

COLORADO GEOLOGICAL SURVEY
Research Notes RN-06
Summary of the Geology, Gold, and Heavy Mineral Placer
Deposits of the Iron Springs Divide Area, Moffat County,
Colorado

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ABOUT THIS REPORT

From the abstract:

“Gold placer deposits occur in the Iron Springs Divide area in Moffat County, Colorado. This area contains several historic mining districts including the Fourmile, Lay, and Timberlake Mining District. Placers in these areas contain gold and, in some areas, heavy minerals that contain critical elements. This report provides a summary of the geology, mineral deposits, and mining history of this area. A bibliography and internal Colorado Geological Survey (CGS) historical documents are also included in this document.”

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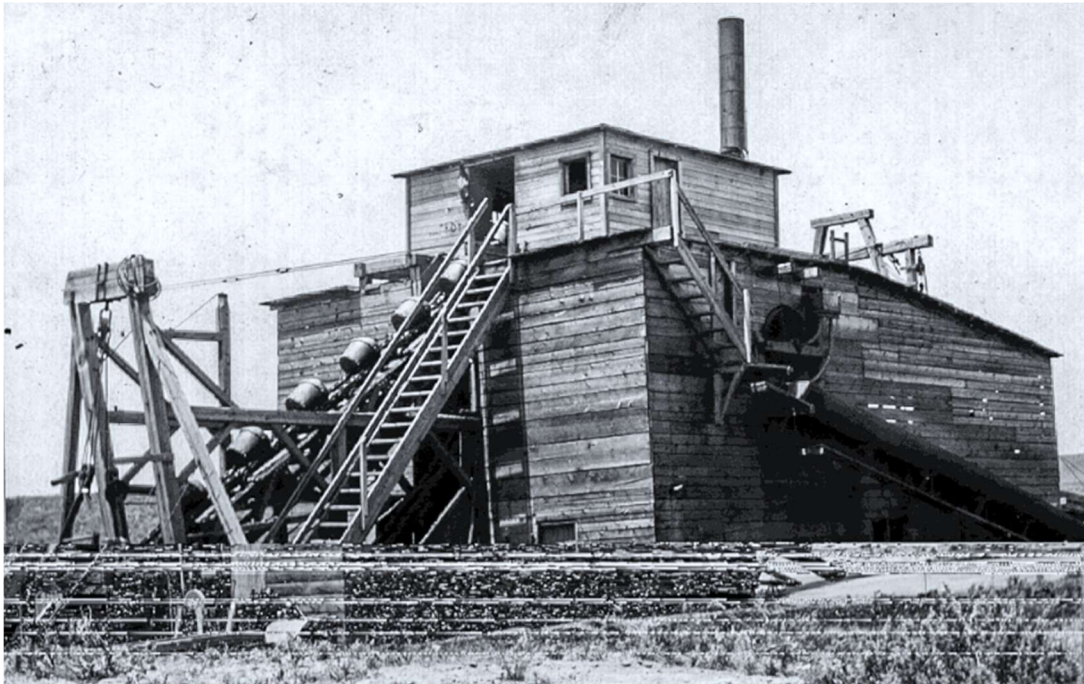


COLORADO GEOLOGICAL SURVEY
COLORADO SCHOOL OF MINES



RESEARCH NOTES 06

Summary of the geology, gold, and heavy mineral placer deposits of the Iron Springs Divide area, Moffat County, Colorado



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Colorado Geological Survey
Colorado School of Mines
Golden, Colorado
2026



COLORADO GEOLOGICAL SURVEY
COLORADO SCHOOL OF MINES

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Cover photo: *Blevins placer dredge in 1906 on Lay Creek about 8 miles north of Lay post office, Moffat County, Colorado. Courtesy of the U.S. Geological Survey, photo by H.S. Gale (see Gale, 1908; p. 93 and Colorado Bureau of Mines, 1907; p. 120), provided by The Diggings (2026).*

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ABSTRACT

Gold placer deposits occur in the Iron Springs Divide area in Moffat County, Colorado. This area contains several historic mining districts including the Fourmile, Lay, and Timberlake Mining District. Placers in these areas contain gold and, in some areas, heavy minerals that contain critical elements. This report provides a summary of the geology, mineral deposits, and mining history of this area. A bibliography and internal Colorado Geological Survey (CGS) historical documents are also included in this document.

INTRODUCTION

Gold-bearing placer deposits occur within a large area centered around a relatively low drainage divide, referred to as the Iron Springs Divide (ISD) area in this report, within the Sand Wash Basin, Moffat County, CO (**Figure 1**). The ISD is at a relatively low elevation, generally between ~6,880 and 7,330 feet above mean sea level, and trends east-west through this area forming a drainage divide (**Figure 2**). Streams to the north of the ISD drain into the Little Snake River and streams to the south drain into the Yampa River. Several gold mining regions or districts are located, or referred to in some publications, within the ISD area shown in **Figures 1** and **2** including the: Fourmile Mining District, Craig-Baggs gold placer region, Four-Mile Placer Mining District, Lay District, Timberlake or Fourmile Placer District, Fourmile Creek District, and Timberlake District. **Figure 1** shows the location of historic placer mines and gold occurrences and **Table 1** includes information about some of the historic placer mines in this area. Placers in this area reportedly contain gold, however, silver and other heavy minerals (e.g., ilmenite, magnetite, rutile, monazite, garnet, zircon, columbite, platinum) have also been reported by several authors.

The first gold in the area was discovered in 1891 along Fourmile Creek (Snow, 1895). Several historic mines were located near this and other creeks in the area (**Figure 1**). Historically, the more productive gold placers mined were along Lay Creek and Timberlake Creek (**Figure 1**) that originate along the ISD. Generally, most of the historic gold mining south of the divide was associated with Lay Creek, Blue Gravel Creek, and Fortification Creek which all ultimately drain into the Yampa River to the south. North of the divide, most of the historic gold mining occurred along Timberlake and Fourmile creeks which drain into the Little Snake River to the north (Prommel and Hopkins, 1968; Parker, 1964; Parker, 1974; Boyle and Cochrane, 1975). However, other gold deposits are recognized along several drainages that also originate along the ISD including Housel Gulch (a tributary to Timberlake Creek), Bighorn Gulch, Scandinavian Gulch, and Dry Gulch (**Figure 1**) (Prommel and Hopkins, 1968; Parker, 1974). Gale (1908) provided a map of some of the historic placer claims with regards to gold which is reproduced here as **Figure 3**. Additional gold placer deposits have been mined on the Little Snake and Yampa rivers (Davis and Streufert, 1990).

Starting in 1892, Moffat County was a steady producer of placer gold and ranked 7th among the historic 37 placer gold-producing counties in Colorado as reported in 1968 (Prommel and Hopkins, 1968). Although this may include production from other gold mines because, prior to 1911, gold production in this region is reported for Routt County as Moffat County was not established until after this time. Thurston (1965) (**Appendix A**) reports that nine operations along Fourmile and Timberlake Creeks produced ~1,785 ounces of gold between 1932 and 1935. Between 1932 and 1940, this same area produced a total of ~2,187 ounces of gold and 109 ounces of silver (Thurston, 1965). Vanderwilt and others (1947; page 146) report similar total productions between 1932 and 1940 but indicate that the more productive gold production period was between 1936 and 1938 (**Table 2**). Gold and other mineral exploration activities have occurred in the area since at least the 1950s. Currently, at least one active mining permit exists at the West Side Placer (**Figure 1**) (DRMS, 2026).

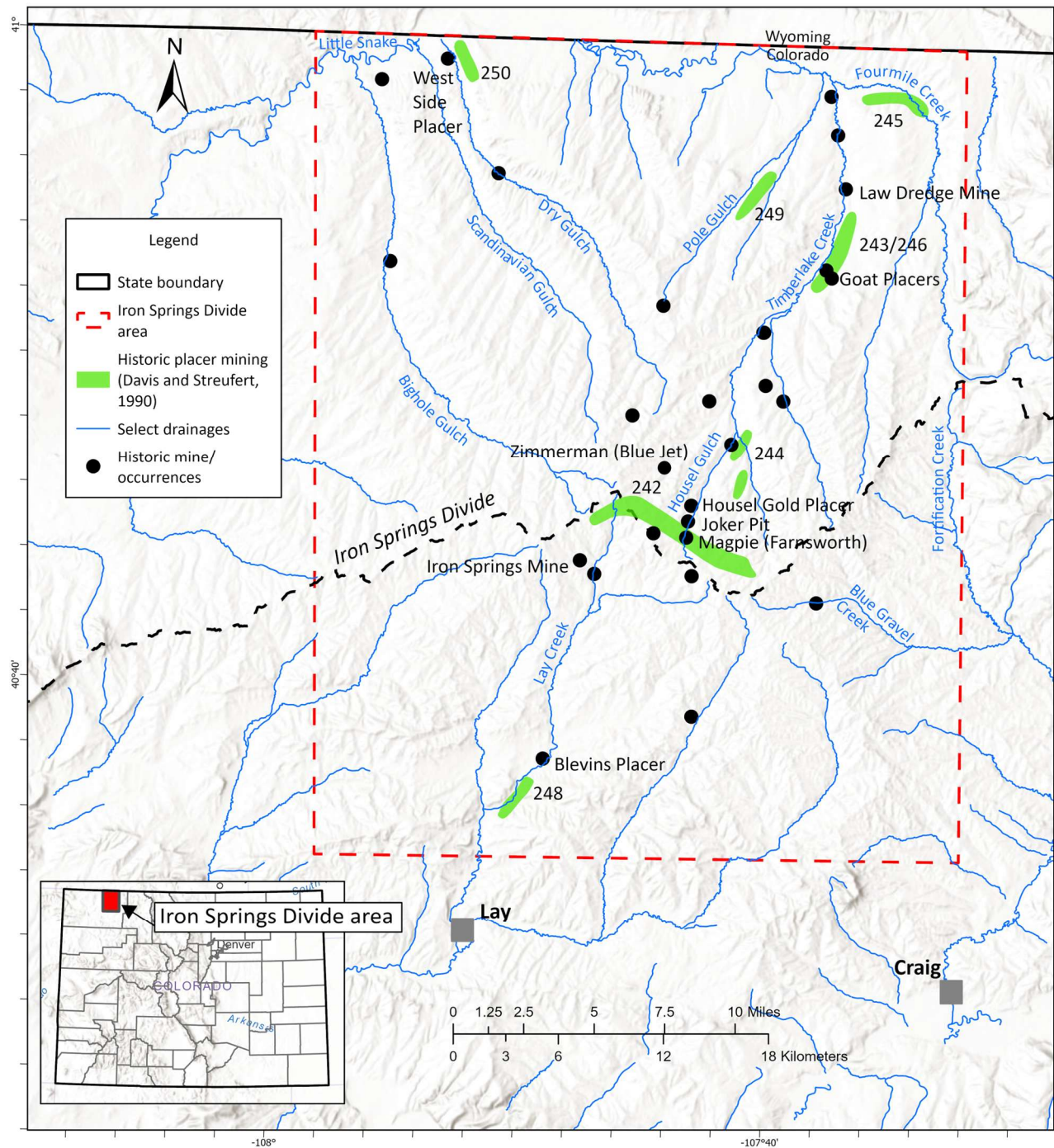


Figure 1 – General location map showing the Iron Springs Divide area, Moffat County, Colorado. Select historic mine locations, gold occurrences (McFaul and others, 2000), portions of select (mostly ephemeral) streams, and historic placer mining areas (Davis and Streufert, 1990) are also shown. All locations and names are approximate. Drainages south and north of the divide, ultimately drain into the Yampa and Little Snake rivers, respectively. Map IDs are summarized in **Table 1**.

MapID	District	Deposit Type	Ore/Mineral	Location/Area description	Host
242	Fourmile Creek (Timberlake)	Placer	native gold	T9N, R92-93W; fossil alluvial placers in Eocene deltaic fan deposits flanking Iron Springs Divide.	Tertiary clastics (Wasatch Formation)
243	Fourmile Creek (Timberlake)	Placer	native gold	T11N, R91W; Timberlake Creek.	Quaternary alluvium (Qa)
244	Fourmile Creek (Timberlake)	Placer	native gold	T10N, R92W; terrace placers on & between Timberlake and Housal Creeks.	Quaternary terrace gravels (Qa)
245	Fourmile Creek (Timberlake)	Placer	native gold	T12N, R91W; upper Fourmile Creek on north side of Iron Springs Divide, 25 miles north of Craig.	Quaternary terrace gravels (Qa)
246	Fourmile Creek (Timberlake)	Placer	native gold	T11N, R91W; Law dredge site on Timberlake Creek.	Quaternary alluvium (Qa)
247	Fourmile Creek (Timberlake)	Placer	native gold	T10N, R92W; Housel Gulch.	Quaternary alluvium (Qa)
248	Lay Creek	Placer	native gold	T8N, R93W; terrace gravels near Jackrabbit Springs.	Quaternary terrace gravels (Qa)
249	Little Snake River	Placer	native gold	T11N, R92W; Pole Gulch.	Quaternary terrace gravels (Qa)
250	Little Snake River	Placer	native gold	T12N, R94W; mouth of Dry Creek.	Quaternary terrace gravels (Qa)

Table 1 – Summary of historic gold placer deposits in the Iron Springs Divide area (modified from Davis and Streufert, 1990). Locations (see the MapIDs in **Figure 1**) are approximate. T = township; R = range; N = north; W = west.

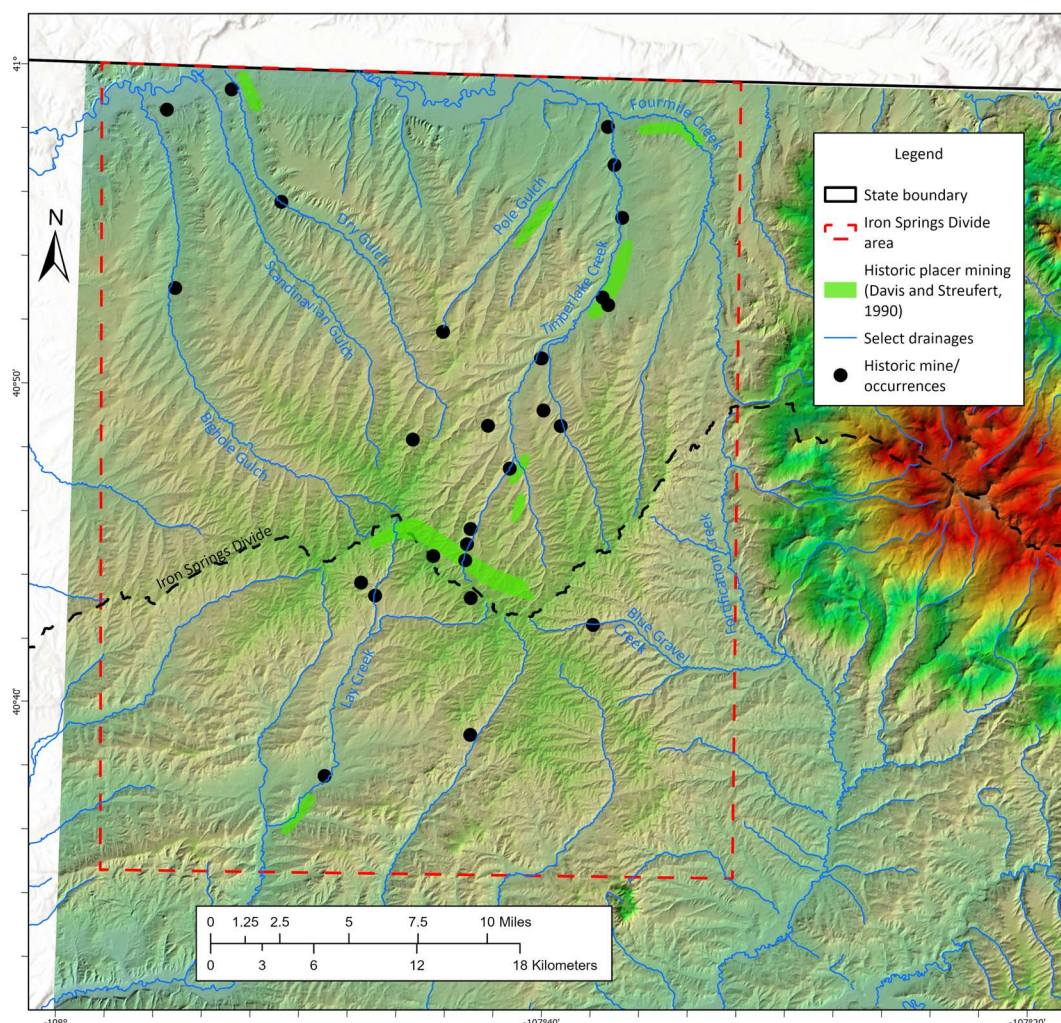


Figure 2 – General topography (1.4x vertical exaggeration, from LiDAR) of the Iron Springs Divide area (reds are high, bluish green are lows).

Year	#Mines Producing Placer	Gold (fine ounces) Placer	Silver (fine ounces) Placer
1932	11	46	2
1933	7	19	-
1934	6	55	3
1935	8	123	7
1936	10	211	13
1937	5	932	44
1938	11	641	31
1939	8	149	9
1940	5	10	-
Total		2,186	109

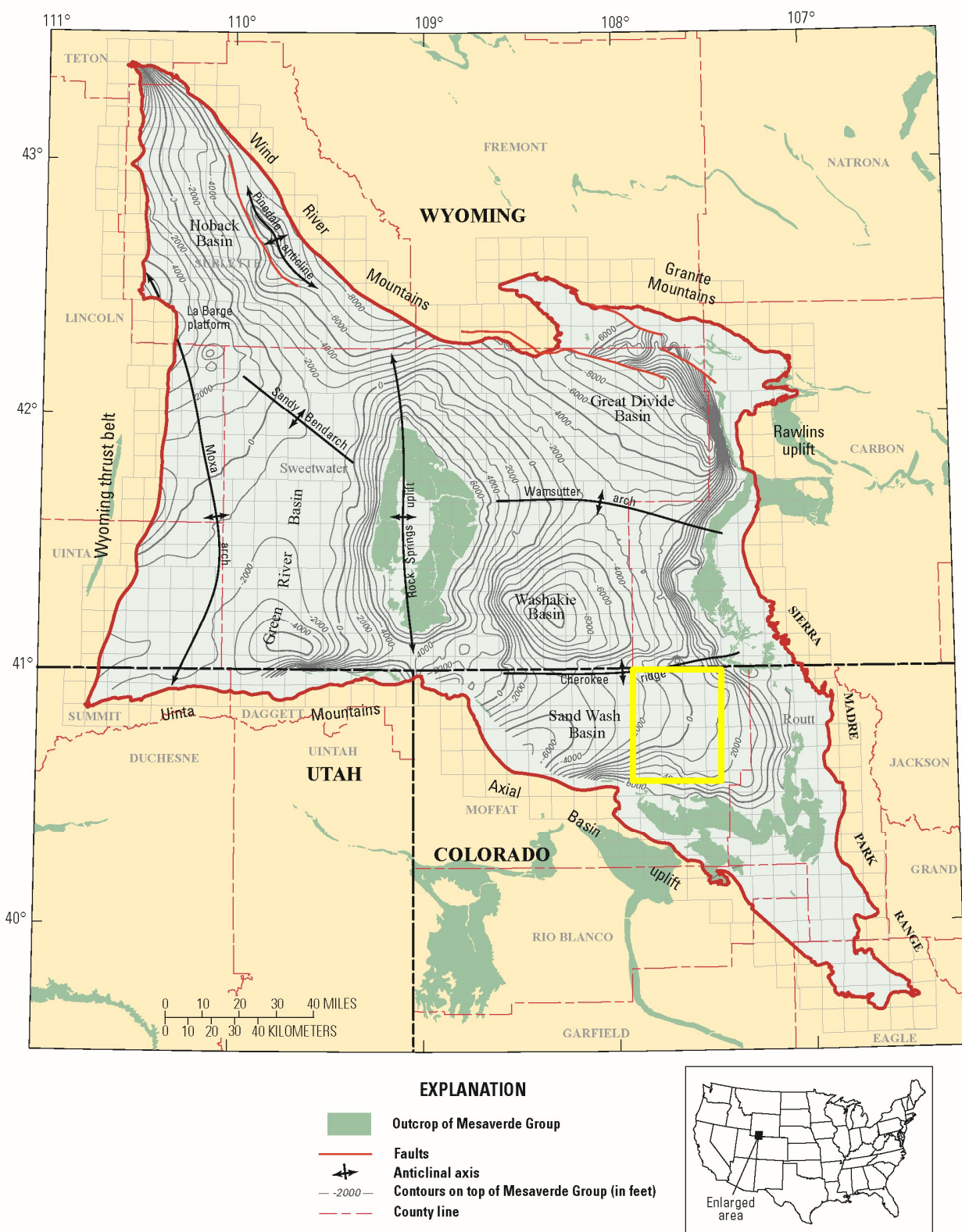
Table 2 – Production of gold and silver at the Fourmile and Timberlake Creek Mining Districts. Table from Vanderwilt and others (1947; page 146).

GENERAL GEOLOGY

The ISD area is in the southeast end of the northwest-trending Sand Wash Basin (**Figure 4**). The Sand Wash Basin is the southernmost structural subbasin within the Greater Green River Basin and is bordered to the north by the east-west trending Cherokee Ridge anticline that separates it from the Washakie Basin to the north (**Figures 4 and 5**). Structurally, the lowest portion of the Sand Wash Basin is to the west, and the eastern portion extends along the synclinal axis of the basin toward the Sierra Madre and Park Range to the east (**Figure 4**) (Roehler, 1992). Within the ISD area, rocks dip in a northerly direction and west, between 4 to 13°, into the basin along Fortification and Fourmile Creeks (Parker, 1974).

The general (1:250K-scale) geology of the ISD area is shown in **Figure 6**. Geological units in the area include Holocene to Pleistocene sand and gravel alluvial deposits mostly associated with valleys and terraces around current drainages as well as alluvial fans, landslide, and eolian deposits. This material is underlain (from youngest to oldest) by: Miocene Browns Park Formation, Eocene Wasatch Formation and interfingered Green River Formation, Paleocene Fort Union Formation, and the Upper Cretaceous Lance Formation and Lewis Shale (Tweto, 1976). Two Pliocene (?) andesite and basalt dikes intrude the Wasatch Formation along the eastern portion of the ISD area (**Figure 6**) (Theobald, 1970a; Tweto, 1976). Holocene to Pleistocene and Eocene deposits underlie most of the ISD area and are associated with the placer deposits.

The Wasatch Formation in the ISD area includes both the Cathedral Bluffs Tongue and older main body of the Wasatch Formation. Roehler (1989; 1991) indicates that the main body of the Wasatch Formation and younger Cathedral Bluffs generally contain fluvial floodplain deposits. These deposits interfinger with the near shore deposits of the Tipton Tongue deposits (sometimes referred to as the Tipton Shale Member or the Tipton Shale) of the Green River Formation. The Green River Formation contains lacustrine and fluvial-lacustrine deposits that formed in and adjacent to the ancient Eocene Lake Gosiute that covered this area from ~52.5 to 47.5 Ma (Self and others, 2011). The Tipton Shale represents the older of two major expansions of Lake Gosiute (Self and others, 2011).



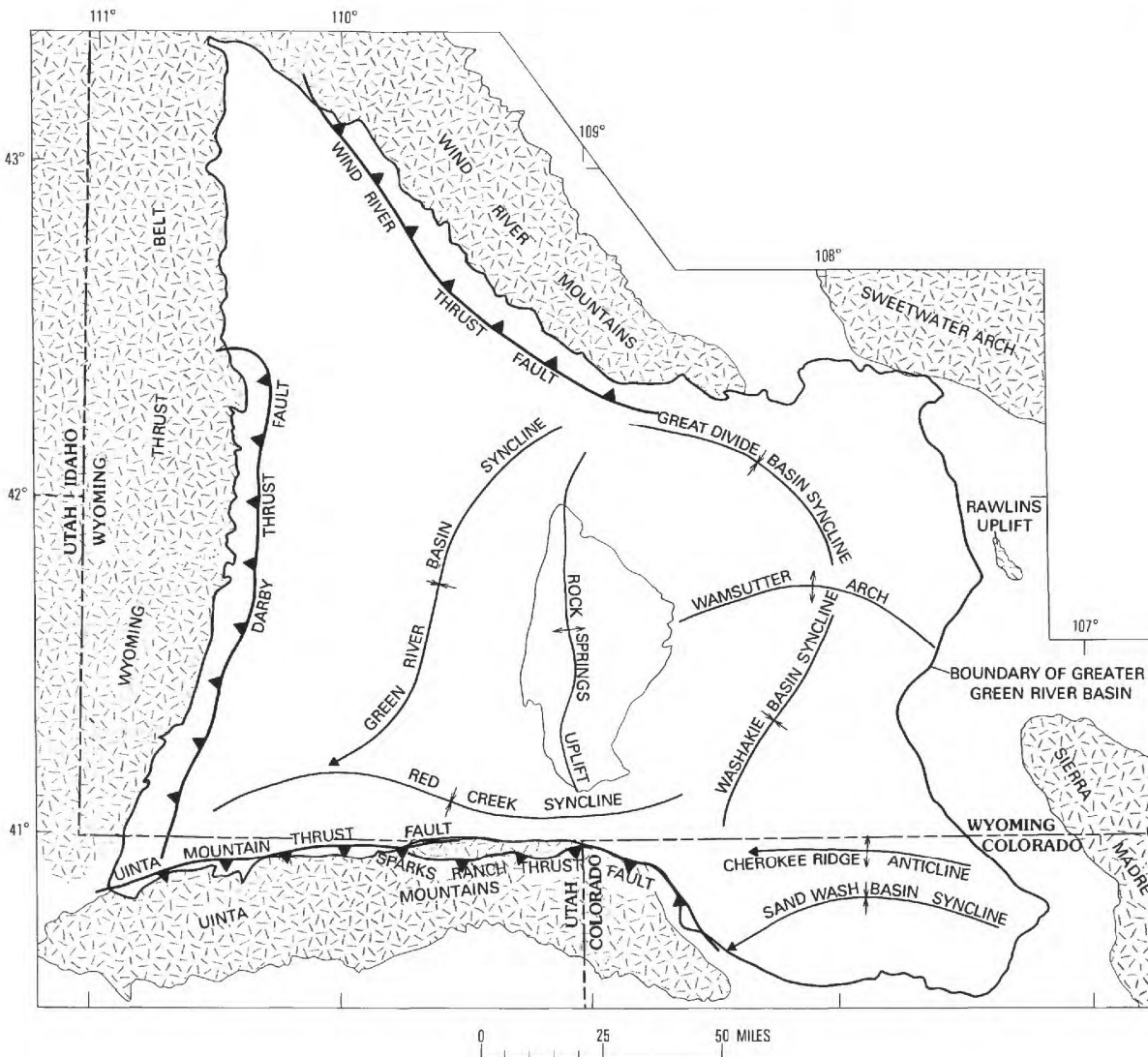


Figure 5 – Major structural features in the Greater Green River basin from Roehler (1992). Structural axes are shown on top of the Tipton Shale Member (Green River Formation) and thrust faults have sawteeth on overthrust blocks.

As summarized by Sullivan (1980; page 5), the Wasatch Formation is generally a sandstone-mudstone lithofacies with three main types of sandstone-mudstone lithofacies according to Roehler (1965; 1974) including: a red-bed fluvialite facies; a pediment facies; and a non-red fluvialite-paludal facies. As described just north of the Sand Wash Basin in Wyoming, the Cathedral Bluffs Tongue includes a red arkosic sandstone facies which has a source in the Sierra Madre to the east and, according to Sullivan (1980; page 13) “represents an alluvial slope assemblage.”

Based on surficial 1:100K-scale geologic mapping, Madole (1982) identified deposits of alluvium, colluvium, eolian, mud-flow/fans, and gravel deposits located along drainages in the north and south portion of the ISD area (**Figure 7**). This includes Holocene and upper Pleistocene alluvium terraces of secondary streams in the area as well as upper Pleistocene younger and older gravel-bearing terraces. Madole (1982) indicates that smaller deposits of

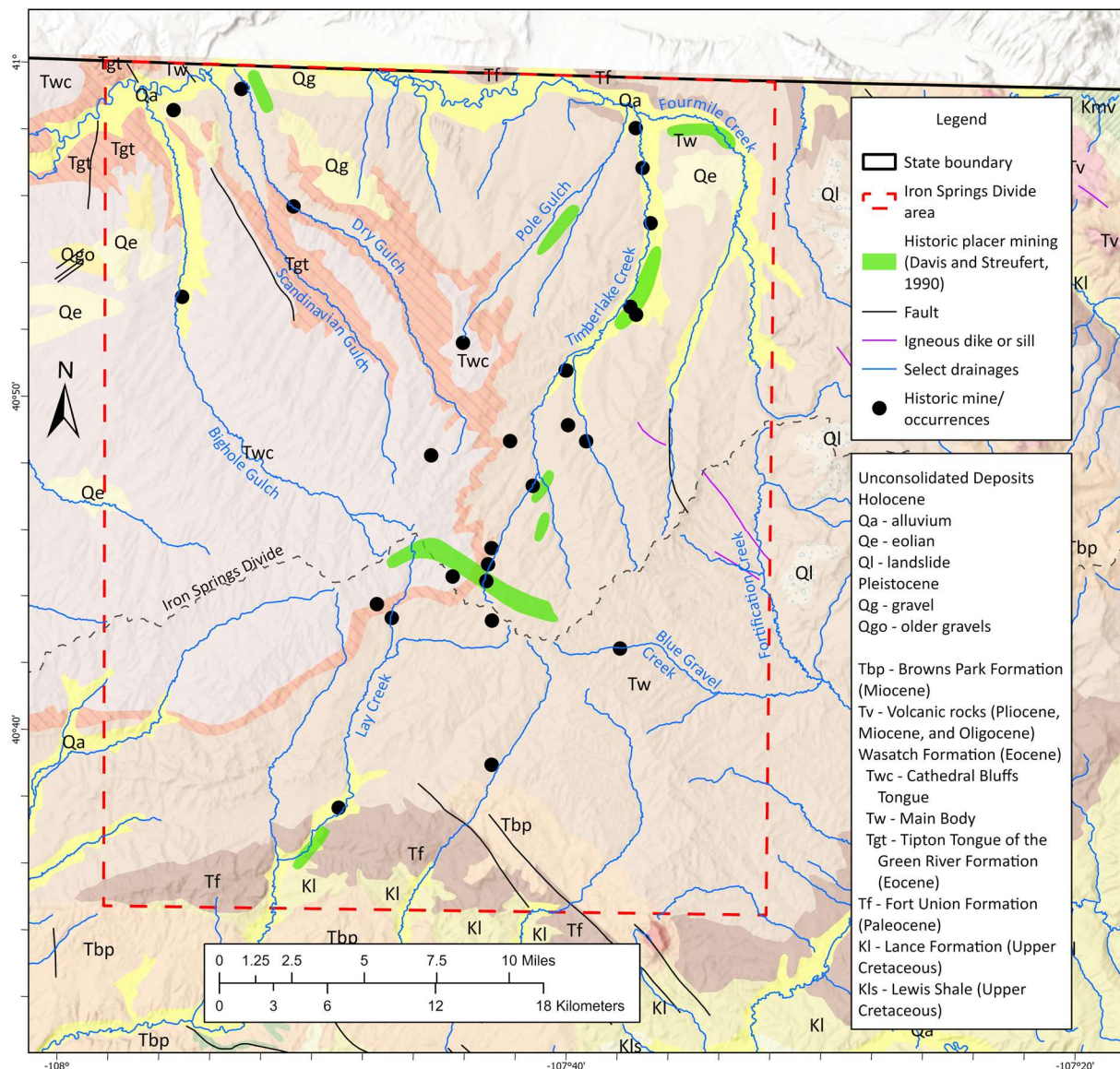


Figure 6 – Geologic map of the Iron Springs Divide Area (1:250K-scale; from Tweto, 1976). See Madole (1982) for additional surface geologic information. Historical mine/occurrences from McFaul and others (2000).

these types exist along the ISD and to the south and north, but they were too small to map at this scale. Over 75% of the ISD area, especially closer to the divide itself, was mapped as Holocene to Pleistocene residuum (sediment formed in place chiefly by disintegration of underlying bedrock) derived from Wasatch Formation (Madole, 1982). Madole (1982) describes the Wasatch Formation residuum material as:

“Granules, sand, silt, clay, and minor amounts of pebbles and cobbles of sandstone, Upper part of the residuum contains abundant coarse sand and granules over much of the area, and probably more than 10 percent clay in most places. Claystone is common in the Wasatch Formation and locally gives rise to a residuum dominated by clay..... Generally, 1-2 m (meters) thick, but less than 1 m on steep slopes (greater than 14 degrees). Grades downward to weakly to well-cemented Wasatch Formation (Eocene). Includes many small outcrops of Wasatch.....Also includes a minor amount of sandy to

clayey residuum from the Tipton Tongue of the Green River Formation (Eocene); several small, widely distributed deposits of windblown sediment, generally less than 1 m thick; and sheetwash and stream alluvium 1-3 m thick on the floors of many valleys that are too small to map.”

Detailed (e.g., 1:24-scale) geological maps in the ISD area are sparse and only a few exist along the southern boundary of the ISD area (Brownfield and Anderson, 1988; Morgan and others, 2014). To the north of the Iron Springs Divide (**Figure 1**), little detailed geological mapping has been conducted below ~1:100K-scale except for Theobald (1970) who conducted preliminary geological mapping in the area (1:96K-scale) and was one of the few authors to contain information about gold occurrences, discussed below, in his geological map descriptions. A summary of the geology presented in the southeast tip of the ISD area (Morgan and others, 2014) and north of the ISD area (Theobald, 1970a) is provided in **Table 3**.

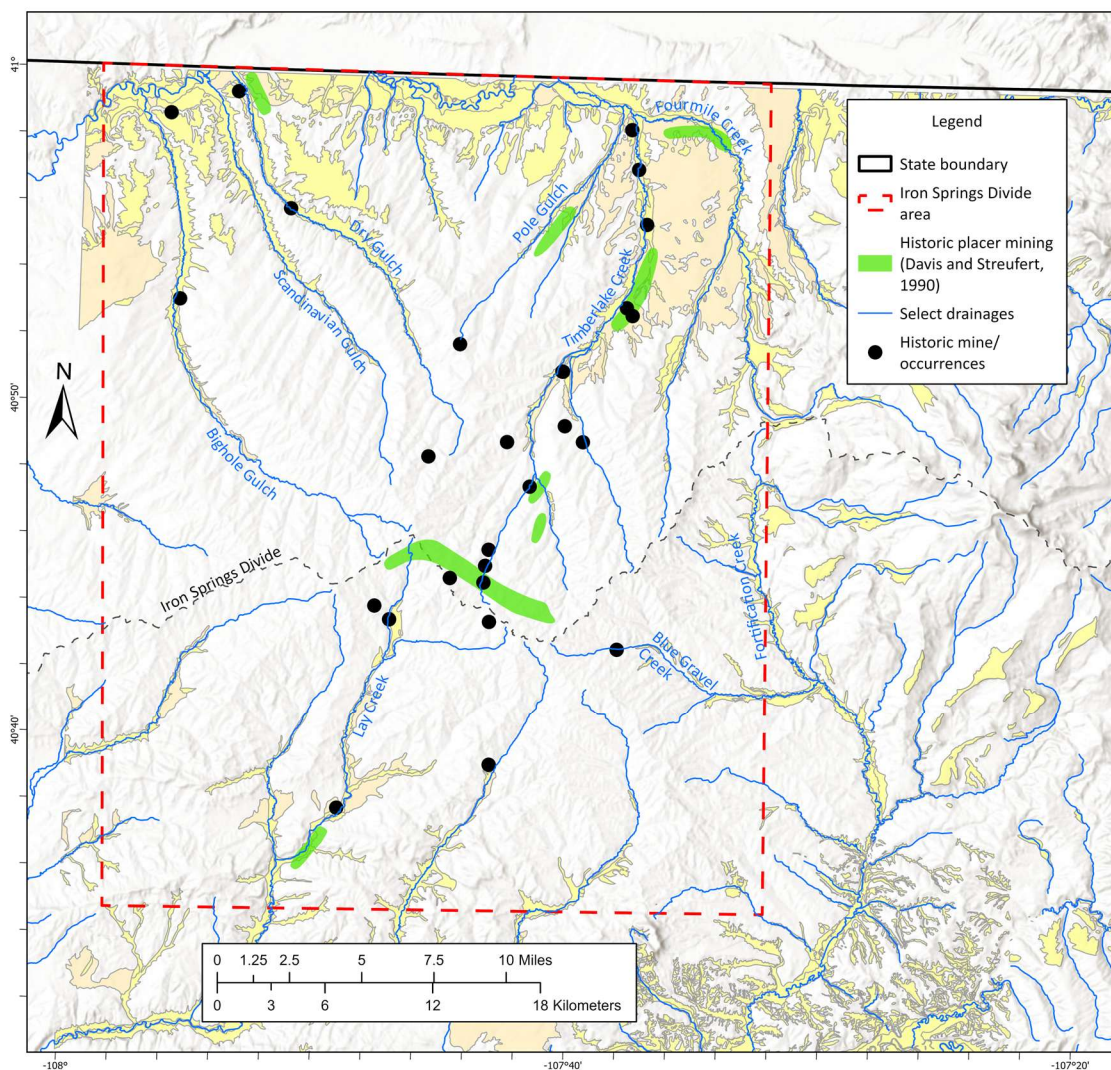


Figure 7 – Map showing the surficial extent of Holocene-Pleistocene alluvium (1:100K-scale) in the Iron Springs Divide area (Madole, 1982; Lindsey, 2023). Smaller deposits were not mapped. Yellow areas along drainages include alluvium (Qa/Qau), colluvium (Qac), mud-flow/fans (Qaf/Qafo), and gravel deposits (Qgy/Qgo/Qgp/Qgt). Light tan areas represent eolian sand deposits.

Morgan and others (2014) identified a late Holocene and older early Holocene to late Pleistocene alluvium in the southeast corner of the ISD area. The maximum exposed thickness of the younger alluvium, deposited <5-feet above active stream channels, and older alluvium, located between 5 and 15 above active channels, is ~10 and over 15-feet, respectively (Morgan and others, 2014). Several terrace deposits were also identified by Theobald (1970a) north of the ISD (**Table 3**).

The Wasatch Formation contains multicolored (reddish-brown, lavender, yellow, tan) mudstone and siltstone with buff colored sandstone. A weakly cemented and stratified conglomerate with gravel to cobble-sized clasts (quartz, granite, red sandstone, chert, petrified wood, andesitic/dacitic volcanics, mudstone, shale, and rare gneiss) occurs near the unconformable basal contact with the underlying Fort Union Formation (Morgan and others, 2014). This basal conglomerate contains interbedded ~5-feet thick zones of poorly cemented and cross-bedded sandstone (**Table 3**) (Morgan and others, 2014). The local geology at some of the specific areas where gold mining occurred is discussed below.

Detailed stratigraphic sections of one mining area were completed by Lidstone (1981) as summarized here. Lidstone (1981) performed sedimentological analysis of the fluvial deposits, within the lower member of the Wasatch Formation, in Housel Gulch (**Figure 1**) to evaluate the development and distribution of alluvial placer deposits. Two rock types of the Wasatch Formation are present at Housel Gulch: a variegated arkosic claystone and sandstone composed mostly of granitic material and, above and below this, variegated claystones with minor fine-grained sandstone lenses. A conglomeratic arkose is deposited near the base of the arkosic units with pebbles averaging 0.7 to 2.5 centimeters (cm) (~0.26 to 1-inch) (Lidstone, 1981). To the south and east of Housel Gulch, the Tipton Tongue contains fossiliferous sandstone, shale, and oil shale and locally, a few claystone beds and several arkosic lenses. At Housel Gulch, it consists of one thin sandstone bed but is several hundred feet to the northwest, towards Dry Gulch, and contains (Lidstone, 1981; page 113) *“deeper water lacustrine sediments (oil shales) at the top of the section”* and *“locally interfingers with the arkose and claystone beds of the Wasatch Formation.”*

GOLD AND HEAVY MINERAL DEPOSITS

Several historic reports document the local geology, nature of the gold deposits, fine-grained nature of the gold, and scarcity of water in the area (Snow, 1895; Hoover, 1897; Marks, 1903 [**Appendix B**]; Gale, 1908; Marks, 1915 [**Appendix C**]; Vanderwilt and others, 1947). It is difficult to determine from some early historical accounts if gold was mined from Quaternary terrace and channel alluvial deposits or from residuum associated with the Eocene rocks in the area. Thurston (1965; page 5) reports that gold-bearing gravels generally cover most of the district *“with little regard to the underlying topography”* and that the deposits should be termed *“sands”* composed of *“loose, fine material, sometimes cemented with a calcareous matrix, with no boulders, and cobbles are present only in the eastern portion of the district along the slope of (the) Elkhead Mountains.”* Subsequent mapping and documentation indicate that the gold and heavy mineral deposits associated with the ISD area occur in both paleoplacer deposits, within the Wasatch Formation and Tipton Tongue (**Figure 6**), as well as in Holocene to Pleistocene

alluvial deposits where post-canyon forming processes reconcentrated this material (Parker, 1960; Parker, 1974; Roehler, 1973; Theobald, 1970a).

Theobald (1970a) indicates that gold, and a heavy mineral suite rich in monazite, occurs (from oldest to youngest) in the arkosic tongue of the Wasatch Formation, the interbedded Tipton Shale Member (sometimes referred to as the Tipton Tongue) of the Green River Formation, and the Cathedral Bluffs Tongue (Cathedral Bluffs) of the Wasatch Formation (**Table 3**). There is no mention of gold within his descriptions of Quaternary alluvial deposits. However, he does indicate in a different publication that (Theobald, 1970; page A6),

“the placer deposits flanking Iron Springs Divide, Moffat County, Colo., have a local source in arkose lenses of an Eocene deltaic fan. The base and northern limit of these lenses are well defined in north-facing bluffs south of the Little Snake River, thus defining the northern limit of possible placers derived from this source.”

Reportedly (Lidstone, 1981, page 4), the paleoplacers in the lower member of the Wasatch Formation at Housel Gulch “are concentrated in zones of maximum reworking, notably in the channel lag and channel margin deposits of the Eocene streams.” Additionally, with regards to modern alluvial placers at Housel Gulch, the (Lidstone, 1981; page 4)

“deposition, concentration and preservation of heavy mineral placers at Housel Gulch is a three state process: 1) episodic introduction of mixed sediment during major flow events; 2) reworking and winnowing of heavy minerals during lower, seasonal flows (and); 3) burial of placers during very low flows.”

The source of the Eocene-age paleoplacer gold is unknown. Currently, no known primary gold or other base metal mineralization occurs in the area. Prommel (1942; page 4) (**Appendix D**) indicates that the ISD area:

“was a large alluvial fan or outwash plain deposited on a peneplained surface. This fan consisted of silt, sand and gravel obtained or originating in the mountains to the east which at the time must have been much higher but which since have been lowered by denudation.”

Additionally, Roehler (1973) reports that the placer gold deposits in the Eocene bedrock within the ISD area may have been sourced from bedrock gold deposits located to the east in the Park Range. However, the closest known gold deposit (~32 miles to the east) is in the Hahns Peak Mining District and these deposits are younger in age. Other potential sources include the Proterozoic rocks in the North Park Range/Sierra Madre area located to the east. Although some authors (Marks, 1903; 1915) hypothesized that the sand and gravel in the area were lake deposits, Thurston (1965, page 6) reports that:

“There is little evidence of the sorting and stratification associated with stream deposition, although such is the case in isolated small areas. There is no evidence that these sands are the result of the re-working of ancient stream channels. The lack of lake terracing and gradational sizing from the mountains westward casts serious doubt upon the origin of the deposits as lake sediments. This enigma, although scientifically interesting has no point of further discussion....”

Southeast corner of the Iron Springs Divide area from Morgan and others (2014; 7.5-Minute Craig Quadrangle, 1:24K-scale).		
Age	Geologic Unit	Lithology/Description
Quaternary	Holocene to Late Pleistocene alluvial fan, sheetwash, colluvial, and landslide deposits	Varies, see Morgan and others (2014).
	Late Holocene alluvium	Poorly to moderately sorted, poorly to moderately consolidated, sand, gravel, silt, and minor clay and sparse boulders in the currently active stream channels or in low stream-terrace deposits < 5-feet above active stream channels. Maximum exposed thickness of the unit locally exceeds 10-feet. Clasts are subrounded to well-rounded with dominant sand with a sandy silt matrix with localized gravels. Alluvium deposited along Fortification Creek consists of at least 10-feet of sand and silt over a pebble and cobble gravel of granite, gneiss, quartzite, chert, basalt, and rare andesite.
	Early Holocene to Late Pleistocene alluvium	Poorly to moderately sorted, moderately to well-consolidated, silt, sand, gravel, and minor clay and boulders in stream terrace deposits ~5-15 feet higher than the active stream channel or as alluvium in valley headwaters. The sediment is dominantly sand with a sandy silt matrix with subrounded to well-rounded clasts. Maximum exposed thickness of the unit locally exceeds 15-feet.
Oligocene - Miocene	Browns Park Formation	Sandstone unit – Moderately calcareous, poorly sorted to moderately cemented, fine- to medium-grained, arkosic and tuffaceous sandstone and siltstone interbedded with mudstone and conglomerate. Mudstone beds often have pedogenic textures and numerous burrows. The exposed thickness of the sandstone unit within the Craig quadrangle is ~820-feet.
Eocene	Wasatch Formation	Variegated reddish-brown, lavender, yellow, and tan mudstone and siltstone with buff colored sandstone and conglomerate near the unconformable basal contact with the underlying Fort Union Formation. The conglomerate is weakly stratified and consists of gravel to cobble-sized clasts of white quartz, granite, red sandstone, chert, petrified wood fragments, andesitic and dacitic volcanics, mudstone, shale, and rare gneiss. Zones of poorly cemented, cross-bedded sandstone, up to 5-feet thick are interbedded with the conglomerate which is typically weakly cemented.

North portion of the Iron Springs Divide area from Theobald (1970a; Preliminary Northern Half of Craig 1 x 2 degree, 1:96K-scale)		
Age	Geologic Unit	Lithology/Description
Quaternary	Holocene and Pleistocene landslide and slump debris	Conspicuously developed east of Fortification and Fourmile Creeks, where relief is maintained on incompetent claystones by resistant mesa caps of volcanic debris.
	Pleistocene and Holocene alluvium	Alluvium of the active flood plains. Largely sand of local derivation along minor streams.
	Pleistocene and Holocene eolian sand	Transverse dunes predominate.
	Pleistocene and Holocene boulder terrace deposits	Composed largely of angular blocks from the volcanic rocks of the western part of the Elkhead Range, to the east. Confined to the area along and east of Fourmile and Fortification Creeks.
	Pleistocene and Holocene cobble-gravel terrace deposits	Caps mesas of at least four levels south of the Little Snake River. Composed largely of well-rounded igneous and metamorphic cobbles derived from the Park Range to the east but includes some pebbles and cobbles from the volcanics in the Elkhead Range and a few angular blocks of local derivation.
	Pleistocene and Holocene terrace sand or gravelly sand deposits	Composed locally derived arkosic sand.
Eocene	Wasatch Formation, Cathedral Bluffs Tongue	Variegated claystone and sandstone of fluvial origin. Coarse arkoses abundant throughout contain a heavy-mineral suite rich in monazite and, locally, gold.
	Green River Formation, Tipton Tongue (Tipton Shale)	Drab brown to gray fossiliferous sandstone and papery shale. Locally includes several coarse arkose lenses and one or more claystone beds. Thickens abruptly from a single thin sandstone at the south edge of the map on Housel Gulch to several hundred feet along Dry Gulch by addition of lacustrine sediments at the top of the section. Arkose contains a heavy-mineral suite rich in monazite and, locally, gold.
	Wasatch Formation, Arkosic Tongue (Main Body)	Variegated claystone and sandstone lithologically similar to the Cathedral Bluffs Tongue. Arkoses abundant throughout are composed almost entirely of material derived from a granite. The base is well defined by a persistent conglomeratic arkose. The heavy-mineral suite is rich in monazite and, locally, gold.
	Wasatch Formation, Claystone Member (Main Body)	Predominantly variegated claystones with minor fine-grained sandstone lenses. Shale-pebble conglomerate is locally common in the eastern part of the mapped area.

Table 3 – Summary of the Quaternary- Eocene geology in the southeast corner (top) and north portion (bottom) of the Iron Springs Divide area. Note that Theobald (1970b; page A6) indicates that the placer deposits flanking the ISD were sourced from arkosic Eocene deltaic fan deposits of the Wasatch Formation and Tipton Tongue.

However, others speculate that the ISD area is a (Prommel and Hopkins, 1968; pg. 92)

“remnant of an outwash plain or fine-grained alluvial fan of gold-bearing gravels and sand that at one time must have covered approximately 900 square miles. The bench deposits formed by gradual erosion of this large alluvial fan and redeposition on stream terraces at various elevations along the tributary gulches.”

Parker (1974) reports that gold is increasingly abundant in terrace and floodplain gravel deposits the farther distance away from the ISD (Parker, 1974). Parker (1974; page 165 and 166) indicates that:

“The gold of the district was derived from such fossil placer deposits in the lower Cathedral Bluffs member and possibly in the Tipton Tongue of the Green River Formation. That these fossil placers were derived from the Park Range to the east is shown by the cobbles found in the modern gravels derived from the strata containing them.....These placers are two kinds. The placers worked in the drift mines are fossil beach and alluvial placers formed in early Eocene time. The terrace and stream deposits are alluvial placers derived from the erosion and reworking of the fossil placers. Their formation probably began in late Pliocene or early Pleistocene time.”

Historically, most of the mining claims appear to be along the larger ephemeral streams and washes draining from the ISD. Although some gold also occurs in the modern stream gravels including areas at the Law Dredge Mine (**Figure 1**) and in Housel Gulch (Parker, 1974), many of the gold deposits were mined from the terrace gravels above the main channels of these streams. Terrace gravels were mined along Lay Creek and the west side of East Timberlake Creek as well as terraces between Timberlake Creek and Housel Gulch (**Figure 1**). The thickness and nature of these deposits vary but several authors report the following:

- Marks (1903) indicates that the Law Dredge (**Figure 1**) operates using water from a ditch built from Willow Creek to Fourmile Creek and that the dredge works a bar between two gulches along Fourmile Creek. Gold deposits reportedly increase from the Little Snake River north to the Iron Springs Divide and seem to be concentrated on wide flat bars than in the main gulches.
- Gale (1908; page 88) indicates that the richest gold deposits *“lie on a bar or terrace ranging from 20 to 100 or more feet above”* the present bottom of the dry washes.
- Marks (1915; page 3) reports that Mr. Gooldy, who worked placer mines in the district for many years, has *“traced channels for a distance of one mile in length and 1,320 feet in width and from every indication they continue much farther.”*
- Vanderwilt and others (1947) report that the gold deposits are within sand and gravel deposits (mostly sand), up to 30 feet thick in a 30- by 40-mile area, which are not associated with current drainage channels and lie on sandstones and shales. The gold deposits north of Lay, on Lay Creek south of the ISD, occur in sand and gravel terraces 20 to 100 feet above the present creek.
- Reportedly, better gold-bearing deposits occur 20 to 100 feet above the bottom of deeper washes south of the ISD and appear to have been deposited in a larger stream valley than the existing drainages (Thurston, 1965). On the south side of the ISD (**Figure**

1), this deposit or bar is ~70-feet above Lay Creek and drops to ~20-feet above the creek further to the south where it is covered by overburden (Thurston, 1965).

- Placer workings further down from the ISD in the Timberlake, Fourmile Creek, and Pole Gulch areas were mostly within a 20 to 30-foot-thick terrace deposit down to bedrock. Parker (1974; page 157) indicates that the “gravels” of the Iron Springs Divide area “are more properly sandy mantle alluvium which contain a few cobbles.” A terrace 20 to 30 feet above Timberlake Creek was mined and the material was similar to the Blevins dredge area along Lay Creek (**Figure 1**). Also, on Fourmile Creek, terraces occur on both sides of the creek, and the “gravel” is like the other deposits but is overlain by silty sand and eolian sand in places (Parker, 1974).
- Lidstone (1981) indicates that some of the better gold placer deposits are 20 to 100 feet above the modern channels along Timberlake Creek and Housel Gulch (**Figure 1**). As drainages developed in the Pliocene/Pleistocene, the paleoplacers in the Wasatch Formation were reworked and deposited in these terraces and modern placers are formed along the modern channels.

Parker (1974) indicates that gold is not abundant on top of bedrock and that the uppermost layers of the terrace gravels appear to contain higher concentrations of gold in areas. However, he also indicates that there were no zones of gold enrichment in these terrace gravels. Along the top of the ISD near Lay Creek, as well as in the headwaters of Housel Gulch (see Lidstone, 1981) on the north side of the divide (**Figure 1**), gold in the “mantle material” decreases above bedrock which includes a 5-foot thick arkosic grit cemented with iron oxide (Parker, 1974). Drift mining occurred in these areas and was conducted at the Iron Springs Mine as well as in Housel and Dry gulches (**Figure 1**). These drift mines reportedly were driven along poorly consolidated sand and gravel channels in the lower part of the Cathedral Bluffs member of the Wasatch Formation (Parker, 1974). In other areas, although high concentrations of black sand and gold near bedrock have been reported, it is difficult to determine from historical descriptions if mining was conducted in bedrock, eroded bedrock, or overlying terrace material (Parker, 1974). Gale (1908; page 90) states:

“No clearly defined bed rock can be traced from place to place among the prospects that show pay dirt. In places it is pointed out to be a coarse white sand, while the overlying pay dirt is composed of similar though more clayey material, the latter probably constituting the true bed rock which has served for the retention of the gold. At other places the bed rock is said to be a mottled clay of irregular pink and blue-gray patches underlying the sand or gravel pay dirt. Evidence seems to indicate that the agency which has served to retain the gold is the clay, which occurs either in the form of well-defined beds or mixed in certain layers of the gravel. The clay readily separates in water, however, and does not interfere with the recovery of the gold in washing. To judge from the descriptions given of values and pay streaks in a number of pits and trenches visited in the vicinity of the Iron Springs bar, as well as the present shallow digging policy at the (Blevins) dredge, it seems a warrantable conclusion that the values are irregularly distributed in depth throughout the body of the gravel or sandbar deposits. Although it would thus not be strictly true to state that the values are uniformly distributed throughout the gravel, any project for the recovery of the gold will probably have to consider the handling of practically the whole of that material from top to bottom...”

Most of the gold occurs as very fine-grained well-rounded nuggets (Gale, 1908; Parker, 1974) throughout the district. Other reports indicate that the fine gold is angular (Thurston, 1965). In one area, gold occurs in well-rounded fine-grained nuggets and the final gold concentrates after processing, are notably free from heavy black minerals such as magnetite, ilmenite, etc. (Gale, 1908). However, Gale (1908) reports that some panned and concentrated samples had less than about one-third of dark minerals (e.g., heavy minerals) with the remainder composed of garnet, other clear colorless minerals, and zircon (Gale, 1908). Roehler (1973) reports that the Eocene arkoses contain ~2% heavy minerals but that the local Pleistocene-Holocene age terrace deposits have pockets with up to 50% reworked and concentrated heavy minerals. Reportedly, the arkoses with the highest gold concentrations only contain 1 part per million (ppm) gold but smaller heavy mineral concentrated material can contain up to 0.3% gold (10 ounces per ton) (Roehler, 1973). Roehler (1973; p. 55) indicates that these gold-bearing heavy mineral concentrates contain monazite, rutile, and columbite; and that these areas are *“too small and widely spaced to support a large commercial enterprise operation at present, though small and intermittent operations continue to be active.”*

Several detailed stratigraphic sections of the arkosic and claystone beds of the Wasatch Formation were measured in a Housel Gulch prospect pit (Lidstone, 1981). At each location, five sub-facies were recognized within a generally fining upward sequence representing a fine-grained meander belt sequence. Spectroscopic analysis of samples from the Wasatch Formation indicated that the channel deposits (lower and coarser grained horizons) within the Wasatch Formation, as well as channel margin deposits, contained the highest concentrations of heavy minerals. Lidstone (1981; see pages 129 to 130 for a more detailed account) recognized heavy mineral laminae and areas that contained higher concentrations of heavy mineral deposits within these channel deposits. Lidstone (1981) concludes that the streams in the Wasatch Formation had low gradients near the ISD and that the angular nature of the pebbles and gold in this area indicate that the transportation distance was relatively short. Analysis of 58 bulk stream sediment samples collected along a longitudinal profile of Housel Gulch in the modern channel detected silver (0.5 to 10 ppm), lanthanum (20 to >10,000 ppm), thorium (100 to 1,500 ppm), and gold (0.19 to 1.10 ppm) (Lidstone, 1981).

Other Minerals

Zimmerman (1960) (**Appendix E**), who mined at a property just west of the Housel Gulch mines (e.g. Farnsworth) on the northside of the divide, reports that the black sands associated with some of the gold-bearing sands and gravels contained monazite, garnet, titanium, thorium, zirconium, and other minerals (**Figure 1**). At the Farnsworth Mine (**Figure 1**) located in Housel Gulch, a black-sand-rich lens in the Cathedral Bluffs Member of the Wasatch Formation contained 28.7 pounds per cubic yard (lbs/cy) of total heavy minerals containing gold, ilmenite, euxenite, columbite, and rutile (11.5 lbs/cy); monazite (6.8 lbs/cy); magnetite (3.4 lbs/cy); and non-magnetics (3.4 lbs/cy) containing mostly zircon and quartz with minor feldspar, garnet, ilmenite, and magnetite (Parker, 1974; see page 160). However, the tonnage of this material was reportedly very small, occurring in pockets containing up to 1,000 tons, and occurred in discontinuous pockets stratigraphically (Parker, 1974).

As indicated above, several authors report that some of the placers contain rare earth element (REE)-bearing minerals like monazite. Reportedly, one of the most significant monazite placers

is associated with Timberlake Creek (**Figure 1**). According to Staatz (1968; p. 135), “*Day and Richards (1906, p. 1192-1193) report that two samples taken from sand near Timberlake (No. 1), Moffat County (known as Routt County back then), contained 416 and 520 pounds of monazite per ton of black-sand concentrate, which according to W.C. Overstreet (written communication, 1964), represent one of the highest grades samples known for black sands in western United States.*” Day and Richards (1906) also report that these samples contained up to 80 pounds per ton (lbs/ton) zircon as well as large quantities of ilmenite (582-792 lbs/ton) and garnet (448-542 lbs/ton).

More recent exploration activities in 1984 reported the results associated with the analyses of heavy mineral concentrates from the Joker and Bailey claims area (**Figure 1**) (Carpco, 1984) (**Appendix F**). A sample from the Joker Claim contained mostly titaniferous magnetite, ilmenite, almandine garnet, monazite, spessartine garnet, and lesser amounts of hematite, rutile, andradite garnet, allanite, zircon, and K-feldspar. Interestingly, a small amount of native iridium was also detected in the sample (Carpco, 1984).

Marathon/Centennial Exploration (Centennial) performed exploration activities in the area in the 1980s (Centennial, 1985) (**Appendix G**). They reported gold grades between 0.012 to 0.022 ounces per ton with ~0.06 to 0.09% monazite and xenotime. In 1990, Blue Jet Mining Company (Blue Jet) also reported elevated REE-bearing mineral sands from the Wasatch Formation (Blue Jet, 1990 (**Appendix H**). An analysis from a sample collected from their property contained 20.5% rare earth oxides (REO) with approximately: 39.95% cerium oxide; 18.06% lanthanum oxide; 16.11% neodymium oxide; 8.14% thorium oxide; 5.16% yttrium oxide; and 4.57% praseodymium oxide. Other REOs were also detected (see **Appendix H** for the results).

Other commodities have been reported in these deposits including platinum group elements (PGE). For example, Thurston (1965) (**Appendix H**) reported that platinum and palladium occur over a broad area within the gold-bearing placers. Samples collected and analyzed from the Fourmile Creek area placer sands contained a significant amount of Au, Ag, Pd, and Pt (Thurston, 1965).

At the time of this report, there is one active surface gold mine in the ISD area at the West Side Placer (**Figure 1**) (DRMS, 2026). More recently (2023), at least one company has proposed to conduct placer mining on ~514 acres at the West Side Placer (**Figure 1**) to recover gold, monazite, titanium minerals (ilmenite, euxenite, columbite, and rutile) as well as secondary garnet, magnetite, zircon, PGEs), sand, gravel, and clay. Mining targets include 8 to 40 feet (average = 20 feet) of unconsolidated alluvium (overlain by 8- to 12-inches of topsoil) at the surface that is derived from the “*Eocene fossil beach and alluvial placers*” and overlies the Wasatch Formation (DRMS, 2026).

Some authors indicate that the miners in the 19th century and later during the depression years failed to mine enough gold due to the lack of water and the use of older machinery/techniques (Thurston, 1965). As reported by Parker (1974), magnetic and radiometric surveys could assist with gold exploration efforts in the ISD area due to the abundance of magnetite and monazite. Besides the terrace gravels, there are likely areas with higher gold and other associated heavy mineral concentrations in paleoplacer channels within the lower Cathedral Bluffs member of the Wasatch Formation. However, these deposits may be limited in vertical and horizontal distribution and may be more suited for smaller mining operations (Parker, 1960; 1974).

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APPENDICES

APPENDIX A

Thurston, R.H., 1965, Report on the gold-platinum placers: unpublished manuscript, 4 May 1965.

RALPH H. THURSTON REPORT

REPORT ON THE GOLD-PLATINUM PLACERS

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INTRODUCTION

This report deals with some of the broader aspects of the geology and metallurgy of the gold-platinum placer deposits of the Four-Mile Placer Mining District, Colorado. More specifically, emphasis is placed upon recent work performed at the instigation of Mr. Russell Twiford, of Denver, Colorado.

The geology of the region has been described in detail by previous investigators, most notable among them being Mr. Herbert Hoover (1) whose report of May, 1897, is probably the most comprehensive with regard to the geology, operating conditions, methods of attempted recovery, and theories as to the possible source and conditions of deposition of the placer sand and gravels. A report by Hoyt S. Gale (2) of the U.S. Geological Survey, outlines in detail the early history of the area and the geology of the southern part of the district.

Recent investigations, undertaken in 1964 by Mr. Twiford, have shown that substantial amounts of gold, platinum, palladium and silver may be recovered by modern metallurgical methods, using equipment readily available to the industry, and that an operation designed to use these methods and equipment is feasible and economically sound. A well-planned enterprise has every reasonable assurance of success and substantial profit.

None of the early writings detail information on metals other than gold and silver in the Four-Mile gravels, and all early attempts

to operate in the district were concerned with the recovery of gold alone. Two possibilities exist for this singlemindedness of purpose; (1) That the early operators were unaware of the presence of the platinum, rare earths and other metallic constituents, or (2) That market conditions were such as to make the metals other than gold and silver of low value. Certainly, the rare earth minerals were of no importance, as markets had not as yet developed, and it is probable that marketing problems might have existed with regard to the platinum assuming that the early operators were aware of the platinum content. Much investigative work remains to be done on the rare earth minerals and on the platinum and palladium in the gravel.

The gold in the Four-Mile District is of exceptional purity, and is reported to range from 885 to 960 in fineness. However, crude methods of recovery, extreme fineness of the gold particles, and the scarcity of water reduced the early operations to un-economic ventures. Great interest was shown in the district during the latter part of the nineteenth century, was revived briefly during the depression years between 1932 and 1940, and has dwindled since that time. Ignorance can be the only reason for this lack of interest, much interest and activity will develop with the erection of the first modern plant in the area.

LOCATION, TOPOGRAPHY, HISTORY, AND PRODUCTION

The Four-Mile Placer Mining District encompasses that area lying generally west of the Elkhead Mountains, east of Powder Wash,

south of Baggs, Wyoming, and North of Craig, Colorado. The bulk of the area is in extreme northwestern Colorado, in Moffat County, and extends a short distance into Wyoming in the southwestern corner of Carbon County. The district is some 30 miles wide by 40 miles long in a rough triangular form with the highest part of the district along an east-west line near the center of the district. The placer area is dissected by the Little Snake River, Timberlake Creek, Lay Creek, and the Yampa River, as well as by many gulches and washed^s, notably Big Hole Gulch, and the North Fork of Big Gulch.

The predominant topographic feature of this area is a broad undulating plain with a divide, known as the Iron Springs Divide, that roughly bisects the district. The divide is of general east-west trend, and separates the Little Snake River and Timberlake Creek drainages on the north from the Lay Creek and Yampa River drainages on the south. The Iron Springs Divide is not an especially prominent topographic feature and is a broad ridge with gentle slopes both to the north and to the south.

According to Gale, the gold deposits were first discovered in 1887 in Four-Mile Culch and in Dry Gulch near the northern part of the district and in the Little Snake drainage. Many claims and groups of claims were located sporadically across the area, and early attempts were made to wash the gravels with methods borrowed from the California placers. Hydraulic mining and ground sluicing were the order of the day. These methods were largely unsatisfactory and the operations money losers, although they did produce a substantial amount of gold, taken as a whole. They were limited to the use of

run-off water, spring water, and the water derived from ditching the available small streams, a meager amount at best in an area of marked aridity.

In 1905, a dredge was installed in the southern one-third of the district on the Blevins property and operated for a few years with indifferent success. The gravel is reported to have contained from 25 cents to as much as several dollars per cubic yard, and in at least one locality to have averaged \$2.40 per cubic yard (values reported on the prevailing price of gold of \$20.69 per troy ounce). With this grade of material upon which to work a dredge, the fact that the operation was unsuccessful is unmistakeably due to poor recovery techniques and equipment.

Elsewhere in the district most of the operators were faced with severe water shortage problems and limited production.

Following scattered exploration work and minor production during the period 1932 through 1935, some nine producers obtained about 1785 ounces of gold from operations along Four-Mile Creek and Timberlake Creek in the period between 1936 and 1938. Total production from this specific area between 1932 and 1940 is listed as 2,187 ounces of gold and 109 ounces of silver sold through the U.S. Mint. Other operations were undoubtedly carried on, and certainly much of the recovered gold was not sold through normal channels and is, therefore unrecorded production.

GEOLOGY

As other writers have detailed the geology of the Four-Mile Placer Mining District and the surrounding area, the writer will

present only a resume of conditions. The data are well substantiated and no reason exists to doubt the authenticity of any of the earlier writings, all made by competent observers of excellent repute. The purpose and scope of this report are so limited as to preclude the reams of description necessary to adequately describe the area in detailed fashion.

The auriferous gravels cover the broad expanse of undulating plain between the Little Snake River on the north and the Yampa River on the south, and between the western slope of the Elkhead Mountains on the east and Powder Wash on the west. The gravels are distributed with great uniformity over the entire district and have been deposited with little regard to the underlying topography. They occur as linked and pillow-like lenses in places overlapping one another, and in other places are stacked one above the other. A basal "bedrock" has not been exposed in the district due to the limited amount of deeper exploration. Such gravels (sands) as presently exposed are those that appear along the margins of the various washes, and these are only incompletely explored and exposed.

The gravels should properly be termed "sands" as they are made up of loose, fine material, sometimes cemented with a calcareous matrix, with no boulders, and cobbles are present only in the eastern portion of the district along the slopes of Elkhead Mountains. There is little evidence of the sorting and stratification associated with stream deposition, although such is the case in isolated small areas. There is no evidence that these sands are the result of the re-working of ancient stream channels. The lack of lake terracing

and gradational sizing from the mountains westward casts serious doubt upon the origin of the deposits as lake sediments. This enigma, although scientifically interesting has no point of further discussion in this report.

Gold is present in all of the sands in varying amount, but only in certain areas is it present in commercial amount. Less is known of the distribution of the platinum minerals, and still less of the minerals other than gold and platinum.

The water supply problem is important in any projected operation. But, whereas the old time operators were largely dependent upon seasonal water supplies, modern pumping equipment can easily supply any projected needs from relatively shallow drill holes. The presently available abundant water supply spells the difference between economic and uneconomic operating conditions.

DISTRIBUTION AND CHARACTER OF THE AURIFEROUS DEPOSITS

Auriferous gravels are exposed along the banks of nearly all of the streams, gullies, and washes in the Four-Mile District, and most of the claims taken up in the past were located along these defiles. In places, as near Iron Springs and vicinity, auriferous gravel of notable gold content crops out near and at the top of many ridges between various gullies and washes. More claims were taken south of Iron Ridge than north of it, and it is presumed that the better gravel lies south of the ridge.

South of Iron Ridge the best of the gravel lies in a rough horizon or bar some 20 to 100 feet above the bottom of the deeper

dry washes. This bar appears to have been deposited in a stream valley of greater (much greater) breadth than that presently developed by the existing drainage. At Iron Springs this bar is about 70 feet above Lay Creek and the springs. Remnants of the bar may be traced across the gulches to the tops or flanks of neighboring ridges at equivalent elevations. Southward from Iron Springs the level of the bar drops to the point that it is only some 20 feet above Lay Creek, and here it is covered by considerable thicknesses of overburden. In the vicinity of Iron Springs the bar has little or no cover and could be most easily mined. Individual lenses within the general horizon range from 0 to about 30 feet in thickness, and contain several tons to several hundreds of thousands of yards of gravel per lens.

The gold fraction within the lenses is notably clean and free and of exceptional purity. Individual particles are angular, but little rounded, and average about 3,500 colors per grain with a fineness ranging from 835 to 960. The high purity and compact shape, as well as the uniformity of particle size auger well for the ease of concentration. Data are lacking with which to assess the distribution of minerals other than gold, but both platinum and palladium occur over broad areas.

METALLURGY

Two laboratories have worked for Mr. Twiford on the concentration of the metal values in the Four-Mile District placer sands. Each has indicated acceptable methods of recovery. They are: The Hesperia Smelting and Refining Works, of Hesperia, California, Mr. Clifford

Taylor, Technician; and the Polaris Laboratory, of Phoenix, Arizona, Mr. Charles Milligan, Technician. Acceptable ratios of concentration and concentrate metal content have been indicated by each of these investigators, and the work presently accomplished has been of sufficient scope to show satisfactory methods of concentration.

Hesperia's work was performed first, and will be discussed first. Four samples were submitted with the following results:

Sample A. 2,700 pounds of bank run material was screened on 1/8" and 16 mesh screens and the products treated separately. For all practical purposes the plus 16 mesh product may be disregarded and only the minus 16 mesh fraction considered. A rough concentrate was made using a Hammond Hydro Gravity Separator. The concentrate weighed 174 pounds and came from 1,500 pounds of minus 16 mesh material. The concentrate was cleaned on a Wildley table to yield 22.5 pounds of cleaned concentrate that assayed 12.70 ounces gold, 13.70 ounces silver, 1.90 ounces palladium, and 0.30 ounces platinum per ton of concentrate. The ratio of concentration calculated against the head sample weight represents 125 to 1, but calculated against the minus 16 mesh screen product weight of 1,500 pounds represents a ratio of concentration of 67 to 1. On this basis the value of the minus 16 mesh fraction is worth \$7.34 per ton or \$11.01 per yard.

Sample B. Unsatisfactory concentration - reason unknown.

SAMPLE C. 2,297 pounds of bank run material was screened on 16 mesh to produce 1,620 pounds of minus 16 mesh sand. The hydro gravity concentrate weighed 162 pounds and assayed 1.20 ounces gold,

2.00 ounces silver, 0.40 ounces palladium, and 0.02 ounces platinum per ton of concentrate. This rough concentrate was not cleaned, but the rough concentrate, calculated against the minus 16 mesh product weight of 1,620 pounds yields a ratio of concentration of 10 to 1 and a screened product value of \$4.65 per ton or \$6.98 per yard.

SAMPLE C & M NO. 1 5,083 pounds of bank run material was screened at 20 mesh and the minus 20 mesh fraction concentrated in the Clark Cone, and the cone concentrate cleaned on the Wilfley table. This concentrate was apparently more carefully cleaned as the finished concentrate weight was only 12 pounds. This product assayed 19.00 ounces gold, 20.99 ounces platinum, and 2.00 ounces palladium per ton. Calculated against the original sample weight of 5,083 pounds, a ratio of concentration of 423 to 1 is indicated and a bank run worth \$6.43 per ton or \$9.65 per yard. This test is unique, inasmuch as the ratio of concentration of the platinum fraction is abnormally high, the other test samples considered.

The Polaris Laboratory split a bulk sample of bank run sand to yield a laboratory size sample. This sample was ground to 100 percent minus 80 mesh, and a size separation made at 200 mesh. The minus 80 to plus 200 mesh fraction was concentrated in a Knudsen Bowl and the bowl concentrate cleaned with a static air table. The minus 200 mesh fraction was discarded after inspection revealed appreciably no metallic values therein. The minus 80 mesh to plus 200 mesh concentrate (cleaned) assayed 5.64 ounces gold, 0.36 ounces platinum, and 0.15 ounces silver per ton of concentrate. For all practical purposes the silver content may be disregarded. At the

attained ratio of concentration of 12.76 to 1 and a value of \$232.32 per ton, the bank run sand has a value of \$18.21 per ton or \$27.32 per yard.

Mr. Milligan, of the Polaris Laboratory, reported to the writer that his preliminary work performed before the treatment outlines above was indicated showed that most of the gold and platinum values were freed at about 100 mesh. If this statement is generally true, grinding of a minus 20 or minus 40 mesh fraction may be necessary to obtain optimum recoveries from the sands. However, Milligan believes strongly that screening at 20 mesh will make it possible to discard approximately 50 percent of the bulk material with little over-all loss, and so proposes. The writer concurs with this view after perusal of the evidence contained in the Hesperia reports. Both Hesperia and Polaris removed and discarded the magnetic fraction in the ores before concentrating the values.

Mr. Milligan, on the basis of his work, proposes a minimum plant built around Knudsen Bowls. He proposes to screen the raw sand, and make a rough concentrate with four Knudsen Bowls, each handling a sized input, and it is his contention the rough concentrates may be combined and cleaned in another Knudsen Bowl. His estimate of the cost to build a plant capable of treating approximately 30 tons of raw material per hour is \$36,350.00 without grinding equipment, not thought to be necessary for the initial start of operations. This plant costs appears on the surface to be somewhat high, but a budget of that size would allow for a certain amount of alteration and experimentation with the unit.

Because of the serious discrepancy between the assay values of palladium as reported by Polaris and Hesperia, and as all concentrate products were not assayed for palladium, the writer has deliberately disregarded the palladium content of all concentrates. This has, in some cases, considerably reduced their value. Assessing one laboratory's work against the other indicates that the metal values in the placer sand concentrates are in order and obtainable, with the single exception of the palladium content. It is the writers's opinion, therefore, that the results indicated by the test work may be expected in an operation working on the type and quality of the sands tested.

The following comments present certain aspects of the recovery of the mineral constituents not as yet explored, and are based upon the writer's past experience and observation. The apparent ease of concentration demonstrated by the work thus far undertaken leads the writer to suggest the use of jigs as rough concentrating units. Jigs are high-capacity machines of low cost, and operate with a minimum of attention and expense. The exceptional cleanness of the gold and its even, chunky texture are factors that indicate that jigs would operate satisfactorily, despite the fine particle size of the gold.

Jigs are uncommon in laboratories due mainly to the fact that they treat such large volumes of material as to make the handling of suitable size samples an onerous task with the facilities of most laboratories. However, a jig could be set up for test purposes at low expense, and could quickly demonstrate its

its capabilities. Jigs are presently in large supply as excellent used equipment due largely to the reduction in placer operations throughout the west, and they are, therefore, available at comparatively low cost. As time may be a factor of considerable importance, jigs are immediately available whereas delivery dates on new milling equipment are currently running from sixty to one-hundred-twenty days.

At least a minimum of jig test work is earnestly urged. This recommendation is made in the face of certain knowledge that either Clark Cones or Knudsen Bowls will do an acceptable job.

CONCLUSIONS

The test work indicates that a substantial operating profit can be obtained through the use of gravity concentration methods when applied to the better of the placer sands in the Four-Mile Placer Mining District. By no means should the entire area be viewed as being underlain by commercial-grade material, but is a proven fact that modern methods of recovery will extract substantial values from some of the sands. There are large tonnages of worth-while material available at moderate cost, and the exploitation of these tonnages will yield large operating profits.

In view of the data thus far assembled, it is entirely feasible to start an operation in the district using gravity concentration methods. At the same time chemical metallurgy and various means of mechanical concentration could well be explored. None of the early machinery installed would become obsolete as it could be utilized in any mill changeover.

The writer concurs with Mr. Hoover's appraisal, as follows:
"Some failures have been due to a misunderstanding of the manner of their (sands) deposition, leading to useless work to locate "channels" of greater concentration in certain zones; other failures were due to inability to save the finely divided gold, and still others to the lack of a sufficient amount of water. But that all difficulties will, in some of the mines, be overcome sooner or later is a conclusion that admits of little doubt. The pioneers in the undertaking may lose money; those who come after will profit by their experience".

The nineteenth century and depression year operators failed because of poor equipment and a lack of water, rather than from a lack of gold. Present day machinery and techniques, backed up by the adequate available water supply, will work successfully and economically. The district as a whole bears investigation, and the areas thus far sampled by Mr. Twiford can be successfully operated with consequent large financial gain.

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Part 1, p. 84

Respectfully submitted,

May 4, 1965

Ralph H. Thurston
Consulting Mining Geologist

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APPENDIX B

Marks, J.H., 1903, Reconnaissance report on the Four Mile Mining District, Routt County (Moffat County), Colorado.

RECONNAISSANCE REPORT ON THE FOUR MILE MINING DISTRICT.

ROUTT COUNTY (MOFFAT COUNTY)

COLORADO.

By
John H. Marks
1903.

J. H. Marks,
504 Empire Bldg., Denver, Colo. 1903

This report is not made as an expert report, nor for a financial consideration.

The question will naturally be asked,—"Why is it made and for what purpose?"

In the seasons of 1893 and 1895 I was employed in Engineering work in the Fourmile country, making surveys of placer lands, ditch surveys and matters in connection therewith, for various parties.

The water problem being so expensive in comparison to the amount of water to be obtained for ordinary hydraulic mining, made the cost prohibitive.

At that time gold dredging was not known or understood as at present. In conversation with Mr. R. L. Smith and a knowledge of the fact that Mr. B. W. Law has a dredge in successful operation in the Fourmile country, I became convinced that there was a great placer dredge mining enterprise to be found there, and we decided to investigate it.

The results, which greatly exceeded our anticipations, are given in this preliminary report.

The calculations of cost of pipe lines are made from an actual survey, and while made as a preliminary survey and somewhat hurried, are sufficiently accurate upon which to base estimates. I have profile of pipe lines in office, but it is too bulky to include with this report.

We are interested in locations amounting to several thousand acres, and associated with us in them are some practical experienced mining men, especially trained in the details of the work that will be needed in carrying out this enterprise, such as machinists, pipe makers, builders, expert accountants, etc.

REPORT ON THE FOURMILE MINING DISTRICT, ROUTT COUNTY, COLORADO

As a result of my examination and surveys of the Fourmile Placer district, I am enabled to make the following report, which I believe to be substantially correct.

The properties in this district consist of placer locations aggregating several thousand acres of unpatented land. It is the intention to combine all placer holdings in this district in this enterprise, the conditions of titles being given in another and later report; it being sufficient to say here that claims are held by location and possession in compliance with U. S. laws, without dispute, and that there are no liens or incumbrances against any of the property to the best of my knowledge.

This placer region is situated in the Fourmile mining district, Routt County, Colorado, 75 miles distant in a south-westerly direction from Rawlins, Wyoming, the nearest railroad station. When completed to Craig, Colorado, the new Moffat railroad now under construction

will be about 28 miles south of the proposed pipe lines and 35 miles from the place of dredging operations.

Dixon and Baggs, Wyoming, are the nearest supply towns, being from 15 to 25 miles northerly from the Fourmile gold fields. Good wagon roads are found in every direction and daily mail line runs to Rawlins. Hahn's Peak, the County Seat, is reached by stage via Dixon, Wyoming, or Craig and Steamboat Springs, Colorado, a distance of about 75 miles.

The placers are found on a desolate sagebrush desert at an altitude of from 6000 to 7000 feet above sea level. The climate is hot, dry and windy in the summer time and cold and windy in the winter with but little rain or snow. The placer ground, which extends probably 20 miles north and south and from 20 to 30 miles east and west, commences about 12 miles west of the Elkhead range of mountains from which an abundant supply of water can be obtained for placer dredging purposes, it being proposed to work the ground by the gold dredging method.

PLAN 1 & 2 Water necessary for placer mining in this country can be had in the Elkhead range of mountains lying to the east of the placers. Reservoirs will be needed to furnish a full supply of water during the dry season of about three months. A survey shows that an excellent reservoir site exists in Slater Park in T. 10, N., R. 87 W., and there are other unsurveyed reservoir sites upon which favorable reports have been made.

The enclosed plat of reservoir site in Slater park shows 30, 60, and 90 ft. contours from an actual survey. A calculation of capacity shows that a dam 75 feet high, costing approximately \$50,000 would give a sufficient supply of water. I would advise that the dam be so constructed and planned that it could be raised to 90 feet if needed. Cost of 90 ft. dam about \$75,000. I would recommend a rock filled dam with steel core backed by cement, as most suitable for this locality.

It would be well to make careful measurements through several seasons as to amount of water that can be had to supply reservoir before building it to a height of 90 ft. Ditches can be made from the reservoir site to the upper drainage areas of Snake River and California Park.

I am told there is an excellent reservoir site in head of west Slater river, but I have not seen it.

A ditch taken out of the main or east Slater river below the reservoir and running near the base of the range for an entire distance of about 21 miles, will intercept a number of good streams, including West Slater and Middle Slater rivers, Willow Creek and other good creeks which will furnish a surplus of water except for the dry season.

Several miles of this ditch have been constructed, water being taken through it from Willow Creek in T. 10 N., R. 89 W., to supply the dredge now in operation in T. 11 N., R. 91 W.

Connecting with the lower end of this ditch on the divide between Fourmile and Willow Creeks, where the country slopes rapidly to the west, a pipe line 36 inches in diameter, 3-1/3 miles long and having a total fall of 940 feet can be made to furnish power for an electric transmission plant. This power plant, of sufficient capacity to supply all power needed for running the dredges would be located in T. 10 N., R. 90 W., 8 to

10 miles east of the placer ground.

Commencing immediately below the power plant a 30 inch water supply pipe or inverted syphon $8\frac{1}{2}$ miles long would carry water in a south-westerly direction to the summit of Iron Springs divide, crossing a low pass which at its lowest point is 410 ft. below the discharge end of the proposed pipe or inverted syphon; said discharge end however being 190 ft. lower than intake of pipe at power plant.

The placer land is situated on the top and on each side of a ridge dividing the drainage areas of Little Snake and Bear rivers.

This ridge having a general south-westerly and westerly direction, is known as Iron Springs divide. The water supply pipe or inverted syphon is planned to raise water high enough to command the entire country on each side of the Iron Springs divide, amounting to many thousands of acres.

From 1000 to 1500 miners inches of water can be furnished by this supply pipe for the entire working season, enough to float a number of gold placer dredges, as the water can be used several times in its descent from Iron Springs divide, by placing the dredges below each other.

Portions of ridges that cannot be reached by dredges can be mined by ordinary methods of ground sluicing.

The Fourmile mining district was discovered in 1892 by prospectors from Aspen, Colorado, who made a practice of panning all the streams they crossed in their travels, the first discoveries being made on Fourmile Creek in T. 12 N., R. 91 W.

Considerable work has been carried on since that time by hydraulic methods. Ditches were built from Fourmile Creek and extensive work planned, but the limited supply of water to be obtained soon caused a suspension of operations.

PLAN 3 In one instance the water problem has been solved by Mr. B.W. Law, who built a ditch from Fourmile divide to Willow Creek, securing water from this stream, turning it into Fourmile Creek for a distance of several miles, then taking the water by ditches to T. 11 N., R. 91 W., where he has installed and successfully operated for the past two years a small dredge that has proved a good paying investment and practically demonstrating the dredge method as best adapted to this region, both on account of the scant supply of water and the lack of grade for ordinary hydraulic methods, which here is usually limited to the edge of the banks along the gulches.

The dredge is working on a bar between two gulches and has during the past two seasons washed about 25 acres of ground; besides 20 acres of bank adjoining the gulch near the dredge have been ground sluiced with water from the ditch above mentioned. Mr. Law is also raising grain and hay on his placer land by using surplus water from his ditch for irrigation. I conclude that it is profitable, as he is arranging to farm several hundred acres of land in addition to that which he now has under cultivation.

For 10 years past numerous parties have made "grubstakes" by haul-

ing sand to springs occasionally found in the numerous gulches traversing the region and there sluicing or rocking out the gold.

The gold is of good quality, being worth from \$19 to \$19.50 per ounce, and is all fine, but not flour gold; is very heavy and easily saved in an ordinary sluice box.

The origin of these gold fields is not easily accounted for, unless it be that they were formed from an ancient lake bed. The values seem to increase from Snake River toward the Iron Springs divide and appear to be greater on the wide flat bars than in the main gulches. The channels, if such they may be called, trend in a northeasterly and southwesterly direction. Nearly all of the bars can be worked by the dredge method to even the tops of the ridges as they are for the most part flat and rolling.

Practically no rock is to be found in this placer deposit which consists of a coarse granite or quartz sand; the bedrock is not deep and is easily cleaned.

I am satisfied from my examinations and what I know of the district that sufficient values exist to make the enterprise a great paying proposition. I would, however, recommend and insist that a thorough and systematic investigation of values be made over a large area of country before extensive development operations are undertaken and think it would be advisable to thoroughly prospect an area sufficiently large to guarantee returns of several million dollars.

In an enterprise of this magnitude it is but fair to investors that they should know in advance and beyond a doubt that there is pay gravel enough in sight to warrant the investment, as all of the capital necessary to put the placers on a paying basis must be expended before any returns can be expected. The values in this placer ground can be demonstrated to anyone who will go on the ground and take time to investigate them.

The determination of values can be made in a thorough and comparatively inexpensive manner as follows:-

There are numerous places on this placer land where a small supply of water, sufficient for the purpose, can be obtained by cleaning out or sinking to bedrock where springs are found in gulches. Procure a small traction engine and centrifugal pump. Place a sluice box above or alongside of the water supply, pump the water to sluice box to wash gravel, letting the water drain back into the pit where it can be pumped to the sluice and used in this manner for an indefinite time.

Lay out in squares of several hundred feet, a tract of land to be tested; at each corner of the squares sink to bedrock a shaft of given dimensions, carefully measuring the contents thereof in cubic yards. With team and wagon haul all of the gravel taken from shafts to the sluice box, wash out the gold and by this means estimate the value of the entire tract of land. This method should give a close estimate of values without great expense as one man would average one or more holes per day.

There is no water to contend with, except a little seepage in gulches and no rock to decrease yardage, so that everything taken from the shaft could be washed through sluice. Prospect several different areas in this manner, enough to prove the values over an extent of country sufficiently large to warrant the expenditure of money to fully equip the whole enterprise from reservoir to dredges. It seems to me the above method should give a good working test of the values, eliminate all elements of guess-work and furnish accurate data.

In regard to values, I am of the belief that the estimates given in the letters attached to this report are conservative, the writers being not only reliable men, but men of years of experience in placer mining.

However, to make assurance doubly sure, we will suppose the values average 15¢ per cubic yard and that it will cost 5¢ per cubic yard to handle the gravel, giving a net profit of 10¢ per cubic yard.

One square acre contains 43,560 square feet, or 4,840 square yards.

If the gravel average 6 ft. or 2 cubic yards deep to bedrock then $4,840 \times 2$ equals 9,680 cubic yards, at 10¢ equals \$968. per acre. $1,000,000$ divided by 968 equals 1,033, the number of acres required to produce one million dollars.

If the gravel averages 9 feet or 3 yards deep (an average of bedrock depths as given in letters attached to this report) then:- $4,840 \times 3$ equals 14,520 cubic yards, at 10¢ per cubic yard equals \$1,452 per acre.

$1,000,000$ divided by 1,452 equals 688, the number of acres required to produce one million dollars.

One township equals 36 square miles, equal to 23,040 acres.

If gravel is 6 ft. or 2 yds. deep, then:- $23,040 \times 968$ equals \$22,302,720.00, in one township.

If gravel is 9 ft. or 3 yds. deep, then:- $23,040 \times 1,452$ equals \$33,454,080.00, in one township.

Of colored area on map approximating 12 townships, suppose $\frac{1}{3}$ part or three townships to contain values equal to 10¢ net, then:- 3 townships gravel 6 ft. deep equals, \$66,908,160.00. 3 townships, gravel 9 ft. deep equals \$100,362,240.00.

An accurate estimate of the entire area known to contain gold has not been, nor could it be made without very extensive prospecting, requiring a great deal of time. Enough has been done, however, to warrant the statement that the district is rich in placer gold and only awaits proper development on a large scale to produce gold in paying quantities for many years to come.

My reasons for making the above statement are:-

Values are known to exist in T. 10 N., R. 92 W., in the vicinity of Mr. Gooldy's camp (see map). It is in this region that the old channels of which he writes are located. The greater part of the gravel hauled by wagon and rocked out is in this section of country. In the same township a dry placer machine has been operating (see photo) the owner claiming he could make \$20.00 per day and that the gravel he was working was worth

75¢ per cubic yard. To the south and west of this township gravel has been hauled from near the summit of Iron Springs divide.

A large amount of pay gravel has been washed in township 12 N., R. 91 W., and in T. 11 N., R. 91 W.

Gravel was being hauled and washed near Dummy Wilson's place in T. 11 N., R. 92 W., when I first visited the country in 1893.

I am reliably informed that placer mining has been carried on in a small way wherever water could be obtained, in the Blue gravel district in T. 9 N., R. 91 W., and I have seen old workings near south-west portion of T. 9 N., R. 90 W.

An average of values on 2700 acres in or near Ts. 10 N. and 11 N., R. 94 W., gave, I am told, 18¢ per cubic yard. I was present part of the time when this examination was made in 1895, but was mostly engaged in surveying work.

To properly equip the placers for profitable working will require 4 dredges costing \$50,000 each. These dredges should mine 2,500 cubic yards per day for each dredge, or 10,000 cubic yards per day.

The profits would be at 10¢ per cubic yard net, \$1,000 per day and allowing 200 days per year actual working time, would be \$200,000 or 20% on an investment of \$1,000,000.

More dredges should be added as the property is opened up, as the electric power available would be sufficient to operate from 15 to 20 dredges. By making the power line 36 inches diameter the capacity of the power plant can be increased to 3000 H.P. at any time by putting in additional electric machinery. The pipe lines should be well made, tarred, rivetted in trench and covered.

A great portion of the placer land is valuable for agricultural use, the extent being only limited by the amount of water that can be obtained for irrigation and in connection with its stock raising. No doubt both enterprises could be carried on simultaneously, as water would probably rise on bedrock in the gulches and be available for use several times before reaching the river.

All construction work in connection with this proposition should be done in the most thorough manner, there being many years work in sight and besides, the power plant, pipe lines and water rights would always be a valuable asset.

The cost of equipping this placer mining property for working is estimated as follows:

Reservoir, Slater Park	\$50,000
Ditches, flumes, headgates, wastegates	30,000
Pipeline (36") for power, 940 ft. head	170,000
2000 H.P. electric power plant	100,000
30" inverted syphon 8½ miles long,	160,000
Pipe making plant and tools,	20,000
Four dredges,	200,000
	<u>\$730,000</u>

To this should be added a large contingent fund for buying and patenting land and for incidentals in connection with perfecting the working plans.

In order that the entire water-shed tributary to this country be controlled, it might be found advisable to buy 3 or 4 ranches that have irrigation water rights.

I have endeavored to be very liberal in making calculations, but as the actual cost of carrying out mining projects usually greatly exceeds first estimates, I do not think this proposition should be started with less than one million dollars cash in sight, for an attempt to cheapen cost at a sacrifice of efficiency would mean a failure.

I think it would require two year time to put the property in active operation.

My examinations and surveys of the present year were made in company with Mr. Ed. L. Smith, who is well known as the most practical and successful dredge builder and operator in the Rocky Mountain region, he having successfully operated dredges in Montana and Colorado for the past 9 years, building and equipping them throughout.

Mr. Smith's statement as to conditions as he found them in the Fourmile country are attached to and made a part of this report.

The best time of the year to visit the placer fields with a view to examination would be in May and June.

Very respectfully submitted,

(Signed) JOHN H. MARKS

(Breckenridge, Colorado)
December 15, 1903

TO WHOM IT MAY CONCERN:

During the summer of 1903 I visited and examined the Fourmile Gold Fields in Routt County, Colorado.

My examination covered a period of several weeks time and extended over a large scope of the gold bearing region, particularly in the vicinity of the drainage areas of Timberlake Gulch and Iron Springs divide.

I have also examined the Law dredge and find that it is of the pattern built by the Urie Co. of Kansas City, Mo. It is of the open chain type, buckets $1\frac{7}{8}$ cu. ft. capacity, capable of handling from 600 to 700 cu. yds. of gravel per 24 hours.

The ground where the dredge is working runs about 25¢ per cu. yd. and from the returns shown me, I know the dredge is netting its owner at least \$100.00 per day.

From my examination of the values in the Fourmile gold district, I am satisfied that the values from the ground operated by the Law dredge increase towards the Iron Springs divide, running from 25¢ to \$1.00 per cu. yd. over a large percentage of this gold bearing district and that a probable average over many thousands of acres would be 15¢ per cu. yd. 25.5¢ to 35.00¢

I find the average depth of this gold bearing gravel or sand to be about 9 ft. to bedrock, which is of a sedimentary nature, being very soft and easy to dig.

This is an ideal gold dredging proposition, the contour of the ridges and gulches being such that almost the entire area can be reached by a dredge and easily handled. In case there should be a few of the highest points that could not be reached by dredge they can be sluiced by ordinary hydraulic methods after the dredging is completed.

The gold bearing material is such that wear and tear will be very little, no grizzlies being required on account of the entire absence of rock. With sufficient water on Iron Springs divide, the entire gold bearing country on each side of said divide can be worked, the same water being available for a large number of dredges by using it several times in its course down the gulches, the dredges being located below each other and requiring in this manner probably 200 to 300 miners inches of water to supply a series of 3 or 4 dredges.

Dredges can be built to handle 3000 cu. yds. per 24 hours.

Owing to the cheap electric power that can be had, the expense of handling and washing the gravel including all repairs and running expenses will not exceed 2¢ per cu. yd.

Dredging could be carried on for an approximate period of 8

months per year and with an average depth of 9 ft. to bedrock, from 40 to 50 acres could be worked by one dredge per season.

The power required to run one dredge would be 150 H.P. and the entire estimated cost of such dredge is \$50,000.

This is the largest gold dredging proposition I have ever seen, one of the most feasible and one in which values can be easily and cheaply determined, nothing necessarily being taken for granted, as the ground is shallow, no water to contend with in going to bedrock and no timbering being necessary.

I have examined the source of water supply in the Elk-head range and find that by building the proposed reservoir on the main fork of east Slater, that not less than 1500 miners inches of water can be had for the entire working season, which would be ample to furnish power and float at least 15 dredges.

I have also been over the ground on the line of the ditch and the proposed pipe lines and at the power plant site and find the entire project is quite practicable and I have no hesitation in recommending the proposition, more especially to persons who have had experience in dredging, as one of extraordinary merit.

Very truly yours,

(Signed) Ed. L. Smith

Baggs, Wyoming
November 20th, 1903

Mr. J. H. Marks,

Dear Sir:

Replying to your letter of inquiry regarding the Fourmile country in Routt County, Colorado, I will say that I have been connected with mining operations there since 1894.

During this time I have had charge of work there for Gold Valley M. Co., Fourmile M. Co., and Timberlake M. Co.

I have prospected and worked the ground over various areas, including Big Hole, Dry Gulch, Scandinavian Gulch, Fourmile and Timberlake Gulches, an area of many square miles. The greater part of my mining has been done in Timberlake Gulch, where I am at present operating for the Timberlake Mining Co. The results of my prospecting there have proven to me that more than ordinary values exist in two channels I have discovered and traced for a distance of one mile in length and 1320 ft. in width and from every indication continue much farther.

These values range from 25¢ to \$10.00 per cu. yd. There is gold over the greater part of this entire area of many hundreds of acres, and I think a conservative estimate of the average values would be 20¢ per cu. yd. with a depth of from 4 ft. to 15 ft. to bedrock, which is of a sandstone nature and very easily cleaned.

An evidence of the great values existing in places is shown from the fact that the gravel has been hauled by wagons to small springs or pools of water and washed with rocker or ground sluiced at various times during the past 10 years and this kind of work is still going on over a large area of country, gravel being hauled at various places from a region 5 miles N. and S. by 15 miles E. and W. The greatest distance I have known gravel to be hauled is about 2 miles. Some of the places from which gravel has been hauled are opened up for several hundred feet. The gold, while it is fine, is very heavy and easily saved and averages about \$10.00 net per oz. in mint returns.

I am also familiar with the water problems to be met with in this country, having worked on ditches, etc. in connection with the placers. I know from actual work on the ground that the proposed ditch and pipe lines and reservoir sites are entirely practicable and that when once installed they will be easily kept up and will furnish an abundant supply of water for the entire working season of about 8 months per year.

Very truly yours,

(Signed) J. Gooldy

Dixon, Wyoming
November 23, 1903

Mr. John H. Marks,
Breckenridge,
Colorado.

Dear Sir:

I have been working in the Fourmile Mining District in different places, hauling and rocking dirt and have in this way taken out about fifteen hundred dollars.

At one time I hauled on a spring wagon about $1/8$ of a yard per load and carried the sand out of the gulch in a sack on my back and emptied it in the wagon and hauled it $1/2$ mile to water and rocked out \$142.00 in fourteen days.

I think this country is all right with plenty of water.

Yours very truly,

(Signed) Geo. Hines

APPENDIX C

Marks, J.H., 1915, Preliminary report, the Timberlake or Fourmile Placer District. Information provided by Orvie Zimmerman in 2012.

JOHN H. MARKS
Hydraulic, Mining & Civil
Engineer

504 Empire Bldg., Denver, Colo.
Phone Main 2470

December 14, 1915

PRELIMINARY REPORT

THE TIMBERLAKE OR FOURMILE PLACER DISTRICT.

This placer region is in the northeast corner of Moffat County, Colorado, from 15 to 25 miles southwesterly from the towns of Baggs and Dixon, Wyoming.

The nearest station on Union Pacific R.R. is Wamsutter, 52 miles northwest from Baggs. Craig, the present terminus of the Denver & Salt Lake (Moffat) Railroad is about 20 to 30 miles southeasterly from the placer district.

Population of Baggs 350, Dixon 200, Craig 800, Wamsutter 125.

Mail stages leave Wamsutter for Baggs every morning, except Sundays. Fare \$5.00.

Automobiles make the trip from either railroad point in from three to four hours time, for \$20 per trip when roads are dry; when wet the trip cannot be comfortably made with machines, and it is difficult for teams on account of adobe roads.

The placers are found on a desolate sagebrush desert at an altitude of from 6000 to 7000 feet above sea level, scattered over various parts of areas bounded roughly by the limits of Townships 8, 9, 10, 11, 12 N., Ranges 91, 92, 93, 94 W., 6th P.M.

Water in small quantities can be obtained at places on the placers for mining purposes, and in comparatively large quantities by reservoirs, ditches and pipe lines from the Elk Head range of mountains lying to the east.

The Fourmile mining district was discovered in 1892 by prospectors from Aspen, Colorado, who in their travels, made a practice of panning all the streams they crossed; the first discoveries being made on Fourmile Creek in T. 12 N., R. 91 W.

Considerable work has been carried on since that time by ground sluice, hydraulic and dredging methods. Ditches were built from Fourmile Creek and extensive work planned, but the limited supply of water obtained from this source prevented development on a large scale. The direct water supply of Fourmile Creek is furnished by melting snow and lasts but a few weeks each spring.

About the year 1900, Mr. B. W. Law built a ditch from Fourmile divide to Willow Creek, securing water from this stream, turning it from ditch into Fourmile Creek, down which stream it ran for a distance of several miles, then taking the water by ditches to T. 11 N., R. 91 W., he successfully operated a small dredge, practically demonstrating the dredge method so well adapted to this region, both on account of the scant supply of water and lack of grade for general placer mining methods, which is usually limited in this district to the edge of banks along or near gulches.

The dredge worked on a bar between two gulches and washed about 40 acres of ground; besides 20 acres of bank adjoining the gulch near the dredge were ground sluiced with water from ditch above mentioned. It is reported that \$140,000 gold was recovered; \$115,000 from dredging and \$25,000 from sluice. Mr. Law raised grain and hay on ground near his placer land, using surplus water from his ditch for irrigation. He worked out the bar about the year 1904; the dredge being second hand and old when purchased by Mr. Law, was abandoned and stands where it was when work was stopped.

Mr. Ed Smith, an experienced gold dredge builder and operator, made quite an extended examination of this placer district in 1903, at the time the B.W. Law dredge was in operation. We quote from a letter written by him:

"My examination covered a period of several weeks time and extended over a large scope of the gold bearing region, particularly in the vicinity of the drainage areas of Timberlake Gulch and Iron Springs divide.

I have also examined the Law dredge and find that it is of the pattern built by the Urie Co. of Kansas City, Mo. It is of the open chain type, buckets $17/8$ cu.ft. capacity, capable of handling from 600-700 cu. yds. of gravel per 24 hours.

The ground where the dredge is working runs about 25¢ per cu. yd. and from the returns shown me, I know the dredge is netting its owners at least \$100.00 per day.

From my examination of the values in the Fourmile gold district I am satisfied that the values from the ground operated by the Law dredge increase towards the Iron Springs divide, running from 25¢ to \$1 per cu. yd. over a large percentage of this gold bearing district, and that a probable average over many thousands of acres would be 15¢ per cu. yd.

I find the average depth of this gold bearing gravel or sand to be about 9 ft. to bedrock, which is of a sedimentary nature, being very soft and easy to dig.

This is an ideal gold dredging proposition, the contour of the ridges and gulches being such that almost the entire area can be reached by a dredge and easily handled. In case there should be a few of the highest points that could not be reached by dredge they can be sluiced by ordinary hydraulic methods after the dredging is completed.

The gold bearing material is such that wear and tear will be very little, no grizzlies being required on account of the entire absence of rock. With sufficient water on Iron Springs divide, the entire gold bearing country on each side of said divide can be worked, the same water being available for a large number of dredges by using it several times in its course down the gulches, the dredges being located below each other and requiring in this manner probably 200-300 miners inches of water to supply a series of 3 or 4 dredges.

Dredges can be built to handle 3000 cu. yds. per 24 hours.

Owing to the cheap electric power that can be had, the expense of handling and washing the gravel including all repairs and running expenses will not exceed 2¢ per cu. yd.

Dredging could be carried on for an approximate period of 8 months per year and with an average depth of 9 ft. to bedrock, from 40 to 50 acres could be worked by one dredge per season.

The power required to run one dredge would be 150 H.P. and the entire estimated cost of such dredge is \$50,000.

This is the largest gold dredging proposition I have ever seen, one of the most feasible and one in which values can be easily and cheaply determined, nothing necessarily being taken for granted, as the ground is shallow, no water to contend with in going to bedrock and no timbering being necessary.

I have examined the source of water supply in Elk Head range and find that by building the proposed reservoir on the main fork of east Slater, that not less than 1500 miners inches of water can be had for the entire working season, which would be ample to furnish power for and float at least 15 dredges."

Mr. J.W. House, 757 Harrison St., Denver, Colo., who has extensive interests in the Timberlake region, states that he has 880 acres of placer ground in Tps. 9-10 N., R. 92 W.

A small amount of ground was worked, much less than an acre. It showed a value of \$1.10 per cu. yd.; reported that about \$3000 was taken out of pit which averaged 6 ft. deep.

A pump was used to raise water from a gulch to which it was returned

In recent years the greater part of the placer mining in this district has been done by a corporation known as the Timberlake Mining and Development Co. Mr. James Gooldy, whose address is Baggs, Wyoming, or Fulton, Mo., is general manager for the company.

The company has built ditches, put in pipe line and worked by ground sluice and small hydraulic methods, probably 10 acres of ground. Their operations owing to a lack of water have been on a small plan of development, the work being done in T. 10 N., R. 91 W. Their work is reported to show gravel from 5 to 15 ft. deep; bedrock soft sandstone easily cleaned; values about 20¢ per cu. yd.

Mr. Gooldy also owns 500 acres of placer land in Sec. 2 and 11, T. 10 N., R. 92 W. His work has all been done by the ground sluicing method, using waste water from Timberlake company's workings amounting to from 3 to 5 second feet.

Gravel averages 6 feet deep and pays from grass roots to bedrock, averaging from 25 to 41¢ per cu. yd., the last mentioned amount being 1915 yardage values. Less than two acres has been mined.

The results of his work for the past 3 years are given in the following

Year	Total Gold Recovered	Cost	Net
1913	\$ 700	200	\$ 500
1914	2475	500	1975
1915	1675		1175
Net Profits			\$3650

Referring to letters and general information received at various times from Mr. Gooldy, who has had a great many years experience as Mine Manager in this district, we abstract:

"I have been connected with mining operations in the Timberlake region since 1894. During this time I have had charge of work there for Gold Valley M. Co., Fourmile M. Co. and Timberlake M. Co.

I have prospected and worked ground over various areas, including Big Hole, Dry Gulch, Scandinavian Gulch, Fourmile and Timberlake Gulches, an area of many square miles. The greater part of my mining has been done in Timberlake Gulch, where I have been and am at present operating for the Timberlake Mining Co. The results of my prospecting there have proven to me that more than ordinary values exist in many places. I have discovered and traced two channels for a distance of one mile in length and 1320 ft. in width and from every indication they continue much farther. The values in these channels range from 25¢ to \$10 per cu. yd. @ \$20.67 gold

There is gold over a great part of this country covering an area of many hundreds of acres, and I think a conservative estimate of the average values would be 20¢ per cu. yd. with a depth of from 4 ft. to 15 ft. to bedrock, which is of a sandstone nature and easily cleaned. The gold, which it is fine, is heavy and easily saved and averages about \$19 net per oz. in mint returns.

In the year 1895 a placer examination was made by Prof. J. Ross Brown of the University of California on ground located in or near Sec. 8, T. 11 N., R. 91 W., known at that time as the Boothe & Nelson bars. This examination was made by sinking pits over an area of about 80 acres. Values reported to be 26¢ per cu. yd. @ \$10.00 gold.

A placer examination was made about the time above mentioned, by Prof. Geo. W. Maynard, New York, and Prof. Benjamin Sadtler of Denver, Colo., of 2700 acres in the vicinity of Big Hole Gulch in or near Tps. 10-11 N., R. 94 W. This examination was made by sinking pits to bedrock and rocking or panning the sand; results showed an average value of 18¢ per cu. yd. for the entire tract of 2700 acres, and an average depth of 7 ft. to bedrock."

30.64 @ \$35.00 gold

30.6¢ @ \$35.00 gold

It is reported that placer mining has been carried on in a small way, whenever water could be obtained, in the Blue gravel district in T. 9 N., R. 91 W., and old workings are found near southwest portion of T. 9 N., R. 90 W.

From top of Iron Springs Divide, at an altitude of 7345 ft. above sea level, the country slopes approximately north 16-20 miles to Little Snake river, eleva. 6100'; south 20-25 miles to Bear or Yampa river, eleva. about 6200'; west 20-30 miles from highest point on divide to Little Snake river, elev. about 6000'. Gold has been found according to above statements over various parts of this territory, and at widely separated distances.

For years prospectors made "grubstakes" by hauling sand to springs, occasionally found in the numerous gulches traversing this region, and there sluicing or rocking out the gold.

The origin of these gold fields is not easily accounted for. Apparently, they were formed in an ancient lake bed. The values seem to increase from Snake River toward the Iron Springs Divide, and appear to be greater on the wide flat bars than in the main gulches. The channels, if such they may be called, trend in a northeasterly and southwesterly direction. Nearly all the bars can be worked by the dredge method, even to tops of the ridges, as they are for the most part, flat and rolling.

Practically no rock is found in these placer deposits which consist in a general way of a coarse granite or quartz sand; the sandstone bedrock is easily cleaned.

An accurate estimate of the entire area known to contain gold has not been, nor could it be made without extensive prospecting, requiring a great deal of time. Enough has been done, however, to indicate that the district is rich in placer gold and only awaits proper development on a large scale to produce gold in paying quantities for many years to come. By prospecting the ground as outlined in this report, values could be determined and the element of risk eliminated at small cost.

In an enterprise of this magnitude investors should know in advance and beyond doubt, that there is pay gravel enough in sight to warrant the investment, as all of the capital necessary to put the placers on a paying basis must be expended before any returns can be expected. The values of this placer ground can be demonstrated, and determined in a thorough and comparatively inexpensive manner as outlined below.

There are numerous places on this placer land where a small supply of water can be obtained by cleaning out, or sinking to bedrock where springs are found in gulches. Procure a small engine and pump. Place a sluice box above or alongside of the water supply, pump water to sluice box and wash gravel, letting it drain back into the pit where it can again be pumped to sluice.

Lay out in squares of several hundred feet (see sketch herein) a tract of land to be tested; at each corner of squares sink to bedrock a shaft or pit, carefully measuring contents thereof in cubic feet or cubic yards. Haul gravel taken from shafts to sluice box, wash out gold and by this means estimate value of entire tract of land. This method should give a close estimate of values without great expense, as one man would dig one or more holes per day.

A post hole auger or similar device might be used to advantage in getting out samples in place of sinking shafts at all angle points. The greatest values apparently are in channels, many of which are not indicated by the present shape of the ground, being in some cases located on or across bars in places of in gulches.

There is no water to contend with, except a little seepage in gulches and no rock to decrease yardage, so that everything taken from the shaft could be washed through sluice and should show true value of ground. Prospect several different areas in this manner, enough to prove values over an extent of country sufficiently large to warrant the expenditure of money to fully equip the whole enterprise from reservoir to dredges. The above method should give a good working test of values.

(Sketch)

OUTLINE PLAN FOR DETERMINATION OF VALUES OF ANY PART OR TRACT OF PLACER GROUND IN TIMBERLAKE DISTRICT.

On equidistant corners of squares, placed by survey at given distance apart, drill holes to bedrock, carefully testing material for values from surface to bedrock. This would show relative position of bedrock with surface of ground, depth of gravel, etc., thus furnishing accurate information for dredge plans; it being necessary to know depth and kind of material to be worked before dredge can be properly designed.

THE FOLLOWING TABLE SHOWS CUBIC YARDS AND VALUE PER YARD ON ONE ACRE OF GROUND: DEPTHS FROM 1-20 FT. VALUES FROM 5¢-25¢ PER CUBIC YD.: ALSO FOR 25, 30, 40 and 50 FEET DEPTH OF GRAVEL.

DEPTH IN FT.	CU. YDS IN 1 ACRE	VALUES PER ACRE AT 5, 10, 15, 20, 25¢ PER CU. Y				
		5¢	10¢	15¢	20¢	25¢
1	1613	81	161	242	322	403
2	3226	161	322	484	644	806
3	4839	242	484	726	968	1210
4	6452	323	645	968	1290	1613
5	8065	403	807	1210	1614	2017
6	9678	484	967	1452	1934	2419
7	11291	565	1129	1694	2258	2823
8	12904	645	1290	1936	2580	3226
9	14517	725	1452	2178	2904	3630
10	16130	807	1610	2420	3220	4030
11	17743	887	1774	2662	3548	4436
12	19356	968	1936	2904	3872	4840
13	20969	1048	2097	3146	4194	5243
14	22582	1129	2258	3388	4516	5646
15	24195	1209	2420	3630	4840	6050
16	25608	1290	2581	3872	5162	6453
17	27421	1371	2742	4114	5484	6856
18	29034	1452	2903	4356	5806	7259
19	30647	1532	3065	4598	6198	7673
20	32260	1613	3226	4840	6432	8066
25	40325	2016	4033	6050	8066	10083
30	48390	2419	4839	7260	9678	12099
40	64520	3226	6452	9680	12904	16132
50	80650	4033	8065	12100	16130	20165

From the above table the gold value of any number of acres can be figured. The cost of working the ground by dredging will probably be from 3 to 5¢ per cu. yd. If we assume cost to be 5¢ per yard the amounts in table would be as follows:

All 5¢ values would equal working cost.

10¢ gravel would equal values in 5¢ column.

15¢ " " " " " 10¢ " "

20¢ " " " " " 15¢ " "

25¢ " " " " " 20¢ " "

30¢ " " " " " 25¢ " "

The great handicap in all of the placer mining operations in the Timberlake district has been an insufficient water supply, which has to date not been obtained in quantities to make placer operations on a large scale a financial

Various attempts have been made to bring water to this desert country from the Elk Head range of mountains which are 10 to 25 miles east of the Timberlake Placers.

Mr. Gooldy states that about the year 1897 Mr. B. W. Law built ditches and brought water to the vicinity of Sec. 8, T. 11 N., R. 91 W. for placer and irrigation use. Ditch has a base width of 6 ft., depth 2 ft., grade 10.56 ft. per mile, and a carrying capacity of 75 second feet. The ditch began at Willow Creek in the Elk Head range. Water was carried through this ditch, two miles in length, to Fourmile divide, turned into the channel of Fourmile Creek and taken down said creek a distance of six to seven miles where it was again taken by ditch to the Law placer and ranch land in T. 11 N., R. 91 W., a distance of 16 miles. (Approx. sea level elev. 6450')

At a later date, about 1903, the Timberlake Mining and Development Co., a corporation, built $7\frac{1}{2}$ miles of ditch, having a base width of 6 ft., depth $1\frac{1}{2}$ ft., grade 10.56 ft. per mile, and a capacity of 40 second feet. This ditch extends from East Slater river to Willow Creek, where it joins the B.W. Law ditch, through which ditch it takes water to the Fourmile divide, turning it down the channel of Fourmile Creek for a distance of 3 miles, at which point it is taken by ditch 6 miles to upper end of pipe; thence by pipe tapering from 22 to 20, and from 20 to 18 inches in diameter, a distance of 28,031 feet; slightly over $5\frac{1}{2}$ miles across Mud Springs Gulch; thence by ditch 7 miles to the placer land owned by the company in vicinity of Secs. 24-25, T. 10 N., R. 92 W. (Approx. sea level elevation 6800')

Continual trouble has been experienced with the pipe line and while its rated capacity is given as 22 second feet, it has not delivered this water. Where the water reaches the Timberlake Company's ground it is approximately 350 feet higher than the ditch at the Law dredge.

Mr. Gooldy also states that by additional expense of \$10,000, the water supply can be increased to 75 second feet.

Of first importance in the development of the Timberlake Fourmile placers is securing title to as large an amount of water as possible. This can be accomplished in two ways:

FIRST: By purchase of existing water rights.

SECOND: By reservoir storage, extension and enlargement of present ditches, pipe lines, etc.

Control of the water being secured, and extensive plan of development could be worked out as follows:

Reservoirs would be needed to furnish a full supply of water during the dry season of about three months. Surveys show an excellent reservoir site in Slater Park in T. 10 N., R. 87 W., and there are other unsurveyed reservoir sites upon which favorable reports have been made.

A ditch taken out of the main or East Slater river below proposed reservoir and running near the base of the range for an entire distance of about 21 miles, will intercept a number of good streams, including Middle Slater and West Slater rivers, Willow Creek and other streams which would furnish a surplus of water except for the dry season.

Several miles of this ditch were constructed, as herein before noted, and have been in use for a number of years; first by Mr. B. W. Law, and at present by the Timberlake Co. and Mr. Gooldy. These various rights should all be in one ownership and the system enlarged to its greatest capacity.

Connecting with lower end of this ditch on divide between Fourmile and Willow Creeks, where the country slopes rapidly to the west, a pipe line 36 inches in diameter, $2\frac{1}{3}$ miles long and having a total fall of 940 ft. could be made to furnish power. This power plant would be located in T. 10 N., R. 90 W., 8 to 10 miles east of the placer ground.

Commencing immediately below the power plant a 30 inch water supply pipe or inverted syphon $8\frac{1}{2}$ miles long would carry water in a southwesterly direction to the summit of Iron Springs divide, crossing a low pass which at its lowest point is 410 feet below the discharge end of proposed

pipe or inverted syphon; said discharge end, however, being 190 feet lower than intake of pipe at power plant, and having a sufficient head to carry the water through the pipe by gravity.

The placer land is situated on top and on each side of ridge dividing the drainage areas of Little Snake and Bear rivers.

This ridge, having a general southwesterly and westerly direction, is known as Iron Springs divide. The water supply pipe or inverted syphon is planned to raise water high enough to command the entire country on each side of Iron Springs divide, and to carry from 1000 to 1500 miners inches of water, enough to operate a number of gold placer dredges, as the water can be used several times in its descent, either north, south or west from Iron Springs Divide, by placing the dredges below each other.

Portions of ridges that cannot be reached by dredges can be mined by ordinary methods of ground sluicing, but the ridges are comparatively flat so that the greater portion of them can be dredged.

The cost of building reservoirs, ditches, pipe lines, power plant, dredges, etc., and equipping this placer mining property for working is on a large scale approximately estimated as follows:

Reservoir	\$ 50,000.
Ditches, flumes, headgates, waste gates, etc.	30,000.
Pipe line (36") for power, 940 ft. head.....	170,000.
2000 H.P. electric power plant	100,000.
30" inverted syphon, 8½ miles long.....	160,000.
Pipe making plant and tools.....	20,000.
Four Hudson Double Dipper Dredges.....	100,000.
	<u>\$630,000.</u>

To this should be added a large contingent fund for buying and patenting land and for incidentals in connection with perfecting the working plans.

In order that the entire water-shed tributary to this country be controlled, as is contemplated by this plan, it might be found advisable to buy ranches that have irrigation water rights.

Under the large development made possible by having all the water-shed under control of one management, the water after it has been used for power and mining purposes would be available for irrigation.

Calculations were made on a liberal scale, but as the actual cost of carrying out mining projects usually greatly exceeds first estimates, this proposition should not be started with less than one million dollars available, after a thorough examination proves its values, for an attempt to cheapen cost at a sacrifice of efficiency would mean a failure.

\$10,000 should be sufficient to thoroughly prospect the ground and outline development plans, and it would require two years time to put the property in active operation.

Should this plan of extensive development be decided upon, all construction work in connection with this proposition should be done in the most thorough manner, there being many years work in sight and besides, the power plant, pipe lines and water rights would always be a valuable asset.

There would be a great excess of electric power for sale. The 38" pipe line would have capacity to carry water to generate 3000 H.P. installation of additional electric machinery. The demand for this power would increase with the development of the country. The project would become in time a public utility, while giving a three fold use of this INTENSIVE USE OF WATER IN A DESERT REGION WOULD BE an attractive and practical application of modern conservation.

While the above outlined plan would be ideal, the present development of the country would not warrant the cost. Years will elapse before the population of this region will make a profitable demand for electric power; however, there are less expensive methods of development possible.

Coal is available as a source of power in the region.

The Law dredge described herein was operated by steam, coal for fuel being hauled by teams from coal mines at Savery, Wyoming, a distance of about 19 miles, at a cost of \$5.25 per ton, delivered at dredge.

Mr. J. W. Housel states that he has a coal mine in Sec. 28, T. 8 N., R. 93 W., about 14 miles southwesterly from his placer mines. He reports that 9 foot vein of first class lignite coal has been opened up by driving a double tunnel, from which 500 tons has been mined, the coal being taken out by wheeling and hauled by team to his placers. The total cost delivered being \$5 per ton. He says there is a 20 ft. vein of coal under the 9 foot vein that has not yet been opened.

Water in small quantities is found at various places in the gulches in the Timberlake district. The melting snows in the spring time furnish considerable water that could be impounded in small storage reservoirs.

A new type of placer mining dredge has recently been placed on the market. It is known as the Hudson Double Dipper Dredge, price \$25,000, made by C.N. Hudson & Sons, Horton Bldg., Georgetown Station, Seattle, Wash.

From inspection of a model and general description of this dredge it appears to be well suited for mining in the Timberlake region. Among the features that commend it are the following:

It has double dippers of back acting steam shovel pattern; the dippers being drawn toward the machine while loading.

It is a surface mining dredge, being placed on top of the ground in place of in pit, is self contained in every detail; all parts of universally standard design; is equipped with the best screening sizing and concentration devices.

Dredge has agitating riffles and all gold saving devices adjustable to any pitch or angle; being capable of working on side hill or uneven ground.

Dredge has settling compartment water tanks, holding from 1000 to 8000 gallons of water, which can be used repeatedly so that only a small supply of water is needed.

Dredge can be operated with any kind of power; has rated capacity of 100 cubic yards per hour for standard size.

Dredge can be dismantled for transfer, weighs less than $\frac{1}{2}$, requires less than $\frac{1}{3}$ H.P. required for other types of dredges, and cost, complete, less than $\frac{1}{2}$ as much as standard float, or bucket type dredges of equal capacity.

The company also makes a prospecting dredge capable of handling from 25-35 cubic yards per hour. Cost \$2500 to \$3500.

By using coal for fuel and securing water on the ground, a cheap and inexpensive plan of mining would be secured.

Probably one of the smaller type of dredges would be best for commencing operations. \$3000 to \$5000 should be sufficient to install the dredge and put it on a paying basis.

With this prospecting dredge in successful operation, numerous plans for enlarged development would become attractive, water could be secured in abundance from the Elk Head range, either with or without power, and it might be found to be more economical to put in an electric plant at coal mine and transmit power to dredges.

The development of the Timberlake Placer District is worthy of intelligent investigation.

Respectfully submitted,
(Signed) JOHN H. MARKS

Denver, Colo.
Dec. 14, 1915.

APPENDIX D

Prommel, H.W.C., 1942, Craig-Baggs gold placer region, Moffat County, Colorado:
Geologic and economic aspects.

CRAIG - BAGGS GOLD PLACER REGION

Moffat County, Colorado

GEOLOGIC AND ECONOMIC ASPECTS

By

H.W.C. Prommel

Denver, Colorado



H. W. C. PROMMEL

June 1942

The Craig-Baggs gold placer region in Moffat County, Colorado, is situated between the towns of Craig, Colorado, and Baggs, Wyoming; it takes in approximately 900 to 1000 square miles and is covered by the "Craig" U.S. Geological Survey topographic sheet. U.S. Highway No. 40 passes through the southern part. State highway No. 13 passes through the easternmost part; a county highway passes through the east central part. Other portions can be reached over unimproved county roads which, however, become impassable during wet weather. The region is sparsely inhabited.

Gold was discovered here in 1892, an influx of some 4,000 placer miners arrived. water was scarce, the boom soon subsided after washing had been done in many placer. Miles of ditches were built from Willow Creek and hydraulicking and sluicing operations were careied on. During 1902-1904 a bucket dredge operated successfully on a high bar along Timberlake Creek. The open bucket line and the boiler of this dredge can still be seen at the location of these dredging operations. Much of the work was guided by promoters, and was badly managed and activities became less and less. Nevertheless, small scale placer mining continued uninterruptedly until 1931 when activities again increased. But even these were carried on by men unfamiliar with placer mining and unsufficiently financed who tried out a number of new, unproven placer machines and equipment and whose operations were doomed to failure before they started, however, one dry land placer dredge, fed by a 1 cu.

yd. dragline, did produce considerable gold from 1936 to 1938. Attempts at placer mining on a small scale are still going on. The history is described in greater detail in earlier reports by Herbert Hoover, Hon. '35, and John H. Marks, Hon. '25.

PAST PRODUCTION

Prior to 1892, Routt county was credited with \$194,518 of placer gold production. This came from the Mahns Peak gold placer region. Since that time Routt and Moffat counties are credited with a production of \$260,044 of placer gold, most of which has come from Moffat County. Nearly one third of this production was obtained during 1931-1939 from the Craig-Baggs area as follows:

1931 - \$ 175	1936 - \$ 7658
1932 - 1249	1937 - 32634
1933 - 610	1938 - 22421
1934 - 2400	1939 - 5215
1935 - 4438	

Most of the production during 1936 to 1939 can be credited to one dry land dredge operation along Timberlake creek which dug to a depth not exceeding four feet. This operation then changed hands and more complicated, but unpractical machinery was installed; the results show only too plainly in the 1939 production figure.

PHYSIOGRAPHY

At first glance the physiographic features of this region appear as gently undulating, rolling desert hills, covered by sage brush and resembling the desert regions of Wyoming. Various sandy, mostly

dry stream beds and gullies traverse it. An inspection of the "Craig" topographic sheet shows a rather intricate pattern of hills and gulches, which appear to have no bearing on the distribution of the many sand and gravel bars and deposits containing placer gold. However, by coloring the areas between certain contour intervals on the map, a better idea of the physiography, which eventually leads to a better understanding of the distribution of gravel bars and of the general geology, is at once obtained. So colored, the map shows an isolated divide which extends in a north, northwesterly and southeasterly direction. This divide is known as the Iron Springs Divide. Drainage extends away from it in all directions. From the divide the country slopes to the north toward the Little Snake River. The northern secondary drainage channels flow into this river. To the northwest, west and southwest, secondary drainages also flow into the Little Snake River. From the divide the country also drops or slopes southward toward the Yampa River, but the drainage channels of Lay Creek, North Fork of Big Gulch and the upper part of Big Gulch, drain into Lower Lay Creek, which parallels the Yampa River to the north of it and finally empties into it outside of the area under discussion.

To the east, Blue Gravel Creek and its tributaries empty into Fortification Creek which occupies the valley between the Iron Springs Divide and the foothills of the Elkhead Mountains. Fortification Creek flows in a southeasterly direction and empties into

the Yampa River at Craig.

The closest connection between the high part of the isolated Iron Springs Divide and the Elkhead Mountains is in the N.E. corner of T.10N., R91W., where Four Mile Creek issues from the mountains.

A study of the map shows that during past geologic times, before the present drainage dissected the Craig-Baggs region, it probably was a large alluvial fan or outwash plain deposited on a peneplained surface. This fan consisted of silt, sand and gravel obtained or originating in the mountains to the east which at the time must have been much higher but which since have been lowered by denudation. A second cycle of erosion, later than the one which deposited the large alluvial fan, cut through it in a north as well as south direction and removed remnants of those formations which earlier may have contributed to the large outwash plain or alluvial fan. This large alluvial fan must at one time have covered the entire area of the "Craig" topographic sheet and may even have extended beyond it. Little Snake River which enters the Craig-Baggs region from the northeast, now flows around its remnant to the north of it, thence turns in a southerly direction around the Iron Springs Divide and finally empties into the Yampa River to the southwest of the divide. In a similar way, Fortification Creek flows around the eastern, and southeastern part of the divide and the Yampa River and Big Gulch now flow in a westerly direction around its southerly extension.

Fourmile Creek, the Little Snake River, Fortification Creek and the Yampa River therefore form a complete major drainage circle

of perennial streams around the Iron Springs Divide. The secondary drainage which radiates in all directions from the highest part of this divide finds its way into this major drainage circle.

AREAL GEOLOGY AND STRUCTURE

Apart from the deposits of silt, fine sand and gravel which are found at numerous places throughout the area covering the compacted sedimentary series, the rocks which outcrop at the surface consist of soft shales, sandstones, conglomerates, and clays of the lower part of the Wasatch formation. In the southern part the underlying post-Laramie coal bearing rocks outcrop at the surface. The sedimentary series dip gently northward at angles ranging from 10 to 2 degrees into the Washakie geosynclinal basin of southern Wyoming. This gentle, northerly dip is interrupted, however, by an east-west trending regional anticline just to the north of the Little Snake River, in the northern half of T.12N., from the northern limb of which the formations again dip gently northward.

It has been pointed out that the Craig-Baggs area at one time was covered by a large alluvial fan or outwash plain extending westward from the flanks of the Elkhead Mountains; it consisted of silt, sand and fine gravel which was carried down by intermittent streams meandering over this plain. It is also possible that glaciers at one time existed to the east and that the alluvial fan was in fact a glacial outwash plain. Together with the silt, fine sand and gravel there was deposited a comparatively large amount of finely divided placer gold.

(

During a later cycle of erosion this fan or outwash plain was degraded and dissected, giving rise to the present form and outline of the Iron Springs Divide, the backbone of which now constitutes the last remnant of the original outwash plain. Even this remaining backbone has probably been somewhat lowered from its original height by degradation.

()

During the processes of erosion the silt, fine sand and gravel which covered the sedimentary rocks were removed along the present general drainage channels from the highest part of the remaining plain. The lighter materials were washed down-stream and a re-sorting of the sand and gravel took place in the higher parts of the tributaries to the main drainage channels which now radiate in all directions from the Iron Springs Divide. These deposits are gulch placer deposits in which good gold values and high concentrations of black sand have been found.

While samples of sand and gravel taken on the very backbone of the Iron Springs Divide show the presence of a minor quantity of placer gold, the gulch placers show a great increase in gold content as well as increases in thickness of sand and gravel. Some of these deposits show concentrations of black sand in their lower parts which contain as much as \$1 to \$5 in placer gold per cu. yd. These gulch placers surround the highest part of the Iron Springs Divide.

During a later cycle of erosion these gulch deposits were attached again; torrential storms moved some of their material

)

farther downstream and redeposited it as larger bars at the confluence of gullies and gulches. More extensive, rather flat bars formed along the lower sections of major drainage channels during the run-off from torrential rains.

At a still later time these secondary bars were again attacked and a part of their sand and gravel was carried farther downstream toward the mouths of the gulches and creeks where they empty into the larger streams of the region.

() The cycle of erosion above described is continually going on and some of the sand and gravel is constantly being carried from the higher deposits through the lower bars - which are now dissected by the drainage - directly into Little Snake River, Fourmile Creek, Fortification Creek and the Yampa River. Old terraces and bars as well as present bars of the Yampa River contain placer gold.

Reviewing the above, it is plausible to assume that different placer deposits of the region originated during successive erosion cycles. On this assumption the placer deposits can be classified into five groups:

1. Gulch placers, at the upper ends of tributaries to the present drainage channels.
 2. Placer deposits at the confluence of drainage channels.
 3. Placer deposits at reduced gradients along main drainage channels.
 4. Placer deposits near the mouths of ~~the~~ drainage channels.
 5. The valleys and courses of present perennial streams encircling the region.
-)

While the gulch placers may contain higher values, they present greater difficulties to exploitation; they also contain less yardage than the bar placers which are easily accessible, are more level and, therefore, much easier exploited. Water condition at the lower bar placers and along present perennial streams make these the most desirable for large scale operations.

WATER RESOURCES

() Most of the gulches and creeks draining away from the Iron Springs divide are dry throughout the greater part of the year, but underflow water is present in almost all of them. Within an area of 720 square miles surrounding the Iron Springs Divide there are 73 known springs and water seeps which are shown on the "Craig" topographic sheet. 44 of these springs lie within the 160 square miles of the divide proper, while 29 springs are scattered around it at lower elevations.

The water from the springs in the vicinity of the Iron Springs divide seeps into the ground, continues downhill as underflow water in the various gulches draining away from the central high ridge and seeps into bedrock sandstones which slope gently to the north toward the Snake River. Drilled or dug wells should therefore encounter plenty of water. In places otherwise dry streams show perennial flows of water.

() From the top of the Iron Springs Divide to the Little Snake River, a south to north distance of about 15 miles, the different

in elevation is 1000 feet, or 66 ft. per mile. The regional dip of geologic formations from the divide to the Snake River has not been accurately determined, but may vary from 1 to 2 degrees. A possible sandstone formation outcropping near the top of the divide should, therefore, lie approximately from 350 to 2500 ft. below the surface at the Little Snake River; in other words, there should be plenty of underground water, some of it under artesian pressure, within the Craig-Baggs region. The east-west anticline to the north of Little Snake river would delay rapid down-dip circulation of underground water. A 4 inch artesian well has actually been drilled near Baggs, Wyoming. Water from this well, encountered at a depth of some 300 feet, is piped to the buildings and barns of a ranch.

Due to the underflow along the apparently dry streams, sumps can be and have been dug along their courses in order to obtain larger amounts of water for placer mining purposes on some of the higher bars.

INTERPRETATION OF PHYSIOGRAPHIC AND GEOLOGIC FEATURES

Various interpretations for the occurrence of gold and its origin in this area have been advanced by Hoover, Marks and others. Some claim the gravel bars represent old channels of the Little Snake River. Others hold that they are lake deposits. Doubt is expressed as to the origin of the gold.

Reviewing the evidence above set forth which is based on detailed reconnaissance studies by the writer during 1938 and 1939

it seems possible and plausible that the original alluvial fan or glacial outwash plain material was derived from the east, from the Elkhead mountain region. It may have been derived from soft sandstone and conglomerate formations of Tertiary or earlier age which have long since been entirely removed by erosion. The occurrence of placer gold in sandstones and conglomerates is not uncommon in Colorado and exists in the Castle Rock conglomerate near Denver from where it has found its way into Cherry Creek and other nearby streams.

Little is known about the Elkhead mountain region to the east which covers more than 1000 square miles. It lies between the alluvial fan or outwash plain and the continental divide. No roads traverse it, but skirt it to the north and south. Horseback is still the only mode of travel over much of this region. Sheepherders occasionally show quartz pebbles containing free gold which they have picked up along gullies in the Elkhead mountains. Apart from the early Hayden maps and reports, no geological maps or reports exist and no geological investigations have been carried on by the U.S. Geological Survey.

ECONOMIC ASPECTS

Whatever the origin of the placer gold in the Craig-Baggs region may be, these facts stand out:

1. Placer gold in commercial quantities has been found and mined at innumerable places in an area covering 1000 or more square miles.

2. The region has produced over one quarter million dollars in placer gold during the past.
3. All past operations have been conducted on a small scale.
4. No well guided and well financed exploratory and research work has been carried on at any time during the past.
5. Not one single test hole has been drilled along 150 miles of perennial stream valleys which surround the area in circular form and into which all secondary drainage channels flow.
6. All of the past desultory placer mining has been carried on on higher bars of gravel where hydraulicking and sluicing through riffled boxes proved unsuccessful on account of the fineness of bank run gravel and lack of sufficient water and grades for such operations.
7. The best results so far obtained were by an old fashioned bucket dredge and a simple dry land dredge fed by a 1 cu. yd. shovel.

() Many placer locations were made during the early history of the district; few, if any, have gone to patent or have been kept up. Some of the ground is owned under homestead entries, some under grazing homesteads, while much of it is public domain. The latter is especially the case of that part of Little Snake River skirting the northwestern and western part of the region where there are no habitations and even range cattle are scarce. Several of the major secondary drainages exhibiting large placer bars along Yampa River which merit careful investigation.

) Little of merit can be accomplished here by small scale undertakings insufficiently financed for thorough exploration and research campaigns, so badly needed for the development of this large and steady gold producing area. Excepting the course of the Little Snake River, Fortification Creek and the Yampa River, all of the gravel is fine and will pass through a 1/8 inch screen.

While the gold concentrates easily, jigs may have to be employed in exploitation and should be used during sampling campaigns. Rotary percussion drills may have to be used for testing along stream channels where water is present. The California cesspool digger type of drill with which large diameter holes (up to several feet in diameter) have been drilled cheaply at other places (39¢ per foot of hole, 27 inches in diameter, in the Mohave desert of California) may find application here on higher bars adjacent to junctions of secondary drainage channels and the Little Snake River. Some sampling can even be carried on with a 6-inch post hole digger, but larger samples are more advisable where possible.

() The average fineness of the gold in the Craig-Baggs district varies from 940 to 955. While it concentrates easily, the particles being small, yet rough and not flattened, sufficient water must be available to wash the fine gravel and sand so that they do not pack in the sluice boxes and thus allow the fine gold to ride over the riffles and escape with the tailings. Samples running as high as \$8.65 per cu. yd. have been obtained at the discharge end of old sluicing operations carried on years ago. The Craig-Baggs region offers possibilities for placer operations of large scale and merits more careful attention from those who are financially able to carry on preliminary work followed by efficient exploitation.

()

APPENDIX E

Zimmerman, O., 1960, Report on the Zimmerman property.

Zimmerman Report

The Zimmerman family held placer mining claims in the Great Divide area. Frank and George Zimmerman located claims in the early 1930s. From the claims they extracted free gold, with values ranging from \$2.00 to \$10.00 per yard. The fineness ranging from 945 to 965. ^{my father} Orvie Zimmerman and ^{my 64th Uncle} George Zimmerman, the sons of ^{my Grandfather} Frank Zimmerman helped in the sluice operation. The claims were then dropped for a short period of time, and then reacquired by the Orvie Zimmerman Sr, family.

Frank Zimmerman stated many times that the black sands were different from other black sands, meaning not ordinary magnetic iron. When the Orvie Zimmerman family began their tests for better methods of concentrating the gold, they also recognized the difference. Several samples of the black sand were sent to Colorado Assaying Company. The results showed a heavy mineral suit containing, monazite, garnet, titanium, thorium, zirconium and other minerals. This started the first interest in the other minerals other than just the gold and silver.

The Zimmermans then began to look for possible markets for the monazite, garnet titanium, thorium, zirconium. Samples were sent to W.R. Grace, Vitrol, American Potash, American Potash showed a great interest and sent to of their top men Frank Weishople and David Holmes to check the size of the deposit. After there investigation, they sent a contract with the purity and other specks that the concentrate would have to meet. With this information the Zimmermans then started looking for the proper milling equipment. The first information gathered was from Westrailan Sands Limited, their operation consisted of Reichert Cone, tables magnetic and electro magnetec separators. The Zimmerman family was unable to raise the proper funding so they could not sign the contract. The Zimmermans contacted American Potash to see if they were interested in leasing the property. American Potash replied that they were, but they would not put the property into production for some time, but would hold it for reserves. The deal never took place, what they wanted to pay for holding the property was not enough.

APPENDIX F

Carpo, Inc., 1984, Separation of monazite and precious metals from mineral sands: 3 April 1984.

Carpco, Inc.

4120 Haines Street / Jacksonville, Florida 32206 U.S.A.

Cable Address: CARPCO / Telex: 5-6367 / Telephone: (904) 353-3681

Ref: T84-143

April 3, 1984

The free gold removed

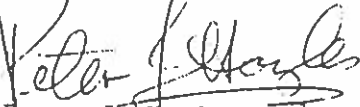
Craig, Colorado 81625

Ref: Separation of Monazite and Precious Metals from Mineral Sands;
Carpco Project TI-1581

We enclose, herewith, the report from the University of Georgia concerning the microprobe studies that have recently been carried out on the heavy mineral concentrates from sites Joker and Bailey (samples 20711-26 and -28 respectively). These samples were heavies of a sink-float separation carried out on each of the samples of table product submitted. The percentages given are therefore percents of the heavy minerals present in the samples.

Yours sincerely,

CARPCO, INC.



Peter J. Hoyles
Manager of Technical Services

PJH/tg

Enclosure: Report from University of Georgia (March 25, 1984) with figures

Electrostatic / Electrodynamic and Magnetic Separation Systems

REPORT ON SAMPLES 20711-26 AND 20711-28, PROJECT TI-1581.

The following is our mineralogical and chemical report on the samples listed above. We first did point counts on both samples using the electron microprobe, using approximately 300 points per sample. These results are given in the first set of columns for each sample in Table 1. We later did more extensive point counts on multiple polished sections, totalling 1000 points per sample. These results are given in the second set of columns for each sample on Table 1. Finally, we calculated the overall percentages from all points counted. This combined percentage is listed in the last set of columns in Table 1. A
B

In addition, we conducted quantitative chemical analyses of the monazites and iridium minerals. These results are given in Tables 2 and 3.

Among the major mineral groups, the only significant change from the 300 to 1000 point analyses is in the proportion of garnet to iron-titanium oxides in sample 28. This is probably due to the large grain size of the garnets, and the fact that the first mounts were not ground so deeply since only 300 points were required. The 1000 point count is probably more accurate on the percentage of garnet grains, but in the whole analysis the large grain size of garnet means that it is more abundant by weight than suggested by the grain percentages. All other results are in agreement between the 300 and 1000 point counts at the 2 sigma level or better, although the thousand point counts are obviously better for minor minerals as they are more statistically reliable.

Iron-Titanium Oxides

In doing this type of analysis it is necessary to define categories within this group. There is however a wide range of chemistry within the iron-titanium oxides. Most of the magnetite and ilmenite are exsolved and recrystallized into a lamellar intergrowth, so that the chemical data shows a wide variation between extreme compositions. The ilmenite comes in a variety of compositions ranging from Mn-rich to Mn-poor. The rutile is minor and is not very clean. It is probably the extreme oxidation product of ilmenite.

Garnets

The garnets also show a wide range of chemical compositions being dominantly a mixture of the almandine, spessartine, and andradite end-members. We have tried to sub-divide them on the basis of the dominant component, but there is a great deal of solid solution and in some cases nearly complete solid solution may be present.

REE Species

The dominant Rare Earth Element phase is monazite in both samples. Most grains appear to be consistent in composition, although some variation is apparent. Typical grains from each sample were analyzed (Table 2, Figures 1 and 2). These show

rather high concentrations of Lanthanum, Cerium, and Neodymium. Praseodymium is also present, but it overlaps Ce and Nd so much that its concentrations cannot be accurately determined.

The amount of Monazite is considerably higher in sample 26 over all sets of counts, and this difference is obvious during the counting.

Native Metals

The most common native metal is iridium. It contains some heavy rare earth elements (Table 3, Figure 3), but is otherwise quite pure containing little osmium or platinum. It is of average grain size for the sample, and forms clean, homogeneous grains so the percentage given by point counting is a good measure of the abundance. It is very dense, however, so its weight percent will tend to be higher than its modal abundance.

Under the microprobe, the iridium can only be identified for certain by its energy dispersive emission pattern, as it is otherwise not very obvious. Therefore, there is no chance that its abundance has been artificially enhanced, and the figures given are an accurate estimate of percentage. It might be added that three separate mounts were made for each sample and the abundance of iridium was about the same in all mounts of each sample.

Gold is present in the sample, but in abundance too low to be picked up in this type of analysis in which nothing below about 0.1 percent can be reliably identified. We did find one grain in one mount of sample 28. It contains a little silver but is otherwise pure. The one grain found was of average grain size for the sample.

Two grains of a mercury-bearing mineral were observed. These grains also contained some iron and manganese. In one grain, some sulfur was seen, but not enough for good cinnabar. The nature of this mineral is not resolved due to its low abundance and variability. It may be that we had an intergrowth of more than one species involving cinnabar.

Two tiny grains of copper bearing minerals were found. They were, however, very small. One (the Cu-Zn one) could have been brass impressed on the surface by contact with some implement during sample collection or handling. The other could also have come from a copper implement but was an independent, small particle.

Accessories

The only unusual accessory mineral found was Barite, which was encountered in sample 26. The barite was of average grain size and the modal data accurately reflects its abundance.

Mineral

SAMPLE 20711-26 (2014.12)

SAMPLE 20711-28 (GALLERY)

	Counts	%	Counts	%	Counts	%	Counts	%	Counts	%	Counts	%
	A		B		A+B		A		B		A+B	
IRON-TITANIUM OXIDES												
Titaniferous Magnetite	72	24.4	236	22.3	308	22.8	57	18.6	205	19.3	262	19.1
Ilmenite	57	19.3	160	15.2	217	16.1	58	18.9	165	15.5	223	16.3
Mn-Ilmenite	21	7.1	96	9.1	117	8.7	17	5.7	148	13.9	165	12.1
Ilmenite-Hematite	14	4.7	55	5.2	69	5.1	6	2.0	52	4.9	58	4.2
Hematite	2	0.7	31	2.9	33	2.4	5	1.6	35	3.3	40	2.5
Rutile	3	1.0	12	1.1	15	1.1	3	1.0	22	2.1	25	1.8
GARNETS												
Almandine (Fe-rich)	48	16.3	111	10.5	159	11.8	46	15.0	95	8.9	141	10.3
Spessartine (Mn-rich)	10	3.4	47	4.5	57	4.2	20	6.5	46	4.3	66	4.6
Andradite (Ca-Fe-Mn)	5	1.7	31	3.0	36	2.7	26	8.5	51	4.8	77	5.6
REE SPECIES												
Monazite	41	13.9	167	15.8	208	15.4	19	6.2	74	7.0	93	6.6
Allanite-Epidote	4	1.4	5	0.5	9	0.7	1	0.3	2	0.2	3	0.2
METALS AND OXIDES												
Iridium	1	0.3	7	0.7	8	0.6	2	0.7	15	1.4	17	1.2
Gold	0	-	0	-	0	-	0	-	1	0.1	1	<0.1
Zn-Spinel (Gahnite)	1	0.3	2	0.2	3	0.2	0	-	0	-	0	-
Hg-Mn-Fe sulfide?	0	-	1	0.1	1	<0.1	0	-	1	0.1	1	<0.1
Chromite	0	-	1	0.1	1	<0.1	0	-	0	-	0	-
Cu metal?	0	-	1	<0.1	1	<0.1	0	-	0	-	0	-
Cu-Zn metal?	0	-	1	<0.1	1	<0.1	0	-	0	-	0	-
ACCESSORIES												
Zircon	5	1.7	38	3.6	43	3.2	3	1.0	21	2.0	24	1.8
Quartz	2	0.7	24	2.3	26	1.9	17	5.5	66	6.2	83	6.1
Albite	1	0.3	2	0.2	3	0.2	0	-	1	0.1	1	<0.1
Plagioclase	0	-	0	-	0	-	1	0.3	1	0.1	2	0.1
K-Feldspar	4	1.4	3	0.3	7	0.5	2	0.7	3	0.3	5	0.4
Epidote	0	-	8	0.8	8	0.6	9	2.9	28	2.6	37	2.7
Sphene	2	0.7	8	0.8	10	0.7	10	3.3	20	1.9	30	2.2
Biotite	0	-	0	-	0	-	0	-	1	0.1	1	<0.1
Amphibole	0	-	0	-	0	-	0	-	1	0.1	1	<0.1
Alumino-silicate	0	-	5	0.5	5	0.4	3	1.0	3	0.3	6	0.4
Barite	0	-	5	0.5	5	0.4	0	-	0	-	0	-
Apatite	2	0.7	4	0.4	6	0.4	1	0.3	5	0.5	6	0.4
Corundum	0	-	0	-	0	-	1	0.3	0	-	1	<0.1
Totals	295	100.0	1056	100.3	1351	100.1	307	100.0	1062	100.0	1369	100.0

APPENDIX G

Centennial, 1985, Marathon/Centennial exploration and development, Moffat County, Colorado: 14 June 1985.

June 14, 1985

Re: Marathon/Centennial Exploration and Development
Moffat County, Colorado

SUMMARY. Centennial Gold Corporation and its publicly held affiliate Marathon Gold Corporation hold a substantial land position and a well developed placer prospect in the Northwest corner of Moffat County, Colorado. The companies are active in an exploration and development mode on selected targets within this land position and have carried advanced exploration and development forward to the mine feasibility stage on one selected group of targets.

The companies can make an excellent case for the possible development of placer mining and milling operations at a phased construction of initially 3,000 dstdpd followed by an additional 3,000 dstdpd. Utilizing conventional mining and gravity concentration techniques the companies expect to realize approximately 13,500 ounces of gold and 400 tons of monazite concentrates annually from the first phase of construction. The second phase of construction and operation is expected to produce at similar levels.

Marathon/Centennial is offering the possibility of a significant interest as a joint venture partner for exploration and development on key target areas within the current land position, or a significant joint venture interest in the development of the currently held ore reserves.

Sufficient data with a high degree of sophistication is not available at this time to accurately forecast capital or operation costs. Studies to date have indicated however that the project under development will compare favorably with other current new mine precious metals projects.

PROPERTY. The Marathon/Centennial lands cover some 250,000 acres in northwestern Moffat County, Colorado. Early in the century and up until World War II, relatively large scale placer dredge operations were active in the district along with a multitude of small, individual, efforts. Although no accurate records were maintained for all of the historical activities it is estimated that approximately 12,000 ounces of gold were recovered utilizing only crude dredging, mining, and sluice box technology.

HISTORY. In the old days the individual miners and prospectors were likely to have concentrated on present day drainage placers and those deposits of earlier deposition which naturally outcropped at the surface. Current work has identified these smaller tonnages as being represented by relatively fine particle gold in the minus 65 plus 250 mesh range with headings of from 0.015 to 0.060 ounces per ton gold. Historical dredge operations were located on placer deposits having higher tonnages in place with commensurately lower headings in the range of 0.009 to 0.020 ounces of gold per ton. Modern day exploration has confirmed this general distribution of values and has pointed up the need for highly efficient mining and milling operations versus the poorly conceived operations of the past.

LAND POSITION. Marathon/Centennial has acquired its right of access to the previously mentioned 250,000 acres through a judicious combination of mining claims, property leases, and outright purchase. The objective of current and long range exploration plans is to gain rapid insight into the relative value of all land holdings so that development work may be concentrated on areas of high potential.

WORK DONE, COSTS. Geological surveys, prospecting, surface sampling, auger drilling, rotary drilling, hollow stem auger drilling, dozer and back-hoe trenching and bulk sampling, assays, pilot mill construction and operation, assay and metallurgical laboratory construction and operation, and maintenance and fabrication facility construction. Marathon/Centennial has spent over \$8,000,000 in obtaining the current land position, constructing support facilities, development drilling, and analytical and metallurgical work.

FINDINGS. The occurrence of gold is widely disseminated over much of the land holdings. The placer reserves have been thoroughly evaluated and have been found to be relatively consistent in their likelihood of occurrence and probable value. Utilizing conventional drilling and bulk sampling techniques some 3,000,000 tons of "proven reserves" have been identified and incorporated into preliminary mining plans. The data developed in engineering this reserve has been extrapolated to indicate the excellent possibility of an additional 10,000,000 to 13,000,000 tons of deposits having characteristics similar to the engineered reserve. The placer ores respond to conventional gravity concentration with process efficiency being directly correlatable to ore heading and throughput rate. Preliminary designs indicate that with ore in place grading at 0.012 to 0.022 ounces per ton gold, and approximately 0.06 to 0.09 percent monazite/xenotime, the recovery of both gold and rare earth minerals can be expected to exceed seventy-five percent.

PRESENT MINING CONCEPT. A series of small open pit style excavations utilizing front end loader and conveyor belt haulage is envisioned

as the mine method most likely to result in low operating costs and adequate grade control. Mine operations will feed preconcentrating facilities located immediately adjacent to the mining area. The preconcentrator will achieve a ratio of concentration of approximately eight to one, resulting in the elimination of some eighty eight percent of the mined material prior to transport to the central milling facility, and achieving a recovery of some 94 percent of the gold and rare earths into a high grade product. This mining concept is limited to the smaller, higher grade placers. The future development of the large "downstream" placer fields will require substantially different methods both in the mine and mill. In addition there remain large tonnages of "unoxidized" material in which the occurrence of gold is certain. Should current planned exploration in these deposits result in the finding of ore grade material the methods of mining and extraction will be totally different in scope and technique from those previously eluded to.

NEXT STEPS, TIMING, COSTS. Marathon/Centennial is currently engaged in a series of interactive activities to bring all aspects of the project along at a budgeted rate. These activities are briefly noted as follows:

1. Feasibility study of the phased approach to placer deposit exploitation. This study is nearing completion and will merit being taken into basic engineering during the 2nd quarter of 1985. Basic engineering is estimated at \$80,000. Detailed engineering and construction for phase one placer estimated at 4.5 to 5.5 million dollars
2. Development drilling program for 1985. Drilling in target areas similar in geological and geographical character to current proven reserves. Utilization of small auger, rotary, and hollow stem auger drilling to increase mine reserves from 3 to 10 million tons.
3. Exploration drilling program for 1985. Drilling in target areas downstream from current reserve position and in areas more remote from past activities. Purpose of program to associate more detailed value to large portions of current land holding.
4. Reconnaissance of areas with little or no geological or assay information. Data useful in assembling the 1986 exploration program will be gathered through auger drilling, surface sampling, and assessment work drilling & sampling.
5. Basic exploration techniques including the interpretation of aerial photography, ground based geophysics, airborne geophysics, and geochemistry. These studies will provide the identification of both placer and unoxidized targets.

In the case of the placers the data will confirm and add to present programs. In the case of the unoxidized deposits the data will aid in determining the need for more expensive exploration in 1985 or 1986.

ENVIRONMENTAL CONCERNS. The project is currently subject to review by the State of Colorado Mined Land Reclamation Board, and the Bureau of Land Management. Although the project is not located in an environmentally sensitive area, the joint use of the land with local farmers and ranchers, will result in high visibility and the necessity of good planning and study. Base line environmental and permit studies have already begun, and will escalate with the start of basic engineering.

APPENDIX H

Blue Jet, 1990, Supplemental data pertaining to the Blue Jet Mining Company precious metal project, Moffat County, Colorado: 30 May 1990.

SUPPLEMENTAL DATA PERTAINING TO THE BLUE JET MINING
COMPANY PRECIOUS METAL PROJECT, MOFFAT COUNTY COLORADO
MAY 30, 1990

Rare Earth Potential

Soon after Centennial Gold Corporation was established in early 1980, we began to evaluate the Rare Earth profit potential together with that of the industrial minerals as well as the precious metals. An unusually high Rare Earth content in the sands of the Middle Member of the Wasatch formation was well known. It, together with the anomalous precious metal content, had been recognized for many years.

Ben H. Parker, Jr. included a profit projection of monazite and xenotime and the industrial minerals occurring in the Middle Member of the Wasatch in his PhD thesis at the Colorado School of Mines entitled "Gold Placers of Colorado" dated June, 1967. See Exhibit A.

Molybdenum Corporation of America, a major producer of Rare Earth Oxides, analyzed our material in May, 1980. The percent of REO distribution is given in Exhibit B. By the end of 1982 we had stimulated considerable interest in our Rare Earth potentials as outlined in the Memorandum of December 14, 1982 - Exhibit C from Rhone Poulenc, the large French consumer and W.R. Grace & Company. Correspondence with them and analyses submitted by them to us are included in Exhibits D through H.

Rhone Poulenc's interest in Centennial and Marathon Gold Mining Companies grew as a potential supplier of monazite and xenotime concentrates after they had sent three of their technical staff from their laboratories in Paris to our laboratories. They were very satisfied with the Rare Earth content of the concentrates, and assisted us in establishing an analytical laboratory which consisted both of electrostatic and magnetic separator units. Extensive testing was completed in addition, with good success. They offered to finance a large scale electrostatic-magnetic circuit for our plant in exchange for a long term contract for all of our production.

Molycorp

Molycorp, Inc. P.O. Box 607 • Louviers, Colorado 80131 • Telephone 303 / 798-8355

May 9, 1980

Dear XXXXX:

As I discussed with you today, we have completed the analyses on the heavy sands that you submitted to XXXXXX. The results are:

		<u>% As Received</u>				
Rough Concentrate						
<u>Monazite</u> Sands	Moisture	2.97				
Rare Earth Oxide	REO	20.5				
		<u>% REO Distribution</u>	<u>lbs/ton</u>	<u>Grade</u>	<u>Price/lb.</u>	
			<u>Conc.</u>		<u>To Refiner</u>	
# Yttrium Oxide	Y ₂ O ₃	5.16	103.20 506.	99%	\$	38.00
# Lanthanum Oxide	La ₂ O ₃	18.06	361.20	"		6.50
# Cerium Oxide	CeO ₂	39.95	799.00	"		7.25
# Praseodymium Oxide	Pr ₆ O ₁₁	4.57	91.40	"	*	-----
# Neodymium Oxide	Nd ₂ O ₃	16.11	322.20	"	*	-----
# Samarium Oxide	Sm ₂ O ₃	3.04	60.80	"		30.00
# Europium Oxide	Eu ₂ O ₃	0.16	3.20	"		825.00
# Gadolinium Oxide	Gd ₂ O ₃	1.93	38.60	"	*	-----
# Terbium Oxide	Tb ₄ O ₇	0.22	4.40	"	*	-----
# Dysprosium Oxide	Dy ₂ O ₃	1.07	21.40	"	*	-----
# Holmium Oxide	Ho ₂ O ₃	0.16	3.20	"	*	-----
# Erbium Oxide	Er ₂ O ₃	0.36	7.20	"	*	-----
# Thulium Oxide	Tm ₂ O ₃	0.04	.80	"	**	2000.00
# Ytterbium Oxide	Yb ₂ O ₃	0.22	4.40	"	*	-----
# Thorium Oxide	ThO ₂	8.14	162.80	"		18.00
Total		99.19	1983.80			

I will await your call next week about arranging a visit to your property by one of our geologists.

Very truly yours,

Possible Markets available:

See attached Minerals Forecast for 1980

Concentrates containing 70% REO \$.90 lb. to producer

* Unable to obtain price

** 1970 Price

A news release, Exhibit R, dated June 18, 1984, summarizes the agreement consummated by Marathon Gold Corporation, our operating company and Rhone Poulenc Chemical Company, whereby Rhone Poulenc was to purchase a minimum of 4,000 tons and a maximum of 8,000 tons of monazite and xenotime per year from Marathon at the world market price under a three year contract which could be renewed annually thereafter. See Exhibit P. Unfortunately, the highly recommended hydrocyclone and Reichert Cone circuits in our plant proved to be ineffective in developing and upgrading our precious metal concentrate for final concentration on our Diesert tables. Funds were lacking to replace these units and the operation was closed on 1987.

Industrial Mineral Potential

Selective Industrial Minerals may offer appreciable support to the cash flow of the Blue Jet operation. Ben Parker's estimates of the combined contribution of these minerals together with the Rare Earths are included in Appendix A.

Dr. Warren Wagner, former Professor of Geology at the Colorado School of Mines completed an analysis of the heavy minerals in the Iron Springs District in 1965 with the following results:

Ilmenite and Rutile -----	11.5	pounds/yd.
Monazite -----	6.8	pounds/yd.
Garnet -----	2.6	pounds/yd.
Magnetite -----	3.4	pounds/yd.
Non-magnetic -----	3.4	pounds/yd.
Gold -----	0.64	oz/ton

A detrital, heavy mineral sample from Hump sulfide pit was completed in October, 1982 by Franz electromagnetic separation equipment. The results are shown on Exhibit J.

Preliminary evaluation of the industrial mineral potential of our sands indicate that Rutile, Ilmenite, Zircon, Columbite, Tantalite and Garnet offer profit potential if separated selectively after the separation of Rare Earth minerals.

Market data on Heavy Minerals in the Iron Springs District were completed in December, 1982. See Exhibit O.