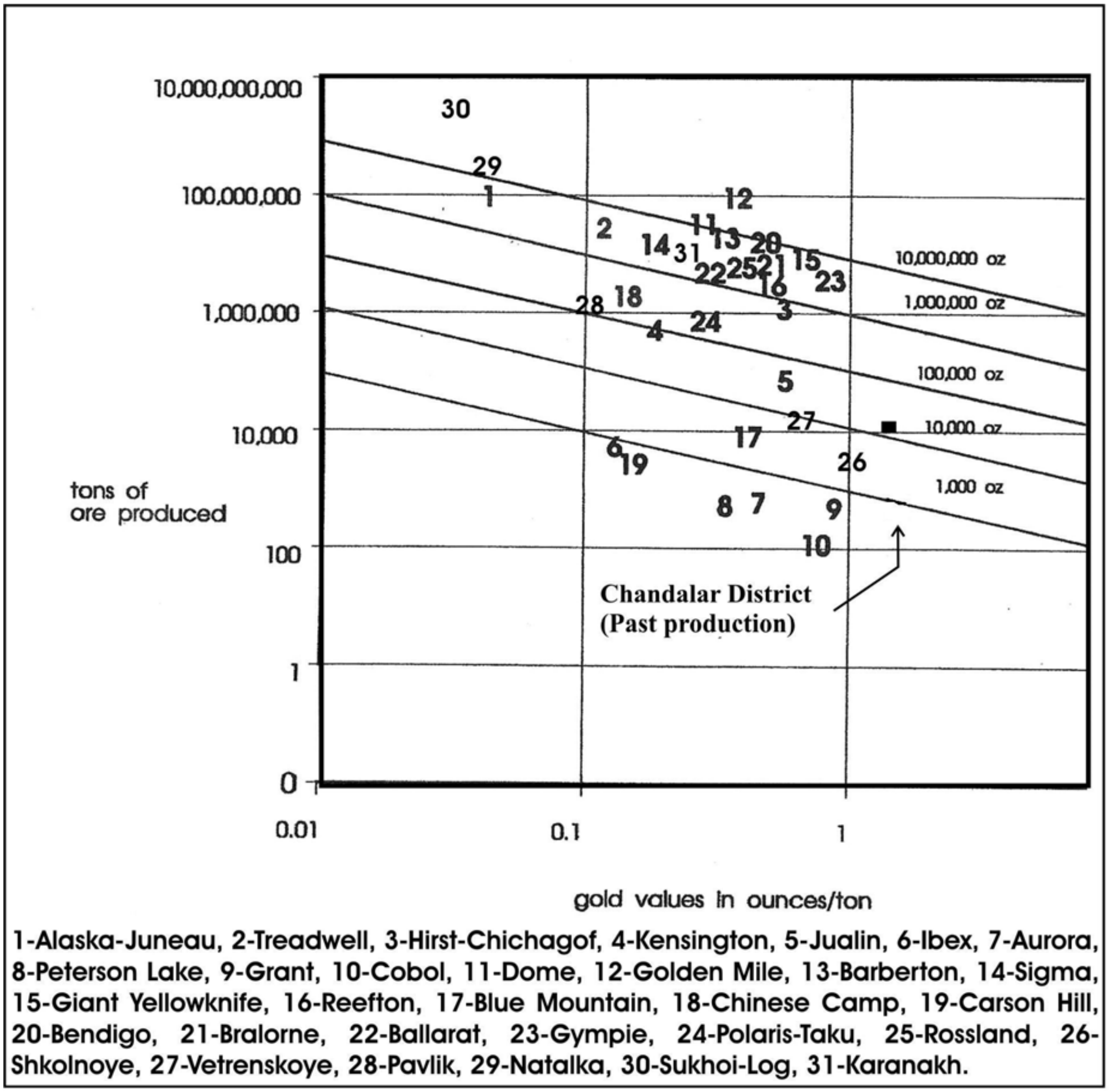



Figure 33. Grade and tonnage of selected low sulfide, mesothermal gold vein deposits from Alaska, Canada, Australia, and the Russian Far East (RFE), data from Goldfarb and others (1997), Eremin (1995), Goraychev (1995), and Bundtzen RFE files.

Historically, exploration and development of gold-quartz-sulfide veins in the Chandalar district has been largely focused on narrow, less than 4-feet wide, high grade ore shoots that frequently average greater than 1.0 oz/ton gold. Values less than that have been disregarded as being too low to mine in this remote area. The potential for much larger tonnage, bulk-minable deposits is permissible given the geologic evidence at hand. This includes wide widths of known shear zones, the existence of parallel zones of veinlets and vein-shears, and documentation of at least 1,600 feet of vertical dimension in the system. Drill sections previously discussed in this report has indicated the presence of subparallel zones of auriferous mineralization over widths of at least 60 feet. Brosge and Reiser (1970) found elevated arsenic more than one mile northwest of the Mikado mine workings, and suggested that arsenic would be a good pathfinder to use in the search for strike extensions of known lode gold deposits.

The timing of thrust faulting (and production)?? of the decollement surface has implications for the resource potential of the Chandalar district. If thrusting postdates auriferous vein formation, then the decollement as recognized by Chipp (1970) could truncate the Chandalar vein-fault deposits at depth (see figures 7-9). If the decollement surface truncates the auriferous structures, the assumed depth of the decollement surface, based on the cross sections proposed by Chipp (1970), is about 2,500 to 3,000 feet below the vein exposures on the surface. It may be desirable to determine by detailed structural analysis and isotopic age dating the specific timing of hydrothermal mineralization and structural deformation in the Chandalar Mining district.

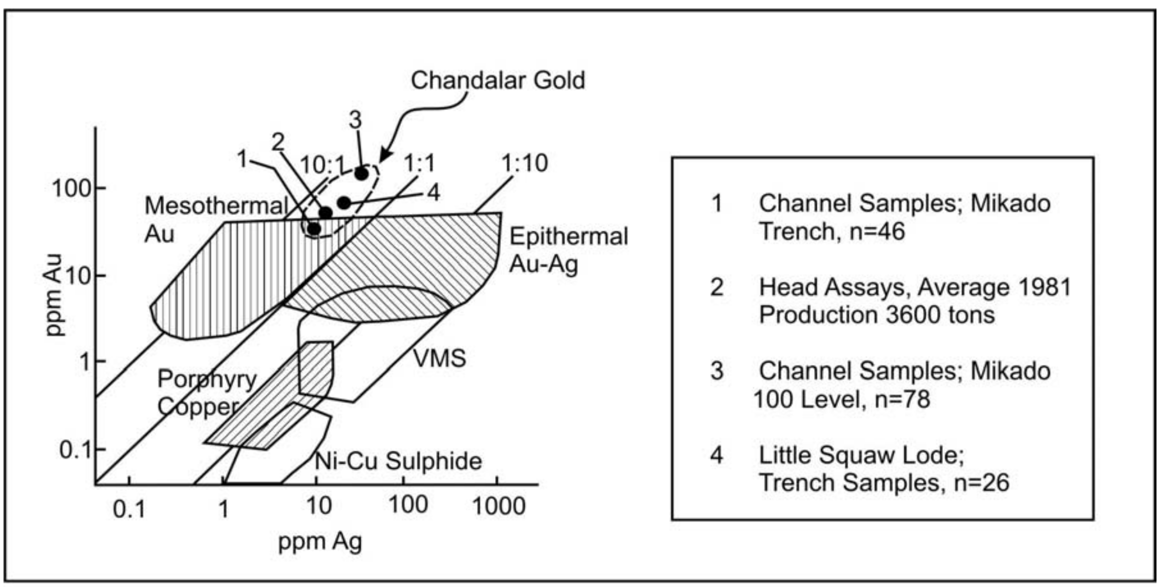



Figure 34. Relationship between gold and silver contents of mesothermal gold deposits in relation to some other major gold-bearing deposit types, with field of Chandalar deposits (modified from Poulsen, 1993).

## XIII Recommendations

A successful hard rock development in the Chandalar Mining district will require an extensive, multi-year exploration program that includes detailed geological studies and deep drilling. Engineering, metallurgical, and environmental studies should follow. These efforts will require a substantial investment in both time and funds to successfully bring into production a significant new Alaskan hard rock gold mine. The district's history is replete with short-lived ventures that rushed into production before proper exploration and engineering studies were completed, by-passing the industry's normally conservative pre-production activities that maximize efficiency and minimize risk of failure. By exclusively focusing on the high-grade gold lodes in the district, previous operators apparently missed the potential of exploring and developing much larger, albeit lower grade, mesothermal gold-quartz deposits, a deposit model that contains the district's greatest lode gold potential.

Placer development, if properly evaluated and engineered, can move into production in a much shorter time frame and be operated by smaller mining companies. Attaining permits for a placer operation should be less contentious, given the long history of placer mining in the district, including State-permitted operations on Tobin and Big Creeks during the 1990s.

### *Placer Development*

Placer gold resources (table 2) termed as 'possible' have been estimated by Strandberg (1990) and Fitch (1997) to total nearly 300,000 ounces of gold for Big Squaw and Little Squaw Creeks (exclusive of 'possible' resources on Tobin and Big Creeks). The Strandberg (1990, 1994) estimates are based on old prospect shafts, past production on Little Squaw Creek, several drill holes, and his extensive personal knowledge of the district. Fitch's resource calculations are based on a 12-hole drilling program on Little Squaw Creek. Because gold was reported in an exploration shaft as far north as Little Squaw Lake, it is reasonable to expect that additional placer resources may be found with systematic exploration of benches adjacent to the valley entrances of both creeks. Additionally, it is commonly accepted in the placer industry that any ground that has been economically drift mined in the past, such as the Mello Bench, can be mined again with open-cut methods when modern mining methods and improved equipment are utilized.

Nearly all of the gold resources estimated by Strandberg (1990) and Fitch (1997) are located in deep, water-saturated, fluvial and glaciofluvial sediments that will require a major stripping operation. Resource estimates by Fitch are calculated for bedrock depths as deep as 164 feet. The potential Little Squaw and Big Squaw deposits are in close proximity and may be contiguous in the vicinity of the present Little Squaw airstrip (Strandberg, 1994). Because of that, they may be workable as a single or several closely spaced mine unit(s). Additionally, there is sufficient valley gradient to install a drain to bedrock below the projected placer deposits, and sufficient level land below the mining area for waste water treatment and stripping disposal. The combined flow of Big Squaw and Little Squaw Creeks is unknown, but it should be sufficient to meet the processing needs of a mine plant. The mine tailings themselves could become much needed aggregate for infrastructure related to both placer and hard rock developments.

**Recommendation 1: It is recommended that, as soon as practical, a placer exploration drilling program be permitted and undertaken**. Supplies, fuel, and drill components will need to be moved over the winter road between late November and the end of March, as stipulated by the permit. A placer drill capable of depths to 200 feet. should be employed. Reverse circulation drills have been deployed to test Alaskan placer deposits in recent years. However, due to the presence of 'live' water and springs in the ground to be evaluated, a cased, rotary drill program may be needed. Initially, exploration should follow recommendations by Fitch in 1997 for 42 holes totaling about 5,040 feet to perform in-fill drilling of Daglow's 1997 program on the Little Squaw Creek left limit. Exploratory north-south drill lines should also test the possible bench south of the Little Squaw airstrip and the lower slope immediately east of the mouth of the Little Squaw canyon. Exploration should target a resource that can support a mine producing at least 15,000 to 25,000 ounces gold per season, predicated on processing about 4,000 cu.yd./day for an approximate 90-day wash season and six month or longer stripping season. Production at this level would provide a cash-flow option to LSGMC for funding infrastructure development, baseline environmental studies, and permitting requirements for the duration of a hard rock exploration/development program.

Concurrent with the initial placer drill program, the value of a seismic refraction survey should be determined by doing comparative profiles over several drill lines as they are completed.  A seismic refraction survey helped locate the discovery drill collar at the Valdez Creek placer deposit (Reger and Bundtzen, 1990).  Instrumentation would have to be sufficiently sensitive to detect perched fluvial channels interbedded with glaciofluvial outwash (see section from Carlson-Buckley shaft, figure 26).  Engineering and development of a placer operation at Chandalar can draw upon recent experience from the deep open-cut placer mine development at Valdez Creek, Alaska, which produced approximately 460,000 ounces of refined gold from 5.96 million cubic yards of glaciofluvial gravels.  This output, which took place over an eleven year production history during 1984-1995, produced an average of about 48,400 ounces of unrefined, placer gold annually (Bundtzen and others, 1996).  However, the Valdez Creek placer was deep and the11:1 stripping ratio designed for the deposit required special engineering technologies. The Valdez Creek district ground was notably wet, some of the exploration drill holes had to be cased, and water had to be collected and pumped into containment facilities.  Large placer deposits of similar size and geologic setting such as the Bolotny-Ravkosky district in the Russian Far East (Tchapko, 1995) could also be modeled (Skudrzyk and others, 1991).

Secondary to placer exploration on lower Big Squaw and Little Squaw Creeks, the LSGMC should attempt to gain mineral rights to lower Big Creek.  East-west shear structures, such as those underlying Letha and Weasel Creeks and that underlie the bed of Big Creek between Claims Nos.13 and 21 Below Discovery may, or may have provided placer gold to the Big Creek drainage.  Additionally, there has been no significant evidence of glaciation found on Big Creek, so the drainage sediments are relatively shallow as compared to the other drainages in the district.  Downstream of Claims Nos. 7 or 8 Below Discovery there is very little information available; however, old prospector reports mention placer gold in prospect shafts at least as far downstream as Claim No.19 Below Discovery, where the Coarse Gold placer prospect is reported (Hesse, 1924).  Hesse reported the placer ground at the Discovery Claim to be 12 feet deep and to range to 35 feet deep on Claim 19 Below Discovery.

### ***Geological Evaluations and Hard Rock Exploration***

Prior to drill evaluation, a study of mineralized shear zones on available aerial imagery should be done, followed by a short ground truth follow-up examination. This study will propose drill sites, hole inclination, and proposed hole depth.

**Recommendation 2: A drilling program should be initiated to determine if larger, bulk minable, hard rock gold deposits are present in the district**, as suggested by past diamond core drilling results at the Little Squaw Mine where wide, multiple zones of gold enrichment (i.e., 60 feet of 0.168 oz/ton gold in DDH-LS-3) occur in four diamond drill holes (figures 22, 23). Inclusion of one or several high-grade ore shoots with thinner, subparallel, lower grade, auriferous quartz veins could provide widths with sufficient gold content for large scale and lower cost mining methods. This type of target should be systematically examined at each of the known mineralized vein systems, specifically parallel.veins and zones of shearing and mineralization at the Chandalar-Eneveloe deposit. Bulk tonnage potential should also be evaluated along the 4-mile-long, 300-400 foot wide Mikado shear zone which hosts numerous mineral showings along at least 7,500 feet of this strike (figures 15, 16).

If initial exploration by LSGMC finds that the shear zones should be thoroughly evaluated at depth, the option of using underground drilling stations should be considered. It would be advisable that these stations be developed from a NNE-striking access tunnel that could, if and as warranted, be eventually developed to link upper Little Squaw Creek with the confluence area of Big and St. Mary's Creeks at an elevation of approximately 3,500 feet. Later, if the Chandalar project moves into development stages, this tunnel could be improved for haulage and access.

**Recommendation 3: Initiate geological studies that will address specific questions regarding the deposit morphology and exploration criteria.**

1) the age of mineralization relative to the timing of thrust faulting in the area;
2) the vertical range of mineralized shear systems;
3) structural controls that can be used to predict high-grade ore shoots or lenses, or zones of wider and subparallel vein swarms;
4) vertical zonation of mineralogy, including gold, and chemistry, including trace

elements, isotope ratios, and fluid inclusion data;

5) research the applicability of ground-based geophysical instruments;
6) improve district-scale geological mapping, including features that may relate to an underlying intrusive system;
7) improve the surface geochemical database to delineate extensions of known deposits; arsenic appears to be a useful pathfinder element to find new veins and vein extensions;
8) determine what features control the small-scale mineralized splays associated with the shear zones and if they be predicted; and
9) examine the carbonate schist as an exploration target as suggested by Duke (1975b)

These studies should be conducted as an on-going program while a drill evaluation is being planned. Surface exploration has been severely limited due to thick accumulations of frozen scree. Due to hillside solifluction, sampling of colluvium is not likely to be representative of local bedrock. Similarly, bedrock features of interest will likely not be detectable at the surface, particularly if they are recessive. A similar geomorphic setting in the Keno Hill Mine area, Yukon Territory, was successfully prospected for narrow high-grade lead-silver vein deposits by use of track-mounted percussion drills capable of penetrating frozen scree and into bedrock. Mine geologists used this technique to rebuild reserves ahead of the mining effort.

Concurrent with the geologic studies, there are 22 or more gold prospects shown on Figure 2. Some of these have not been re-examined in more than 80 years, yet early reports speak of significant gold assays. **Recommendation 4: Examine, sample, and map the poorly assessed, out-lying gold-quartz prospects, especially to the east of Little Squaw Creek.** Examine why Claim No.3 Above Discovery on Little Squaw Creek was the richest claim on that creek with placer values falling off in both directions; and if there is a link to the Pallasgren prospect to the east of there. Much of the gold in the Chandalar district occurs as free grains, clots, and wires that are challenging to properly evaluate because of the inevitable “nugget effect”. A drill program should include a combination of reverse-circulation drilling to maximize sample volume and large diameter diamond-drill core.

Experience with previous diamond drilling has shown very poor core recovery where the altered shear gouge zones are intersected, in part because drilling thawed sheared rock fragments and gouge around the drill bit as the hole advanced, or simply the core thawed, disintegrated, and came up with the cuttings.

There has been past concern over the difficulty of obtaining repeatable and accurate assays of the mineralization found in the Chandalar district. Hoffman (1981) noted the difficulty in reconciling head assays with gold production and tails grade. Both Gallagher Company and American Cyanamid Company independently reported erratic head assays on the mill test samples they studied (Liss, 1961; Jankovich, 1961) Discrete grains and agglomerates of gold grains are common in the high-grade veins. Future channel sampling, where possible, should be done with gasoline powered chain saws with carbide blades to cut slots for channel sampling to avoid bias in the sample collection. Additionally, it is recommended that a group of oversize channel samples be collected and tested for repeatable assays using metallic screen assay procedures. It is both authors' observation from the Ryan Lode project near Fairbanks that sampling integrity was compromised by free, sometimes coarse gold. A program of metallic assays was instigated for mineralized areas (>0.02 oz/ton of gold) and drill intercepts were composited into 10-to-20 foot lengths for sample assays. The result of this effort increased reserve grade by 10-to-15 percent (Richard Hughes, written communication, 2004) The results of this work should be considered for future evaluation sampling in the Chandalar district.

Previous ore beneficiation tests were limited to bench scale testing of small, partially dried and likely oxidized samples shipped from Chandalar. The lab testing indicated acceptable recoveries using standard gravity and cyanidation processes; several flow sheets also incorporated flotation. In practice, however, the Tobin Mill failed to achieve similar recoveries. Reports by Hoffman (1980, 1981, 1982a) point to mill design, the variable mill feed, and the nature of the high-moisture, gouge-rich Mikado ore, variably containing graphite. The mill design can be corrected, and the variable feed can be blended in an improved mill design.

**Recommendation 5: If the Mikado type of mineralization is discovered in bulk-minable quantities, it will require laboratory bulk sample testing and on-site pilot mill tests.** An additional scrubber circuit and controlled pH de-sliming should be investigated.

Two exploration programs, accompanied by proposed budgets, have been provided in Appendix V of this report. One exploration scenario would: 1) conduct surface exploration of the district lodes; 2) follow up with a first phase, twinned, 10 hole, 5,000 foot core and 2,500 foot rotary drill program on selected gold lodes outlined in these recommendations; and 3) conduct a separate, 5,000 foot auger/rotary drill program on the placer deposits in the Little Squaw Creek area. The estimated cost for this 90 day program is approximately $1.5 million. A second exploration scenario would: conduct a surface examination of the district lodes; and 2) conduct a 5,000-foot auger/rotary drill program on the placer deposits in the Little Squaw Creek area. Drill programs on the lodes, which would not be conducted until the following year, was not budgeted. The estimated costs for the later 70 day effort would be about $750,000 USD.

The estimated exploration costs are qualified in the following ways. Helicopter, drill, and various logistical costs are derived from previous exploration budgets constructed for past Alaskan exploration programs worked on by PRGCI. As such, they represent average or "ball park" estimates for the costs of those services and do not constitute bids from private sector vendors for exploration in the Chandalar district. Furthermore, there is no guarantee such services could be acquired during the 2004 exploration season. For example, Alaskan exploration programs during 2003 was negatively affected by shortages in drilling and helicopter services, and in some cases could not be obtained for late-season exploratory efforts. Similar conditions may also exist for Alaskan exploration work conducted in 2004.

### *Infrastructure*

LSGMC is pursuing arrangements with the State of Alaska for cooperation on a pioneer road development from Coldfoot to the Chandalar district with emphasis on the RS 2477 route RS 009. On March 17, 2004, the State of Alaska notified the U.S. Bureau of Land Management that it intends to file a quiet title action for the right-of-way from Coldfoot to

Chandalar Lake (Borell, 2004). LSGMC should monitor and assist this effort as possible.

Historically the Chandalar district has been considered isolated and no security has been required during the off-season. The LSGMC is advised that with modern snow machines and favorable winter-spring snow conditions, the district can be reached in several hours time from the Dalton Highway to the west or from other communities in interior and northern Alaska. Experience elsewhere in Alaska has shown that camp equipment, supplies, and easily portable equipment is subject to pilferage during the winter season.

LSGMC should consider moving the permanent camp for both lode and placer properties from Tobin Creek on the south side of the mountain massif to Little Squaw Lake, which poses a better overall location for aircraft landing approaches, a site for a 5000-foot long airstrip, surface access, and space requirements for a large exploration and mining camp. Application for various permits can be reviewed with appropriate agencies.

The company should initiate cooperation with governmental agencies and the public. A good working relationship developed with the Alaska Division of Mining, Land, and Water and the Alaska Department of Environmental Conservation will be beneficial as the company begins to acquire operational permits. During the late 1980s and early 1990s, some mine-related environmental issues were identified by the State of Alaska when they received title to the lands from the U.S. Bureau of Land Management. LSGMC should discuss a mitigation plan with the Alaska Department of Environmental Conservation and Alaska Department of Natural Resources for resolving those environmental issues addressed during the 1990s, which include disposal of ferrous scrap and lead acid batteries, and a small mercury contamination cleanup site at the Tobin Creek mill.

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# XV Appendices

## Appendix I

# Pacific Rim Geological Consulting, Inc.

**Thomas K. Bundtzen-President**
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# Statement of Qualifications
# Mineral Resource Sector

### *Opening Statement*

Pacific Rim Geological Consulting, Inc. (PRGCI) is an Alaskan based 's' corporation licensed to do business in Alaska, and has been providing high quality geological consulting for a variety of industrial and government clients in Alaska, Canada, and the Russian Far East. The firm was founded in July of 1997 by Thomas K. Bundtzen, who served as Senior Economic Geologist for the Alaska Department of Natural Resources from 1975-1997. In 1981, Bundtzen designed and wrote the first annual Alaskan mineral industry reviews, and authored or co-authored subsequent annual reports every year from 1981-1997. Bundtzen has worked throughout Alaska on regional and detailed geological mapping programs, and has established a reputation for excellent bedrock and surficial geologic mapping skills. During the early 1990s, he participated in the program that selected the final 25 million acres of land from the State of Alaska from the U.S. Government, as well as mineral evaluations on School Trust and Mental Trust Lands. A bibliography that contains more than 150 papers, books, and periodicals authored or co-authored by Bundtzen is available upon request.

From1989-1995, Bundtzen was the Alaska State representative on an international project that examined the mineral deposits and regional geology of the Russian Far East, Alaska, and NW Canada. Experts from the Geological Survey of Canada, the U.S. Geological Survey, the Russian Academy of Sciences, and the State DNR jointly co-managed the 5 year program. Numerous joint publications have since been published.

### *PRGCI Mining Sector Project Overview*

From 1997-to-2004, PRGCI has provided mining sector clients with a wide variety of products that reflected their specific needs. They include:

1) *discovery and management of hardrock mineral exploration programs in Alaska*
2) *expert witness testimony in several court cases;*
3) *implementation reclamation programs for exploration;*
4) *claim staking and management of regulatory requirements for work in Alaska;*
5) *bedrock and surficial geologic mapping for both private and public clients;*
6) *educational short courses for University, public, and private clients;*
7) *evaluation of industrial mineral resources*
8) *work with Russian and western clients in the Russian Federation.*

### *Client Base*

Privileged client protocol prevents PRGCI from disclosing specifics of past and ongoing projects, but clients have included the following:

| | |
|---|---|
| *Placer Dome U.S.* | *International Bravo Resources* |
| *Newmont Mining Corporation* | *Northair Group* |
| *American Copper and Nickel Inc.* | *Doyon Limited* |
| *Kinam Gold Corporation* | *Calista Corporation* |
| *North Star Exploration, Inc.* | *Sitnasuak Native Corporation* |
| *BHP Billiton* | *Alaska Office of Attorney Generals* |
| *CH2M Hill* | *Alaska Department of Natural Resources* |
| *Tri Valley Corporation* | *U.S. Geological Survey* |
| *Silverado Mines* | *Russian Company 'KoryakGeoldobycha'* |
| *Nevada Pacific Mining Company* | *Little Squaw Gold Mining Company* |

### *Recent PRGCI Mining Project Case Histories*

<u>Management of Alaskan Field Operations for North Star Exploration, Inc.</u> From 1999-2002, PRGCI managed programs and the Alaskan field office of the Denver-Based junior company North Star Exploration, Inc. (NSEI), which leased 7 million acres of interior Alaska lands owned by Doyon Limited, a native regional corporation based in Fairbanks. The work plan carried out programs ranging in size from $1.5 to $3.2 million USD in exploration using up to 15 geologists, logistical personnel and geophysics experts annually. First-phase drill programs were carried out on five properties. Exploration Confidentiality agreements were signed with 13 companies.

Projects under PRGCI management resulted in the discovery of PGE-Ni prospects near Farewell, a high grade silver-gold-copper prospects near Northway Junction, a copper-gold prospect at Divide in the Goodpaster district, a high sulfidation gold-silver prospect at Kaiyah on the Yukon River, and promising gold prospects in the Innoko district near McGrath.

Diamond drill programs and large camp structures required compliance with both State of Alaska and Federal regulatory framework. All of our reclamation work passed compliance field officer inspections.

<u>Industrial Mineral Assessments</u>:, PRGCI recently completed a 'mineral in character' assessment for the Alaska Office of the Attorney General and another client for sand and gravel deposits in interior and south-central Alaska. The assessments required drilling, a geologic mapping effort, an environmental analysis, and a marketability tests.

A large mining client is employing PRGCI to find a limestone resource suitable for lime production and various acid-mitigation applications to be applied at a large mining development project in the Kuskokwim River area of southwest Alaska.

<u>KoryakGeoldobycha (KGD) Mine Developments in Kamchatka, Russian Far East</u> PRGCI was under contract with the Russian mineral firm Koryak Geodolbycha (KGD). Technical input on the design of a 120 km long road in central Kamchatka was solicited, as well as in marketing of several important mineral projects for the firm in the western mining meetings. PRGCI represented KGD at the Prospectors and Developer Association of Canada Annual Meeting in Toronto, Canada, March 7-10, 2004.

<u>Western Client Assessment of Infrastructure Needs in Russian Far East</u> A large western mineral firm has deployed PRGCI to provide information on road access, power availability, and miscellaneous environmental regulatory issues in a remote region of the Russian Far East.

## Appendix II

**QUALIFICATION STATEMENT -- JAMES C. BARKER**

*The undersigned hereby certifies that:*

I am an independent consulting geologist with an office located at the following address:


James C. Barker
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Co-author Thomas K. Bundtzen (Pacific Rim Geological Consulting, Inc) and I have prepared the April, 2004 report “Gold Deposits of the Chandalar Mining District, A Discussion and Recommendations” for Little Squaw Gold Mining Company. From time to time I have been associated with Pacific Rim Geological Consulting, Inc. as a Consulting Geologist.

My qualifications:

- Since 1991 I have been certified by the American Institute of Professional Geologists as a Professional Geologist (AIPG # 8205).
- Since 1991 I have been licensed by the State of Alaska as a Professional Geologist (license # G-262).
- Since 1966 I have been employed in the mining, metallurgical and petroleum industries.
- I hold a B.S. Degree of Mineral Engineering from University of Alaska.
- Between 1975 and 1991, as Supervisor of the Fairbanks Office of the U.S. Bureau of Mines, I conducted studies throughout Alaska and authored numerous reports and publications describing Alaskan mineral deposits. Several of these studies concerned deposits in the eastern Brooks Range in the vicinity of the Chandalar mining district.
- I am a member of the Society of Economic Geology (membership #51047).
- Since 1975 I have been a member of the Alaska Miners Association and have served on the Board of Directors and as Statewide Vice-President.

I have had no prior interest in nor have I ever held stock in any of the Chandalar properties. I am not employed by Little Squaw Gold Mining Co. other than on a contractual basis for the preparation of the subject Technical Report.

I am not aware of any material fact or material change with respect to the subject matter of this Technical Report that the omission to disclose would make the Technical Report misleading.

I consent to the filing of the Technical Report with any stock exchange or other regulatory authority and the publication or public release by them or as authorized by Little Squaw Gold Mining Co.

Signed____________________________________ April 3, 2004

James C. Barker, Consulting Geologist

## Appendix III

### STATEMENT OF QUALIFICATIONS

THOMAS K. BUNDTZEN

I, THOMAS K. BUNDTZEN, a professional geologist, HEREBY CERTIFY THAT:

Co-author James C. Barker and I have prepared the April, 2004 report "Gold Deposits of the Chandalar Mining District, A Discussion and Recommendations" for Little Squaw Gold Mining Company. My qualifications are as follows:

1. I am currently employed as President of Pacific Rim Geological Consulting, Inc., P.O. Box 81906, Fairbanks, Alaska 99708, USA, which is an Alaskan 'S' corporation;

2. I am a graduate of the University of Alaska-Fairbanks, Fairbanks, Alaska with a B.S. degree in Geology (School of Mineral Engineering, 1973). I am also a graduate of the University of Alaska-Fairbanks, Fairbanks, Alaska with a M.S. Degree in Economic Geology (Department of Geology and Geophysics, 1981);

3. I am currently a member of the Society of Economic Geology (since 1980; and 1998), the Geological Society of America (since 1974), the American Association for the Advancement of Science (since 1982), the Alaska Miners Association (since 1975), the Alaska Geological Society (since 1990), the Yukon Chamber of Mines (since 1995), the Prospectors and Developers Association of Canada or PDAC (since 1999), and the Alaska Mining Hall of Fame Foundation (since 1997);

4. I am currently statewide President of the Alaska Miners Association;

5. I have practiced the field of economic geology in Alaska, the Russian Far East, NW Canada, Scandinavia, and New Zealand since 1970;

6. I have published reports, report chapters, and geological maps as both senior and junior author with the State of Alaska, Division of Geological and Geophysical Surveys, the U.S. Geological Survey, the Journal of Economic Geology, the Geological Society of America DNAG Volume, the Metallurgical Society, Inc., The Alaska Geological Society, the Alaska Geographical Society, the Canadian Institute of Mining Metallurgy, and Petroleum (CIM), the Journal of Geology, Tectonophysics, and the Alaska Miners Association;

7. I have read the definition of "qualified person" set out in National Instrument 43-101 (NI43-101) and certify that by reason of my education and affiliation with professional organizations (as defined by NI43-101), and past relevant work experience, I fulfill the requirements to be a "Qualified Person" for the purposes of NI43-101;

8. I briefly visited the operations of the Chandalar Development Corporation (CDC)

Mikado gold-quartz mine during the summer of 1982, and observed underground mining operations during the last year of production by that firm;

9. I had no prior involvement with the property that is the subject of the Independent Technical Report, except the brief 1982 visit described above;

10. I have never owned stock or other assets of Chandalar Development Corporation or Little Squaw Mining Company, and any other private firm that has operated in the Chandalar Mining District;

11. I am not aware of any material fact or material change with respect to the subject matter of the Independent Technical Report (when completed) that is not reflected in the Independent Technical report, the omission to disclose which would make the Independent Technical Report misleading;

12. I consent to the filing of the Independent Technical report with any stock exchange or other regulatory authority and the publication by them, including publication of the Technical report in the public company files on their websites accessible by the public.

DATED in Fairbanks, Alaska, April 20, 2004

________________________________________

Thomas K. Bundtzen, BS, MS, ABSLN # 279639

# Appendix IV

## APPENDIX IV-1

## LITTLE SQUAW GOLD MINING CO. MINING CLAIM INVENTORY

**55 ALASKA STATE MINING CLAIMS LOCATED IN 2003**
**160-ACRE CLAIMS STAKED ACCORDING TO MTRSC STAKING REGULATIONS**
***NOT* SUBJECT TO 2% ROYALTY PAYABLE TO ESKIL ANDERSON**

| CLAIM NUMBER | ADL NO. | CLAIM NUMBER | ADL NO. |
|---|---|---|---|
| 312 | 641504 | 914 | 641532 |
| 313 | 641505 | 915 | 641633 |
| 314 | 641506 | 916 | 641534 |
| 413 | 641507 | 917 | 641535 |
| 414 | 641508 | 918 | 641536 |
| 513 | 641509 | 919 | 641537 |
| 514 | 641510 | 1010 | 641538 |
| 612 | 641511 | 1011 | 641539 |
| 613 | 641512 | 1012 | 641540 |
| 614 | 641513 | 1013 | 641541 |
| 615 | 641514 | 1014 | 641542 |
| 711 | 641515 | 1015 | 641543 |
| 712 | 641516 | 1016 | 641544 |
| 713 | 641517 | 1017 | 641545 |
| 714 | 641518 | 1018 | 641546 |
| 715 | 641519 | 1019 | 641547 |
| 716 | 641520 | 1112 | 641548 |
| 811 | 641521 | 1113 | 641549 |
| 812 | 641522 | 1114 | 641550 |
| 813 | 641523 | 1115 | 641551 |
| 814 | 641524 | 1116 | 641552 |
| 815 | 641525 | 1117 | 641553 |
| 816 | 641526 | 1118 | 641554 |
| 817 | 641527 | 1119 | 641555 |
| 910 | 641528 | 1216 | 641556 |
| 911 | 641529 | 1219 | 641557 |
| 912 | 641530 | 1316 | 641558 |
| 913 | 641531 | | |

## APPENDIX IV-2

**7 UNPATENTED ALASKA STATE MINING CLAIMS LOCATED PRE-2003**
***NOT* SUBJECT TO 2.0 PERCENT ROYALTY PAYABLE TO ESKIL ANDERSON**

| CLAIM NAME | ADL # | DATE RECORDED | RECORDING DOCUMENT # | BOOK:PAGE (Fairbanks Recording District) |
|---|---|---|---|---|
| Shamrock Lode | 515468 | 08/31/1987 | 1987-018283-0 | 541:516 |
| Rex Lode | 515469 | 08/31/1987 | 1987-018284-0 | 541:518 |
| Summit | 515470 | 08/31/1987 | 1987-018285-0 | 541:520 |
| Chandalar Lode | 515471 | 08/31/1987 | 1987-018286-0 | 541:522 |
| West Chandalar | 515472 | 08/31/1987 | 1987-018287-0 | 541:524 |
| Star East Fraction | 515473 | 08/31/1987 | 1987-018288-0 | 541:526 |
| Golden Eagle Fraction | 515474 | 08/31/1987 | 1987-018289-0 | 541:528 |

**APPENDIX IV-3**

**19 UNPATENTED ALASKA STATE MINING CLAIMS LOCATED PRE-2003**
***SUBJECT* TO 2 PERCENT ROYALTY PAYABLE TO ESKIL ANDERSON**

| CLAIM NAME<br>LOCATION | ADL# | DATE RECORDED | RECORDING DOCUMENT # | BOOK:PAGE (Fairbanks Recording District) |
|---|---|---|---|---|
| No. 2 Below Discovery<br>Big Squaw Creek | 319523 | 09/12/1972 | 011493-0 | 26:544 |
| No. 3 Below Discovery<br>Big Squaw Creek | 319524 | 09/12/1972 | 011494-0 | 26:545 |
| No. 4 Below Discovery<br>Big Squaw Creek | 319525 | 06/22/1973 | 007280-0 | 28:88 |
| No. 5 Below Discovery<br>Big Squaw Creek | 319526 | 06/22/1973 | 007281-0 | 28:89 |
| No. 6 Below Discovery<br>Big Squaw Creek | 319527 | 06/22/1973 | 007282-0 | 28:90 |
| Spring Creek No. 4<br>Near Little Squaw Creek | 319528 | 06/22/1973 | 007285-0 | 28:93 |
| Spring Creek No. 3<br>Near Little Squaw Creek | 319529 | 06/22/1973 | 007274-0 | 28:82 |
| Spring Creek No. 2<br>Near Little Squaw Creek | 319530 | 06/22/1973 | 007273-0 | 28:81 |
| Spring Creek No. 1<br>Near Little Squaw Creek | 319531 | 09/12/1972 | 011489-0 | 26:540 |
| No.1 Below Discovery<br>Little Squaw Creek | 319532 | 06/22/1973 | 007284-0 | 28:92 |
| Discovery<br>Little Squaw Creek | 319533 | 06/22/1973 | 007283-0 | 28:91 |
| No. 2 Below Discovery<br>Tobin Creek | 515440 | 08/31/1987 | 018292-0 | 541:534-5 |
| No. 3 Below Discovery<br>Tobin Creek | 515441 | 08/31/1987 | 018293-0 | 541:536-7 |
| No. 4 Below Discovery<br>Tobin Creek | 515442 | 08/31/1987 | 018294-0 | 541:538-9 |
| No. 4 Below Fraction<br>Tobin Creek | 515443 | 08/31/1987 | 018295-0 | 541:540-1 |
| Discovery<br>Woodchuck Creek | 515444 | 08/31/1987 | 018296-0 | 541:542-3 |
| No. 2 Above Discovery<br>Little Squaw Creek | 515445 | 08/31/1987 | 018297-0 | 541:544-5 |
| Upper Discovery<br>Big Creek | 515447 | 08/31/1987 | 018299-0 | 541:548-9 |
| No. 5 Below Upper Discovery<br>Big Creek | 515452 | 08/31/1987 | 018304-0 | 541:558-9 |

**Appendix IV-4**

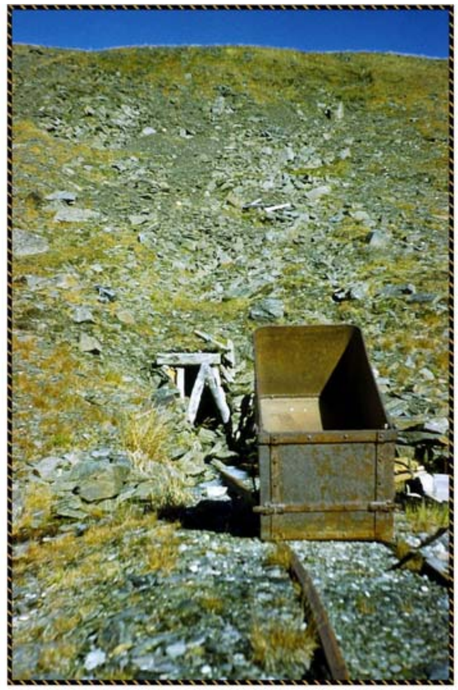
**23 PATENTED FEDERAL CLAIMS**
***SUBJECT* TO 2 PERCENT ROYALTY PAYABLE TO ESKIL ANDERSON**

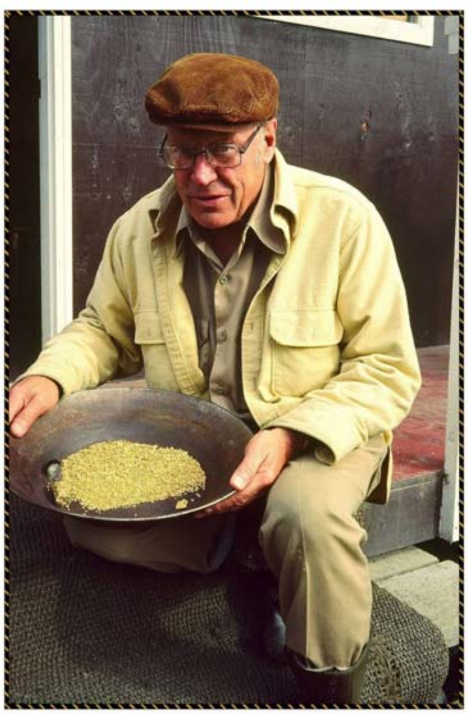
| CLAIM NAME | CLAIM GROUP | ACRES | U.S. PATENT # | DATE ISSUED | U.S. MINERAL SURVEY # | BLM SERIAL # | NO:VOL:BOOK:PAGE (Chandalar Mining Precinct, now Fairbanks Recording District) |
|---|---|---|---|---|---|---|---|
| Little Squaw Quartz Lode<br>Big Squaw Quartz Lode<br>Sine Lode<br>Cosine Fraction Lode<br>Crystal Quartz Lode | Little Squaw | 96.215 | 1022769 | 01/23/1929 | 1746 | AKF 001374 | |
| Tobin Quartz Claim Lode<br>Mikado Lode Claim<br>Little Mikado Lode Claim | Mikado | 58.964 | 1024558 | 03/20/1929 | 1745 | AKF 001373 | 185:1:Miscel.Rec.:95 |
| Golden Eagle Lode Claim<br>Bonanza Lode<br>Eneveloe Lode | Bonanza Gold | 61.446 | 1036358 | 04/19/1930 | 1995 | AKF 001887 | 98:1:Deeds:137 |
| Star No. 1 Lode<br>Star No. 2 Lode<br>Star No. 3 Lode | Star | 50.553 | 1036359 | 04/19/1930 | 1996 | AKF 001888 | 95:1:Deeds:128 |

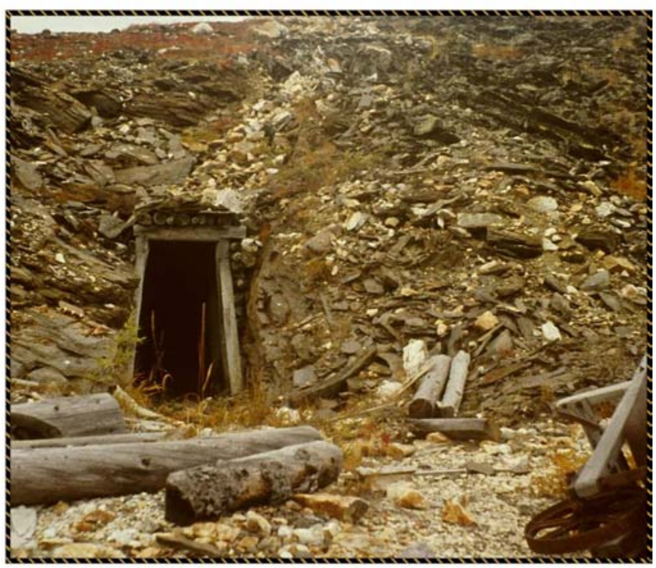
| CLAIM NAME | CLAIM GROUP | ACRES | U.S. PATENT # | DATE ISSUED | U.S. MINERAL SURVEY # | BLM SERIAL # | NO:VOL:BOOK:PAGE (Chandalar Mining Precinct, now Fairbanks Recording District) |
|---|---|---|---|---|---|---|---|
| Cosine Lode Claim | Little Squaw | 20.102 | 1036360 | 04/19/1930 | 1997 | AKF 001889 | 99:1:Deeds:141 |
| Crystal No. 2 Lode | Little Squaw | 19.582 | 1036361 | 04/19/1930 | 1998 | AKF 001890 | 100:1:Deeds:144 |
| No. 1 Above on Little Squaw Creek Placer Mining Claim | Placer | 15.718 | 1036362 | 04/19/1930 | 1999 | AKF 0011891 | 97:1:Deeds:134 |
| Jupiter Lode Claim<br>Woodchuck Lode Claim | Bonanza Gold | 37.209 | 1085903 | 09/25/1936 | 1629 | AKF 003020 | 125:1:Deeds:176 |
| Venus Lode Mining Claim | Bonanza Gold | 20.655 | 1085904 | 09/25/1936 | 1630 | AKF 003021 | 126:1:Deeds:179 |
| Cosine No. 1<br>Cosine No. 2 | Little Squaw | 41.101 | 1088433 | 02/16/1937 | 1628 | AKF 003081 | 127:1:Deeds:181 |
| Spring Creek Mill Site | Mill Site | 4.961 | 1094946 | 01/06/1938 | 1633 | AKF 003021A | 130:1:Deeds:186 |

**Appendix V**
**The following are selected photos of historical and more recent mineral development activities and relevant physiographic features present in the Chandalar Mining District of northern Alaska. Most of the photos are from the files of the Little Squaw Gold Mining Company, but several have been provided by Michael R. Garverich, as cited.**


Old stamp mill at Little Squaw mill site (date unknown); photo by Michael R. Garverich.


Original Mikado adit as it appeared in September, 1958.


Eskil Anderson with a pan of gold, July, 1981


Little Squaw adit portal as it appeared in 1950.

Summit Mine workings and camp as they appeared in 1982.

Chandalar Lake (looking northwest) is about 6 miles west of LSGMC camp on Tobin Creek.

The old bunkhouse on Mello Bench housed drift miners active during the early 20th century.

Tobin Creek sluice box as it appeared in 1961. Note: hand-stacked boulders on the right.

Little Squaw Lake camp as it appeared in the 1970's.

Toussaint Mill upper Big Creek as it appeared in 1958.

Tobin Creek placer sluice box maintenance and repair, August, 1986

C-46 aircraft taking off from Tobin Creek airstrip, circa early 1980's.
Photo by Michael R. Garverich.

Ackels IHC Holland alluvial treatment plant, June, 1990

Mikado open pit as seen in 1984.  Photo by Michael R. Garverich.

Looking up Little Squaw Creek at the Mello Bench (on the left), date unknown.

Looking northeast down Little Squaw Creek, an inactive rock glacier is exposed down-slope and Little Squaw Lake in the foreground.  Photo by Michael R. Garverich.

Big Creek airstrip, placer tailings, and camp near the confluence of St. Mary's Creek looking southeast, September, 1972.

Little Squaw Peak oversite and Spring Creek mill site, date unknown.

Gold crystals in quartz from upper portal of Little Squaw vein; gold is about 1 cm across.  Photo by Michael R. Garverich.

Herringbone gold from Tobin Creek, date unknown.

## Appendix VI  Two Scenarios for 2004-2005 Mineral Exploration in Chandalar Mining District, Alaska

PRGCI provides the following estimated costs and suggested procedures for two exploration scenarios for the evaluation of hard rock and placer resources owned by Little Squaw Gold Mining Company in the Chandalar Mining District, Alaska.   The first exploration scenario would aggressively pursue a surface exploration program, and undergo both placer and hard rock drill programs during a single field season.  The latter proposal would conduct surface exploration of hard rock resources, but only undertake a first phase placer exploration program, leaving a hard rock drill program for a subsequent season.

The estimated costs are qualified in the following ways.  Helicopter, drill, and various logistical costs are derived from previous exploration budgets constructed by PRGCI for past Alaskan exploration programs.  As such, they represent average or "ball park" estimates for the costs of those services and do not constitute bids from private sector vendors for exploration in the Chandalar Mining District.  Furthermore, there is no guarantee such services could be acquired during the 2004 exploration season, the year this report was written.  For example, Alaskan exploration programs during 2003 were negatively affected by shortages in drilling and helicopter services.  Similar conditions may also exist for Alaskan exploration work conducted in 2004.

**VI-1 Combined lode and placer evaluation in one field season.**

A) Permitting for exploration program, including materials necessary for camp and diamond drill and RC program for lode prospects and RC program for placer prospects (early part of year).

B) Conduct 30 day geological mapping and sample program. Samples would be taken over widths and strike lengths of known shear zones using arsenic, gold, antimony, lead, and zinc as indicators of significant lode gold mineralization to help site drill collars for drill program. Conduct ground-based geophysics program over placer target (seismic refraction) to help site collars for placer drilling. Work would take place over 30 days, probably early in the season before drilling.

C) Conduct 6,500 feet of churn or RC placer drill, 72 hole program at four sites on Big and Little Squaw Creeks; camp-setup during this time (July-August).

D) Mid to late June; permit collars for a 5,000 foot diamond core drill program. We estimate that it will take about 3-4 weeks to get this permitted.

E) Drill 10 holes to 500 feet each (total 5,000 feet, ‘H’ core) from 3 collars on Mikado structure, 3 collars on Little Squaw structure and 4 more on sites to be determined based on earlier geochemical/geophysical results; work to be completed in mid-August to September.

F) Twin at least 5 of the DDH holes with an RC rig, possibly the one used for the placer evaluation, for a total of 2,500 feet. It will be important to compare the two methods, as core recovery was a significant problem during past drill programs in the district.

F) Camp break-down and drill program termination in October; report write-up.

## VI-1 Estimated budget to conduct 2004-2005 combined first phase lode and placer evaluation.

| Task | Itemized Costs | Costs in USD (Rounded) |
|---|---|---|
| Pre-field permitting for exploration | Permitting and planning 21 @ $600/day | $15,000 |
| Camp Mobilization and maintenance at Chandalar Lake ('Taiga'-Quoted Camp) | $150/day per person for 70 days; 8 people; Includes Cook plus assistant; Aircraft in and out @ $8,000 per trip | $100,000 |
| Conduct geological mapping and sample program | 1) 2 geologists and one field assistant $1,500/day for 30 days; 2) Analyses for 400 samples @$20/sample | $53,000 |
| Helicopter Contract | Hughes 500D $850/day for 3.5 hours for 30 days | $90,000 |
| Helicopter and Camp Fuel Needs | Average $3.50 per gallon of Jet-A delivered. | $10,500 |
| 4-Wheeler ATV Surface Transport | Four 4-Wheelers @$100/day to supply all camp needs for 70 days | $28,000 |
| Seismic Refraction Survey | 2-3 week contracted effort | $35,000 |
| RC placer drill program | 72-hole 6,500 foot program @ $50/foot | $325,000 |
| Drill Transport | Rental of tractor for drill transport (bid estimate) | $66,500 |
| RC Drill Program Geological Staff | One professionals @ 45 days each @$600/day each; one assistants @ $250/day | $38,000 |
| Hard Rock Drill Program—Basic Drill Costs | 5,000 feet @ $42/foot for 'H' core | $210,000 |
| Drill Program Overhead Rates During Operation | $125/hour per person; two shifts of ten hours each; 40 day drill program | $100,000 |
| Drill Program Overhead Rates While Not in Operation | $110/hour; 4 hours/day 40 days | $18,000 |
| RC Hard Rock Drill Program | 2,500 Feet @ $50/foot; mobilization costs included above | $125,000 |
| Drill Program Geological Staff | Two professionals @ 45 days each @$600/day each; two assistants @ $250/day each for same time | $76,000 |
| Camp Demobilization | 5 days @ $1,400/day; three flights return | $25,000 |
| Drill Transport (both RC and Diamond Core) to Chandalar | 8 C46 Flights to and from Fairbanks @ $8,000/flight | $64,000 |
| Report Write-up | Writing and production | $25,000 |
| Overhead | 10 percent of total | 136,000 |
| **Total** | **NA** | **$1,540,000** |

## VI-2 Conduct surface exploration. Conduct cased RC placer drill program first year; defer twinned hard rock drill effort until following year.

A) Begin permitting for exploration program, including materials necessary for camp and diamond drill and RC program for lode prospects and RC program for placer prospects. Permit specific placer drill hole collars with State of Alaska (May).

B) Conduct geologic mapping and sample program over widths and strike lengths of known shear zones using arsenic, gold, antimony, lead, and zinc as indicators of significant lode gold mineralization to help site drill collars for drill program (30 days). Conduct ground-based geophysics program over placer target (seismic refraction) to help site collars for placer drilling if contractor is available. Begin to set up camp infrastructure for remainder of season.

C) Conduct 6,500 feet of RC placer drill 72 hole program at four sites on Big and Little Squaw Creeks (July-August).

D) Camp break-down and drill program termination early September.

E) Report write-up for early October deadline.

## VI-2 Estimated budget to conduct surface lode exploration and placer drill program; defer twinned hard rock drill effort until the following year. (Includes set-up for 8 man camp for 45 days.)

| Task | Itemized Costs | Costs in USD (Rounded) |
|---|---|---|
| Pre-field permitting for exploration | Permitting and planning 21 @ $600/day | $15,000 |
| Camp Mobilization and maintenance at Chandalar Lake (‘Taiga’ Style Camp) | $150/day per person for 45 days; 8 people; Aircraft in and out @$8,000 per trip | $70,000 |
| Helicopter Contract | Hughes 500D $850/day for 3.5 hours for 45 days | $134,000 |
| Conduct geological mapping and sample program | 1) 2 geologists and one field assistant $1,400/day for 30 days; 2) Analyses for 400 samples @$20/sample | $53,000 |
| Seismic Refraction Survey | 2-3 week contracted effort | $35,000 |
| Drill Transport Costs of RC rig to Chandalar Mining District | 6 C46 Flights to and from Fairbanks @ $8,000/flight; | $48,000 |
| 72 Hole RC placer drill program | 6,500 feet @ $50/foot Transport of RC rig to field to and from with fixed wing | $325,000 |
| Tractor Rental | For service of RC Drill | $50,000 |
| 4-Wheeler ATV Surface Transport | Four 4-Wheelers @$100/day to supply all camp needs for 45 days | $18,000 |
| Drill Program Geological Staff | One Professional geologist @ $600/day with geological assistant @ $250/day both for 45 days | $40,000 |
| Camp Demobilization | 5 days @ $1,400/day; three flights return | $25,000 |
| Report Write-up | Writing, drafting; production of 10 copies | $25,000 |
| Miscellaneous Overhead | 10 percent of total | $80,000 |
| **Total** | **NA** | **$918,000 USD** |