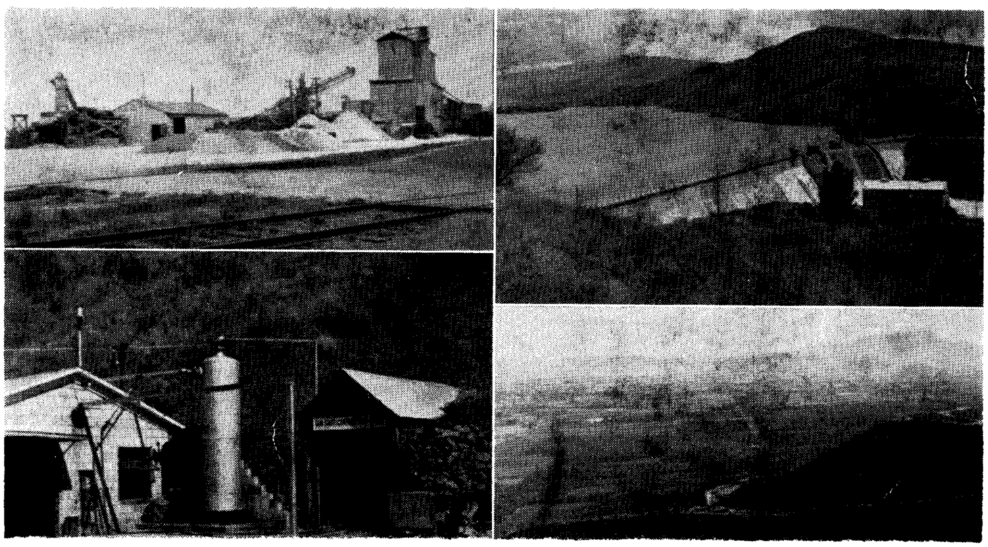
County Report No. 4 September, 1961

Geology And Mineral Resources Of Gem And Payette Counties

by
C. N. Savage



STATE OF IDAHO

Robert E. Smylie, *Governor*

IDAHO BUREAU OF MINES AND GEOLOGY

E. F. Cook, *Director*

Moscow, Idaho

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Moscow, Idaho

FOREWORD

In 1956 this Bureau started an ambitious project to map the geology and evaluate the mineral resources of each county in Idaho, to the end that such resources might play their full share in the developing economy of our state.

Because such a project requires, not just compilation of existing knowledge, but new field investigations, it takes time to produce the finished reports. With this present publication on Gem and Payette Counties, we have published four County Reports, covering the geology and mineral resources of six counties. Three more County Reports are "in the mill".

It is our hope that reports like this one by Carl Savage on Gem and Payette Counties may aid in the development of mineral resources in a manner compatible with other land uses, and complementary to other facets of the local economy.

E. F. COOK, Director
Idaho Bureau of Mines and Geology

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GEOLOGY AND MINERAL RESOURCES

OF

GEM AND PAYETTE COUNTIES

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C. N. Savage

ABSTRACT

Gem and Payette Counties are within a region of mountainous uplands, low mountains, mesas, buttes, and alluvial plains drained principally by Payette River and its tributaries.

The area is underlain by igneous rocks, including granodiorite and quartz monzonite of Cretaceous age; younger diorite and related porphyries; mafic flows and pyroclastic rocks of Miocene and Pliocene age; and silicic volcanic rocks of Pliocene to Pleistocene age. Sedimentary materials, from Miocene to Recent in age, include clay, ash, lime, silt, and sand and gravel; locally, induration of these produced limestone, shale, sandstone, arkose, and conglomerate.

Important mineral commodities in this region are silica sand, and sand and gravel; less abundant and of uncertain value are impure forms of clay, limestone, diatomite, and pumicite. Sandstone, arkose, and basalt are available as dimension stone.

Ground and surface water supplies are reasonably plentiful except in more remote, undeveloped areas.

Several unsuccessful attempts have been made to develop natural gas and oil wells in this area. Neither resource seems to be present in commercially valuable accumulations.

Deposits in the West View (Pearl) district contain minor amounts of gold, silver, copper, lead, and zinc. Total value of these metals produced over the period 1915-59 (five years not recorded) amounted to about $534,000. Tenor of ore, though low, appears to have remained constant at all exploited depths.

INTRODUCTION

LOCATION AND EXTENT OF AREA

Gem and Payette Counties are in southern Idaho 15 to 20 miles northwest of Boise (Fig. 1). Gem County has an area of 567 square miles and extends from Ada County on the south approximately 48 miles to Adams County on the north. Boise and Valley Counties form its eastern boundary, and Payette and Washington Counties lie to the west.

Payette County, just west of Gem County, lies adjacent to the Snake River and the State of Oregon. Bounded on the north by Washington County and on the south by Canyon County, Payette County has an area of 403 square miles.

PURPOSE OF INVESTIGATION

Southwest Idaho and a portion of nearby Oregon--a promising area for industrial expansion--constitute an economic unit sometimes called the "Gateway to the Pacific Northwest." Gem and Payette Counties form part of this area. This report presents an overall picture of the mineral resources in these counties, emphasizing geology and mineral locations, state of development, and potential; it is hoped the report may encourage greater use of the area's mineral resources.

METHODS AND SCOPE OF INVESTIGATION

Information was obtained by several weeks of field investigation during 1958-59; personal interviews with prospectors, mine operators, and public officials; and from other sources of information, including the references cited. Accumulated data have been expanded by inferences, and conclusions have been made possible from assembling the above information and by compiling maps, sketches, and diagrams. These illustrations should be useful in better understanding the area as a whole.

Previously published County Report No. 3 (Savage, 1958) deals with the geology of Ada and Canyon Counties just south of the area discussed in this report. The earlier publication is an important adjunct to the geologic study of the Gem-Payette region and, to a marked degree, the following pages expand and supplement the earlier report. The regional illustrations included in the Ada and Canyon County report may be used to supplement the illustrations in the present report. Persons more seriously interested in the geology of southwest Idaho are urged to read both publications.

County reports are designed to include those economic factors related to mineral use and development, in order to further encourage the use of our mineral resources: accordingly, considerable general economic information is made available in the following pages.

Certain aspects of this report may be of interest to naturalists, amateur geologists, and "rock hounds"; also the report may be useful to construction, soils, and mining engineers, particularly as an aid in the advanced planning of a variety of projects. Agricultural, reclamation, and water resources scientists may find portions of the report useful; however, its primary concern is with the needs of the mineral industry.

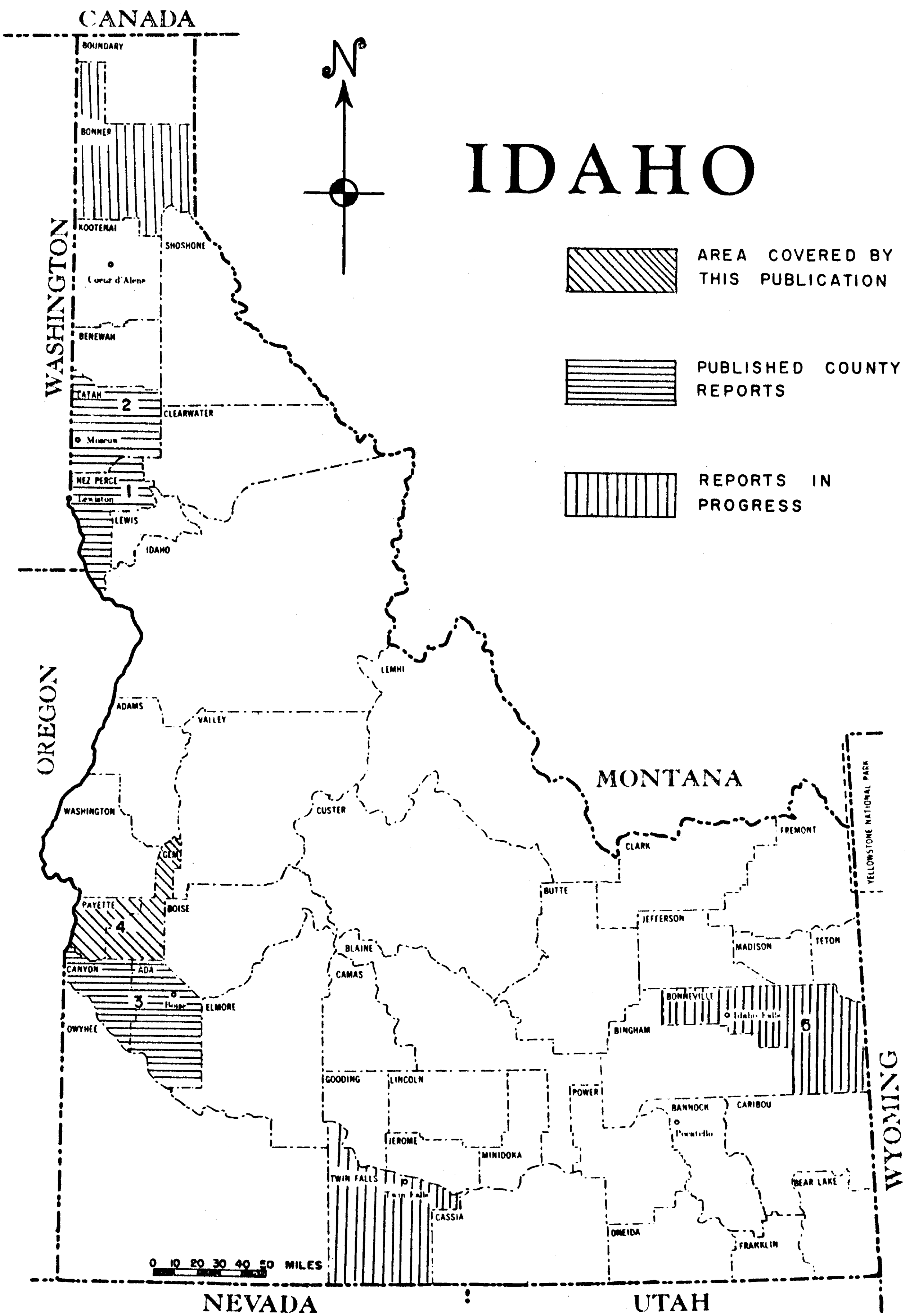


FIG. I – LOCATION MAP

GENERAL GEOGRAPHY AND ECONOMY

TOPOGRAPHY, RELIEF, AND DRAINAGE

Natural subdivisions

Nearly all of Gem and Payette Counties lies in the Columbia Intermontane geomorphic province, which includes parts of the Boise-Payette section of the Snake River Plain subdivision, and the Wallowa-Seven Devils section of the Central Mountain subprovince (Fig. 2). Southeastern Gem County is in the Boise Ridge section of the Idaho Batholith subdivision--a part of the northern Rocky Mountain province.

Relief and drainage

The terrain of these two counties embodies great contrast (Fig. 3) which is best observed on a clear day from Squaw Mountain at approximately 5,850 feet elevation. This vantage point reveals to the south, west, and northeast, the Payette River Valley which topographically is basin-like, but whose floor is a piedmont plain; this plain extends from a point east of Emmett to the Snake River on the west near Payette. This surface of low relief decreases in elevation from 2,379 feet at its eastern margin to 2,140 feet at its western margin. A somewhat similar topographic low parallels north-trending Squaw Creek Valley on the east side of Squaw Mountain upland. Squaw Creek Valley descends from approximately 5,400 feet elevation on the north to about 2,500 feet south of Sweet. A flat area in the vicinity of Montour is nearly separated from the main Squaw Creek lowland. Most surfaces of gentle relief in Gem and Payette Counties are terraced.

High, massive mountains--part of West Mountain, an upfaulted ridge--form the extreme northeastern boundary of Gem County. Wilson Peak (7,865 feet) and Gabes Peak (7,655 feet) are the highest elevations in the map area, producing a maximum relief of about 2,400 feet on the north. By contrast the Snake River elevation north of Payette is 2,010 feet, lowest in the region.

Squaw Butte, near Emmett, has a relief of 900 to 1,000 feet, and to the south and southeast in Gem County, low mountains in the Pearl district rise 2,700 feet above the Payette Valley. Pearl is dominated by two eminences called Crown Point (5,230 feet) and Prospect Peak (4,874 feet). Less prominent but very noticeable are the widely distributed mesas and buttes formed by local remnants of resistant bedrock. Occurring principally in Gem County, these landforms are sculptured from lava, sandstone, conglomerate, and arkose. Little Butte (3,494 feet, Fig. 5) and Regan Butte (3,310 feet) are examples of these relief features. They contrast sharply with the relatively low relief of Payette Valley.

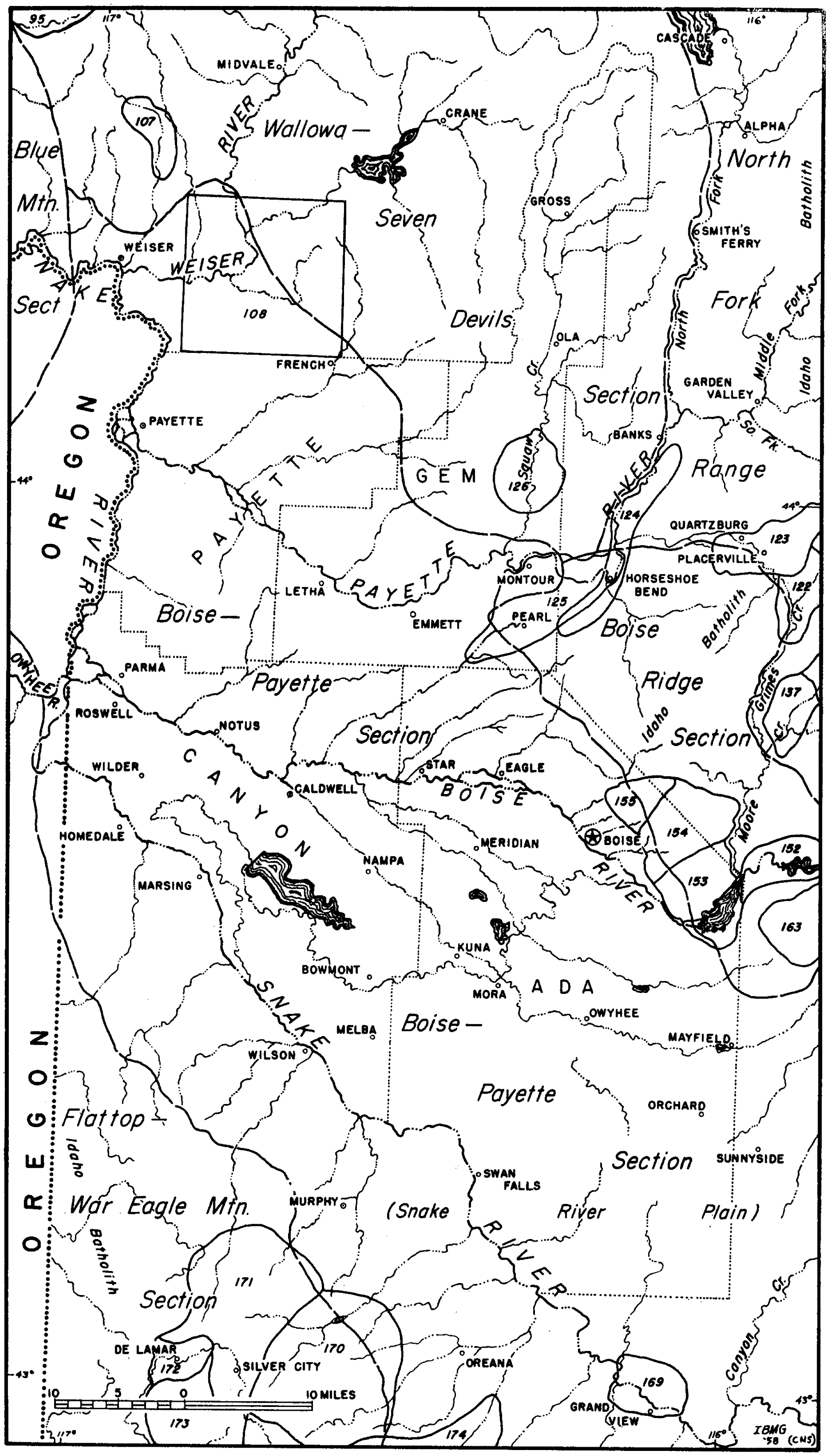


Fig. 2 —GEOMORPHIC AND MINING SUBDIVISIONS OF SOUTHWESTERN IDAHO

155 *Mining Districts* — *Geomorphic Subdivisions*

95	MINERAL	126	SQUAW CREEK	164	HIGHLAND
107	MONROE	137	MOORE CREEK	169	ROUGH MOUNTAIN
108	WEISER QUICKSILVER	152	TWIN SPRINGS	170	FRENCH
122	CENTERVILLE	153	BLACK HORNET	171	CARSON
123	QUARTZBURG	154	SHAW MOUNTAIN	172	DE LAMAR
124	HORSESHOE BEND	155	BOISE	173	FLINT
125	WEST VIEW	163	NEAL	174	CASTLE CREEK

Separating Payette Valley and its main tributaries from the more massive, higher uplands are dissected areas of gravel, arkosic sand, silt, clay, and ash of the Idaho Formation (Fig. 6), in which the relief--in the hilly districts just north of Payette River--ranges from 350 to 450 feet, increasing to 900 feet farther north. In southwest Payette County, where the terrain is underlain by the Idaho Formation, relief ranges only from 100 to 300 feet.

Surface drainage patterns of Gem and Payette Counties are greatly complicated by the presence of extensive diversion and irrigation canals and two reservoirs. As is often the case, natural drainage lines have been shifted and modified to fit the needs of various irrigation projects.

Payette Valley is a broad, terraced alluvial plain with a low gently rolling surface and only a few feet of relief along the river. Almost without exception, secondary tributary streams are dry much of the year. The tendency toward trellis type drainage in portions of Gem and Payette Counties is caused by beds of gravel, arkosic sand, silty clay, and ash which are gently folded and warped. Locally, the terrain has been dissected sufficiently to resemble badland topography

Large contrasts in relief seem to have resulted principally from faulting and from the presence of underlying rock and rock material of variable resistance to erosion. Earth stresses have produced uplift and subsidence accompanied by gentle folding, prominent faulting, and extensive volcanism.

CLIMATIC CHARACTERISTICS

Gem and Payette Counties experience a broad range of climatic conditions. Much of Payette and western Gem County have mild, nearly semi-arid climate; however, extensive irrigation practice tends to produce a rather humid local environment--especially in summer. Upland areas in southeastern and northeastern portions of Gem County experience more rigorous climate with higher precipitation and lower winter temperatures. The following summary of selected data indicates precipitation and temperature conditions in the two-county region and adjacent areas (U. S. Dept. of Commerce, 1958):

<u>Total mean annual</u>

	Precip. (inches)	Snowfall (inches)	Temperature (°F) Averages Ann.	Max.	Min.	Extremes High	Low
Emmett	11.93	13.7	51.8	65.9	37.6	110	-19
Ola	19.62	53.0	47.7	62.9	32.3	118	-32
Parma (Canyon Co.)	8.47	13.7	50.8	65.5	36.1	109	-28
Payette	10.83	21.5	50.9	64.4	37.5	109	-26

General climatic data may be summarized as follows:

Average number of frost-free days range from approximately 168 in the uplands northeast of Ola, to 116 in Emmett Valley;

Valleys experience dryer and warmer weather than adjacent hilly uplands;

In general, southwest Payette County is dryest and warmest;

Precipitation is heaviest, largely in the form of snow, in the colder months of winter; and

The prevailing winds blow from west to east.

VEGETATION AND SOILS

Most of the surface at lower elevations in Gem and Payette Counties supports natural vegetation of grasses and shrubs; at high altitudes, especially in northern and northeastern Gem County, greater precipitation encourages tree-growth and forest cover. About 17 percent of Gem County is National Forest land.

Among the widely distributed plant types in this region (Dorf 1938, p. 79, and Troeh and others 1958, p. 888-892), are big blacksage, winter-fat, saltbush, and rabbitbrush; occurring less commonly are greasewood, hop sage, antelope brush, and patches of bunch and blue grass. Black cottonwood, wild rose, western aspen, common cattail, willow, western chokecherry, and staghorn sumac grow along the margins of some perennial streams while at higher elevations, where more moisture is available, mountain maple, Douglas fir, and ponderosa pine may thrive.

A recently completed soil survey (Troeh and others, 1958), has grouped the soils of Gem County into 14 soil associations. Because of a wide range of elevations and parent bedrock material, these soils are rather complex. Their composition is influenced by silicic parent materials in some localities, by mafic rock types in others, and by environment in all areas. Much of the soil at lower elevations has been derived from silica-rich ash, clay, silt, and arkose of the so-called Idaho Formation. Varying thicknesses of loess also form soil types. Rhyolitic and granitic materials both seem to weather faster than basaltic rock. Notably basaltic soils seem less susceptible to erosion than do soils derived from silicic rock.

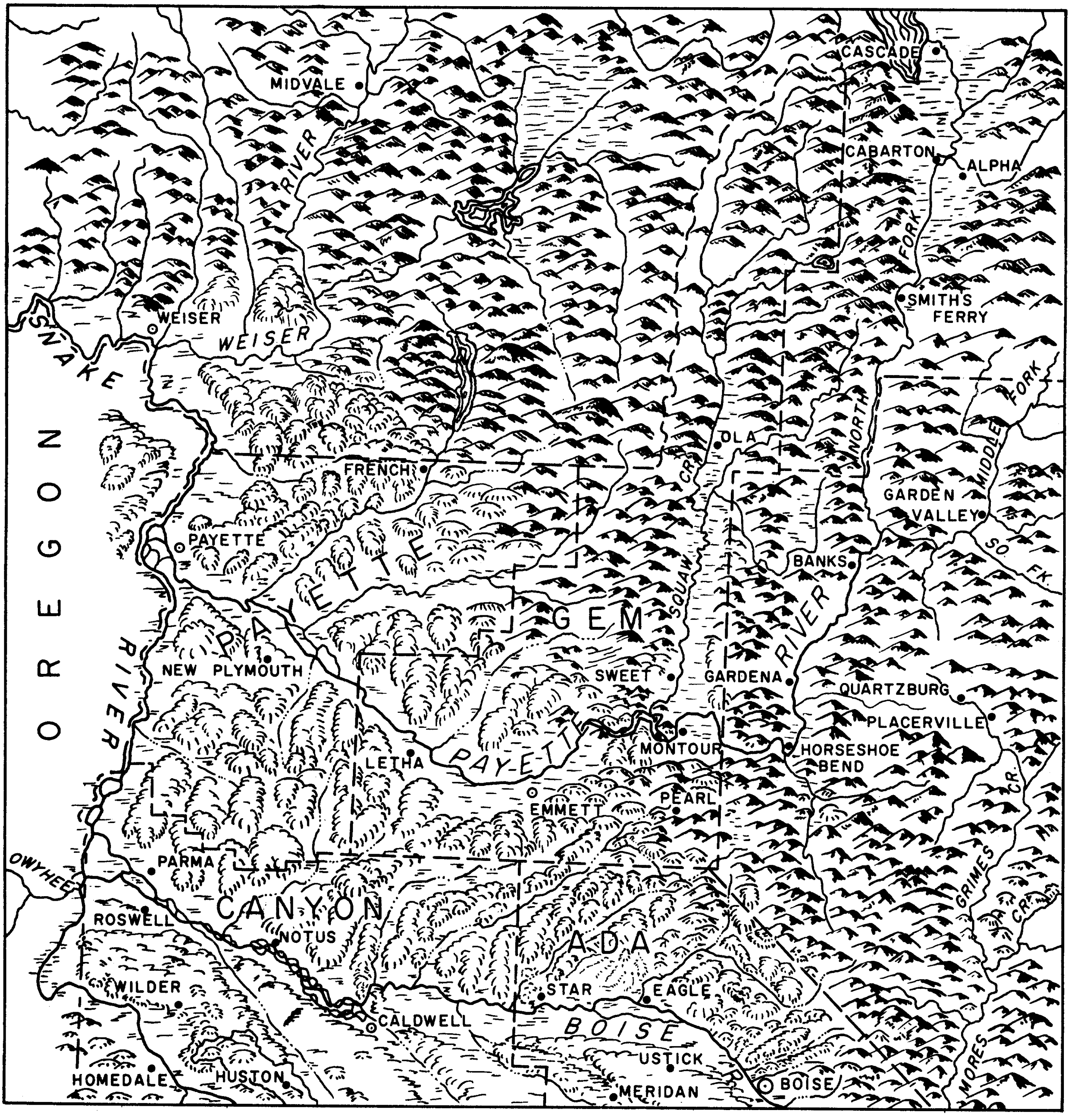
Like much of southwest Idaho soil, the soils of Gem and Payette Counties are both residual and transported. They consist of stony mountain soils, and alluvial, colluvial, and eolian soils. They are thick to thin, wet to well-drained, and rich to poor in humus. Gray desert soils are common in the drier, lower areas, particularly in Payette County.

Soil associations and their environment have been more formally summarized for Gem County by the U. S. Soil Conservation (Troeh and others, p. 10):

Series	General environment
Chilcott-Lanktree-Lilalita	Light-colored soils of the semiarid uplands.
Power-Purdam	Light-colored soils of the semiarid high terraces.
Emerson-Wardwell-Quenzer	Light-colored nonsaline soils of the low terraces.
Harpt-Cashmere	Soils of the alluvial fans.
Letha-Baldock-Vanderdasson	Saline, alkali, or dark soils of the low terraces and basins.
Haw-Payette-Van Dusen	Medium-colored soils of the semiarid uplands over sands.
Ruckles-Tripod	Medium-colored soils of the semiarid uplands over basalt.
Pearl-Black Pearl	Medium-colored soils of the semiarid uplands over rhyolite.
Sweet-Kepler	Medium-colored soils of the semiarid high terraces.
Gem-Tripod-Klingback	Dark-colored basaltic soils of the dry subhumid zone.
Figart-Rainey	Dark-colored granitic soils of the dry subhumid zone.
Gwin-Mehlhorn-Jacknife	Dark-colored basaltic soils of the moist subhumid zone.
Brownlee-Rainey-Ola	Dark-colored granitic soils of the moist subhumid zone.
Moulton-Falk	Soils of the bottom lands.

This U. S. Soil Conservation report on Gem County soils contains many detailed soil characteristics applicable to the soils of this area, including discussion of soil association, types, agricultural use, and land capability. It presents valuable statistical data about the following soil characteristics:

Water holding capacity and basic intake;
Water table, and internal and surface drainage;
Bank stability, permeability, and compressibility;
Piping hazard and shear strength; and
Structural characteristics of compacted soils.



GEOMORPHIC DIAGRAM OF GEM AND PAYETTE COUNTIES

10 5 0 10 MILES

FIGURE 3

GENERAL ECONOMY

Population and transportation facilities

Except for northern Gem County, Gem and Payette Counties are reasonably accessible. Main highways are paved and secondary roads are generally graveled and graded; in more remote districts roads are best negotiated with four-wheeled drive vehicles. In wet weather, normal traffic may be impossible to maintain on some ungraveled roads because of their clay surfaces. These "slick" roads are generally located in areas underlain by basalt. Main highways in this area are open all year and, with the exception of those in higher areas north of Ola in Gem County, most secondary roads are trafficable even in winter months.

Emmett and Payette are the largest settlements as well as the county seats of Gem and Payette Counties respectively. Payette is the largest city and principal business center of the Payette Valley.

Smaller settlements in the two-county area are Fruitland, New Plymouth, Letha, Pearl, Montour, Sweet, and Ola. These smaller settlements are inhabited by persons associated with either the fruit or cattle industries.

According to the U. S. Census of 1950, approximately 40 percent of the population of Idaho was in five counties of the Snake River Plain; 29.9 percent of Idaho's total population was in southwestern counties. Preliminary figures from the U. S. Census of 1960 indicate that these percentages still apply and that southwestern Idaho's population is still expanding. The following are comparative population figures for Gem and Payette Counties:

Total population

	1940	1950	1960
Gem County	9,544	8,730	9,127
Payette County	9,511	11,921	12,245

Settlements

	1950	1960
Emmett	3,067	3,769
Payette	4,032	4,401
Fruitland	573	940
New Plymouth	942	1,100

Southwest Idaho is accessible by air and surface transportation. For example, Payette Valley is served from Nampa and Weiser by branch lines of the Union Pacific Railroad, which join at Emmett; from Emmett a single branch line extends through Horseshoe Bend, Banks, Smiths Ferry, Cascade, Donnelly, and Lake Fork, to McCall. Bus service is available to Boise. West Coast Airlines serve the area from Boise and Ontario, Oregon, and airports for light aircraft are located at Emmett and Payette. Available to this area is sufficient freight and cargo moving equipment to insure distribution of raw materials and finished products to local markets or to more distant points of the Pacific Northwest.

Main industries

Agriculture

The meadows along the floodplains of Payette and Squaw Creek Valley first attracted homesteaders in agriculture, the oldest activity in the region. Early development of irrigation ditches opened the way for reclamation of nearby arid lands like those in Boise Valley to the south. Mild climate and abundant primary water sources, both favorable to growth of forage and ensilage crops, soon stimulated the now multimillion-dollar livestock industry in this part of Idaho. Cattle, hog, and sheep raising, as well as a thriving dairy industry, are basic elements of the regional economy.

Payette is a trading and shipping center where dairy products, beef, and fruit are primary commodities. Dairying constitutes a $4,000,000-a-year industry and about 20,000 head of beef stock are raised in Payette County each year.

Characteristic of diversified farming in the Gem-Payette region are such agricultural products as corn, beans, sugar beets and wheat. Among the major fruit crops are prunes, apples, peaches, cherries, pears, and apricots. Over 42,000 acres within the district are irrigable. By 1954, 93 percent of the farms in Gem County (92 percent of the land area) were irrigated farms (Troeh and others, 1958, p. 881).

Agricultural problems in this area involve decreasing soil fertility, erosion control, reclamation of wet or saline-alkali soils, improvement of water intake, and occasionally frost hazard. In some sections where range land has been depleted as a result of overgrazing, such land needs reseeding. Some land now used for grazing is suitable for irrigation. A fairly large total acreage is being used for dry farming, but locally, climatic conditions are such that dry farming is not recommended because the land is susceptible to soil erosion.

Emphasizing the importance of agriculture to this region, Troeh and others (1958, p. 882) cite the following figures:

Value of products sold and percentages of total value by source in Gem County, 1954

Product	Value	Percentage of Total Value
All crops sold	$2,664,365	42.43
Field crops other than vegetables and fruit	550,843	8.77
Vegetables	174,689	2.78
Fruits	1,938,483	30.87
Horticultural specialties	350	trace
All livestock and livestock products	3,593,308	57.23
Dairy products sold	1,543,290	24.58
Poultry products sold	109,381	1.74
Livestock and livestock products other than dairy and poultry	1,940,637	30.91
Forest products	21,278	0.34
Total all farm products	$6,278,951	

Manufacturing and mining

One of the major industries in Gem County is a saw mill operated by Boise-Payette Lumber Company at Emmett that employs from 400 to 450 persons. Timber for the mill is obtained from the 39,000 acres of commercial timber located on National Forest lands in northern Gem County, and from forests north and east of Gem County.

Also important to the economy of the area are the De Dee Box Factory, producers of wood products; and Gem Canning Company, a food processing industry.

The Gem Silica Division of Del Monte Properties Company, Pacific Grove, California, produces several silica sand products from local sand at a processing plant in Emmett. This operation will be discussed later. Raw materials are obtained south of Emmett from Freezeout Hill.

The West View (Pearl) mining district south of Emmett yields some metallic minerals, although it is not very productive at present. Assessment activity on several properties occurs periodically. Among a number of small operations noted during a field investigation in 1959, the largest was Gem State Consolidated. This mining company has employed some 10 men, on the average, in the past year or two. Activity at this mine has been restricted to assessment work and stock-piling of ore.

The Farmer's Cooperative Creamery Company, Rinelli Fruit Company, and R. H. Share and Sons' Packing plant are leading industries of the Payette area.

Utilities

In the Gem-Payette area adequate natural gas service is provided by Intermountain Gas Company from sources outside the area; power of unlimited potential is supplied by the Idaho Power Company; and the municipal water supplies are excellent. Water resources are plentiful except in remote portions of the more arid lands.

Labor reserve

The Idaho Employment Security Agency indicated that as of May 1, 1959, the Emmett labor market employed a total of 1,625 people in the following categories (statistics supplied by Emmett Chamber of Commerce):

Mining	10	Wholesale and retail trade	248
Construction	50	Finance	50
Manufacturing	750	Other services	150
Transportation and utilities	50	Government	317
		Season food industry	50

GENERAL GEOLOGY

PREVIOUS GEOLOGICAL INVESTIGATIONS

The geology of portions of Payette and Gem Counties was first discussed by Lindgren (1898a and 1898b) and Lindgren and Drake (1904). Lindgren's early descriptions of the mines and mineralogy in the West View (Pearl) district were particularly important. Although his reports were based upon reconnaissance surveys, they were the only ones available until the early 1930's. In 1930-31, Kirkham prepared reports on the area discussing among other things erosion surfaces, the Snake River downwarp, igneous geology, and the Payette and Idaho Formations in southwest Idaho (1930, 1931a, 1931b, and 1931c). In 1934, Anderson described the geology of the Pearl and Horseshoe Bend areas in some detail. Because his report is out of print, an adaptation of his geologic map is included in this report (Fig. 7). It should be noted that township and range and section lines on Anderson's map do not agree with those drawn on later maps.

Additional short publications on the geology and mineral resources of this area have appeared through the years; for example, Chaney (1922) and Dorf (1938) described plant fossils collected from Tertiary sediments in Payette County. Two reports by Prater (1947 and 1952) described his tests on silica and manganese-bearing sands from this area. Natural oil and gas potential in the Payette region have been evaluated several times by Washburne (1911), Buwalda (1923), Kirkham (1935), and Youngquist and Kiilsgaard (1951).

A recent publication which includes a discussion of the general geology of southwest Idaho is: Geology and Mineral Resources of Ada and Canyon Counties by Savage (1958).

ROCK UNITS AND ROCK TYPES

Idaho batholith and related rocks

Batholith rocks

The Idaho batholith contains the oldest rock in the area (Table 1). Its rock types are grayish with some light and dark mottling; textures tend to be equigranular, but porphyritic facies occur locally. Quartz diorite, typical of the border facies of the batholith in central Idaho, is the common rock type in the Pearl district (Fig. 7). Also characteristic of these facies is good gneissic banding. In places east of Pearl the batholith is composed of granodiorite and quartz monzonite.

The batholith is generally resistant and unweathered in the Pearl district in comparison to other regions where it is exposed, such as in Long Valley to the northeast. However, thereabouts, in mineralized and sheared zones, the rock is less firm and often soft and friable because of hydrothermal alteration.

According to Anderson (1934, p. 5-6) minerals found in typical samples of the batholith at Pearl are:

quartz	sphene (titanite)	magnetite
andesine	epidote	zircon
microcline	muscovite	chlorite
biotite	allanite	zoisite
hornblende		

The approximate composition in percentages of typical batholith rock are:

Quartz 25 (ranging from 15 to 30)
Andesine 50 (ranging from 35 to 70
Microcline 5 to 10
Biotite and hornblende 12 (ranging from 8 to 15)

The minerals sphene and epidote, usually present, make up from one to three percent of the rock. Accessory minerals are muscovite, allanite, magnetite, zircon, chlorite, and zoisite.

Anderson (1945, p. 6) considered the batholith of possible Late Jurassic age modified by early and mid-Tertiary intrusions; however, the batholith now is more commonly referred to the Cretaceous. More will be said about the age of these rocks in the following pages on geologic history. Anderson's so-called "younger intrusives" resemble similar rocks in Boise Basin to the northeast; some intrusions may be of Late Cretaceous instead of Tertiary age. Undoubtedly these intrusions are younger than the main batholith rocks because they cut the latter.

Diorite

The most abundant of the younger intrusions is a diorite (Fig. 12), an elongate body that seems to conform with a northeast trending zone of dikes or a "porphyry belt." This intrusion, about 8 miles long, starts just north of Crown Point and extends to about two miles northeast of Horseshoe Bend. Its width varies from 500 feet to as much as 1.25 miles. The stock-like body resembles a gabbro in composition, varying locally from a dark gray to black equigranular diorite, granodiorite, and granite. Locally, the diorite is porphyritic. Among minerals present are:

muscovite	andesine	zircon
biotite	chlorite	apatite
hornblende	epidote	magnetite
hypersthene	quartz (a little)	zoisite
augite	orthoclase (a little)	

Table 1

MAJOR ROCK UNITS AND ASSOCIATED MATERIALS OF GEM AND PAYETTE COUNTIES

Geologic Age			Formation or Unit (with est. thickness in feet)	Brief description
QUATERNARY	RECENT		Late fluviatile and eolian deposits 0-6 (Qfe)	Clay, silt, sand, and gravel; non-consolidated modern floodplains. Semiarid climate and "little ice age".
			Early fluviatile and eolian deposits 50± (Qfe)	Clay, silt, sand, and gravel; generally unconsolidated. Some caliche. Low strath terraces. Arid climate. "Hypisthermal".
	PLEISTOCENE	LATE	Caldwell sediments 0-50 (Qcn)	Clay, silt, sand, and gravel; chiefly unconsolidated. Some caliche. Generally below 2,500 feet elevation; "Provo flood".
			Nampa sediments 0-50 (Qcn) --UNCONFORMITY-------	Clay, silt, sand, and gravel; non-consolidated, some caliche. Generally below 2,500 feet elevation; "Bonneville flood".
		EARLY	Tenmile Gravel 500± (Qtg)	Silt, sand, gravel, and cobbles; non-consolidated to poorly consolidated, some caliche. Fluviatile with some crossbedding, channeling and stratification. Generally good imbrication-- current flowing south-west or west. Piedmont alluvial fill, chiefly crystalline rock with some disintegrated pebbles. Aggrading Pleistocene stream deposits.
TERTIARY to QUATERNARY	PLIOCENE to PLEISTOCENE		Idaho Formation 0-1800 (Qti)	Clay, ash, silt, sand and fine gravel; nonconsolidated. Diatomite (impure), limestone, shale, and sandstone. A fluviatile deposit with local lacustrine beds. Generally below 3,000 feet elevation.
			--UNCONFORMITY(?)--- Poison Creek Formation or Boise Sandstone (QTpc)	Arkose, sandstone and conglomerate; also orthoquartzite.
			--UNCONFORMITY------ Silicic volcanic rocks including Owyhee Rhyolite 1000? (Qtsv)	Felsitic flows locally layered and folded: variously called rhyolite, quartz, latite, etc. May be related to Salt Lake Formation in southeastern Idaho. Some breccia zones and perlite locally.

Table 1 (Continued)

Geologic Age		Formation or Unit (with est. thickness in feet)	Brief description
TERTIARY	MIOCENE to PLIOCENE	Late Columbia River volcanic rocks (Tcr)	Fine-grained basalt to coarse-grained diabase; augite, plagioclase and olivine phenocrysts. Erosional remnants and larger masses, for example, Squaw Butte. Locally folded and upfaulted many feet to produce a steep dip. Ash, pumice and ignimbrite layers, scoria and obsidian.
		---UNCONFORMITY---	
		Payette Formation 1,200 (Tp)	Clay, ash, silt, sand, and fine gravel; fluviatile-lacustrine(?) origin. Also shale, sandstone, and grit. Not common in map area. Upfaulted segments in eastern Gem County(?).
		---UNCONFORMITY---	
		Early Columbia River volcanic rocks (Tcr)	May or may not crop out in map area; not differentiated.
		---UNCONFORMITY---	
CRETACEOUS to TERTIARY	MID-CRETACEOUS to MIOCENE	Diorite and related porphyry belt rocks (Td)	Most abundant youngest intrusive rock in vicinity of Crown Point and to the east. Varies to quartz diorite and granodiorite facies, mafic dikes.
		Granitic rocks (Idaho batholith) (Kg)	Granitic type rocks. Grayish to light and dark mottled, equigranular quartz diorite. Local variations with porphyritic and gneissic facies. Pearl district and area along eastern boundary of Gem County.

Dark minerals, ranging from 20 to 45 percent, average 30 percent of the diorite; biotite is always readily visible. The percentage of principal minerals present are:

Calcic andesine, 60 to 70 percent
Orthoclase, 2 or more percent
Hypersthene, 2 to 20 percent
Augite, 2 to 15 percent
Hornblende and biotite, 5 to 15 percent
Quartz, less than 4 percent usually, may reach
8 to 25 percent

Common accessory minerals are zircon, apatite, magnetite, chlorite, epidote, zoisite, and muscovite.

Porphyry dike rocks

The Pearl district has a number of porphyry dike rocks similar to those of other so-called "porphyry belts" in central Idaho. During Late Cretaceous or early Tertiary, these rocks intruded both the batholith and diorite bodies previously discussed. Dikes range from one to 400 feet wide and they reach a maximum length of 8,000 feet. Referring to these dike rocks, Anderson (1934, p. 7) stated:

> The list includes dacite porphyry, granite porphyry, syenite porphyry, rhyolite porphyry, moderately basic dikes apparently intermediate between rhyolite porphyry and lamprophyre, and andesite and lamprophyre. Their succession from oldest to youngest appears to be in about the order given.

The dacite porphyry locally resembles the diorite porphyry described above. Widely distributed dikes of dacite porphyry vary in thickness up to 400 feet and range from several hundred up to 5,000 feet long. Gray to greenish-gray in color, among others, this rock contains the following minerals:

plagioclase	zircon	hornblende	augite (rare)
orthoclase	apatite	biotite	hypersthene (rare)
quartz	magnetite	chlorite	

Anderson (1934, p. 8) describes the granite porphyry in detail: a gradational series ranging from granite porphyry to granodiorite with quartz monzonite types predominant. Widely distributed dikes of this rock may range from 30 to 400 feet thick and they may be as much as 8,000 feet long. Occurrence of this rock is recognized from soil fragments or float because outcrops are rare.

Syenite porphyry occurs in comparatively long, narrow dikes of brownish weathering, orthoclase-rich rock which contains some accessory quartz, zircon, apatite, and magnetite, and it is much sericitized.

Among the remaining dikes, rhyolite porphyry apparently occurs widely, greatly resembling some of the other rock types.

Anderson (1934, p. 10) commented on one occurrence of andesite:

> ...a dike about 2,000 feet long and 200 feet across, along the north side of the porphyry belt not far west of Rock Creek.... It is composed almost wholly of tiny, poorly twinned, oligoclase laths and a little accessory quartz (less than 5 percent).

More basic dike rocks include small lamprophyric varieties which occur commonly as veins in fissures. According to Anderson (1934, p. 11) "...they have been intruded in and along side the lodes...," in places they cut across the lodes. These narrow intrusive rocks include "...minette, kersanite, and spessarite," all considerably altered. They also contain calcite, chlorite, and sericite.

Columbia River volcanic rocks and the Payette Formation

Difficult to distinguish from the younger Idaho Formation, the Payette is composed of clay, silt, silty ash, ash, arkosic sand and thin coaly layers, all of which are of fluviatile and lacustrine origin. According to Kirkham (1931, p. 193-239), the Payette Formation contains middle or upper Miocene plant fossils and he "redefines" the formation as a sedimentary series between two major basalt flows. The basalt flows are early (lower) and late (upper) Columbia River flows. None of the dikes in the Pearl district seems to be younger than the Payette Formation, but basalt flows and ash are intercalated through the Payette sedimentary rock series.

The Payette Formation does not have an extensive area of outcrop in Gem and Payette Counties. Small exposures tentatively identified with this geologic horizon are the result of major faulting and elevation of crustal segments along Squaw Creek Valley.

Columbia River eruptive rocks occur widely distributed over Gem County and parts of eastern Payette County; however, no attempt was made in the field to distinguish between early and late flows. Scattered erosional remnants of basalt are exposed southwest of a line drawn from Pearl diagonally northwest to a point about 16 miles northeast of Payette. Northeast of this line volcanic rocks are nearly continuous. A basalt surface probably was more extensive in the past.

A major unconformity separates the Columbia River lavas from the batholith rock, while unconformities also separate Columbia River flows from the Payette and the Idaho beds.

More than one rock type is found in the Columbia River volcanics. The basal flows, according to Anderson (1934, p. 14), are olivine-free, for example:

> ...basal flows near the Lincoln mine...are strikingly porphyritic and contain 10 to 20 percent labradorite phenocrysts in narrow tabular crystals ranging up to 10 millimeters long embedded in a rather dense fine-grained, dark gray groundmass.... The groundmass consists of a matrix of small labradorite laths of essentially the same composition as the phenocrysts, pale brownish titaniferous augite, brownish glass, ilmenite and magnetite grains, and long apatite needles.

A second type of flow is olivine-rich and varies from fine-grained basalt to coarse-grained diabase. Augite, plagioclase and olivine phenocrysts are present locally. This flow rock is generally dark-gray to black and may be vesicular or massive. It frequently weathers to a reddish-brown.

Excellent exposures of Columbia River volcanic rocks may be seen along the north side of Black Canyon Reservoir, and also from Squaw Butte north to the boundary of Gem County. Rocks and rock materials vary from dense basalt to porphyritic plagioclase basalt, and may be ash or cindery in texture. Along the reservoir these volcanic exposures are scoriaceous and in places, brick red in color. Some of the volcanic rock seems to be related to rift-type or fissure-type vents; local faulting has disrupted the flow layers and bedded pyroclastics.

Silicic volcanic rocks

The Owyhee Rhyolite (Kirkham, 1931c) and related silicic volcanic rocks are younger than the Payette and early Columbia River rocks. Well exposed south of Pearl along the South Fork of Willow Creek, this silicic rock is reddish-brown, gray to almost black, and pinkish to lavender: it contains lithophysae, perlitic structures, and flow layers; the layers are in places folded and contorted or brecciated. The sedimentary rocks lying above the Payette at points contain clastic fragments of these silicic rocks. Kirkham (1931c, p. 579-587) correlates the silicic volcanic rocks with his Owyhee Rhyolite (and quartz latite).

Excellent exposures of Owyhee Rhyolite on Prospect Peak in the Pearl area show massive rhyolite containing widely scattered quartz and feldspar crystals; the feldspar is mainly orthoclase. Anderson (1934, p. 14-15) commented:

> ...The phenocrysts are usually rounded and embayed by the groundmass, but some preserve perfect crystal outline. The groundmass consists largely of aggregates of closely packed microspherulites, which accentuate fluidal lines, and of scattered streaks or patches of a granular crystallization of quartz and orthoclase. Accessories include scattered grains of magnetite and occasional small crystals of zircon. The color of the rock is mainly due to disseminated reddish and brownish iron oxides.

Poison Creek(?) and Idaho Formation

Kirkham (1931a) defined the Idaho Formation as a series of sedimentary rocks that lie above the upper Columbia River flows and Owyhee Rhyolite; while some have recognized the Poison Creek Formation, (Buwalda, 1923) as a unit separated from the Idaho Formation, the Columbia River lava, and the Owyhee Rhyolite by unconformities. It is possible that the characteristically coarse clastic here called the Poison Creek Formation(?) is a unit basal member of the Idaho Formation. Unconformities are not always reliable to establish principal time gaps: for example, there are many local unconformities in the Idaho Formation, and the presence of such a number of unconformities in terrestrial fluviatile deposits is not unusual. H. T. Stearns (oral communication) states that the Poison Creek Formation is invalid because it does not exist at the so-called type section.

Kirkham (1928, p. 1) referred to a massive sandstone in his discussion of the water resources of the Weiser area. He stated that the unit lies above 600 feet of Columbia River basalt and is a "...massive grit or sandstone locally known as the Boise sandstone..." (see discussion of Table Rock, southeast of Boise, in Savage, 1958). This reference is to the Poison Creek Formation of "probable" Pliocene age.

Insufficient time was available during the present field study to attempt a general subdivision of these sediments near the base of what has been called the Idaho Formation, but following Buwalda, they are tentatively referred to the Poison Creek Formation(?) South of the Snake River in Owyhee County the Poison Creek Formation lies above 1,000 feet of rhyolite flows (Kirkham's Owyhee rhyolite). Buwalda (1923, p. 3) said:

> Poison Creek formation immediately overlying the rhyolite is made up of ash, clays, shales, and sandstone very similar to the Payette but contains mammalian fossils indicating an age of Lower Pliocene or later...
>
> The Idaho formation lies in the middle and flatter part of the [Snake River] valley unconformable on the underlying formations. It is generally made up of cream-tinted silt and volcanic ash. Mammalian remains indicate a Pleistocene age.

South of the Pearl district, sandstone, conglomerate, arkose, and orthoquartzite lie just above rhyolite rocks; and fragments of the rhyolitic are included in the sandstone, the Boise Sandstone or the Poison Creek Formation(?) The rhyolite is equivalent to Kirkham's Owyhee Rhyolite. The same conglomerate, sandstone, etc., crops out in mesa remnants over a belt seven miles wide, that strikes N 42° W, starting at a point southeast of Boise and extending approximately 60 miles to a point northeast of Weiser.

Figure 5 Little Butte, an arkose remnant of the Poison Creek Formation(?) east of Emmett.

Figure 6 Dissected ash, silt, and sand layers of the Idaho Formation in northeastern Payette County.

Poison Creek Formation(?) in Gem and Payette Counties consists of clay, silt, ash, arkose, sandstone, conglomerate, and orthoquartzite. Much orthoquartzite occurs along belts of suspected or known faulting. Its high degree of local cementation is the result of the rise of springs and ground water with a high silica content. Scattered from Boise northwest to Weiser (Fig. 5) are the resistant, high-standing mesas and buttes composed of lower Poison Creek Formation(?). In the area of the South Fork of Willow Creek, this sandstone contains clastic fragments of Columbia River Basalt and Owyhee Rhyolite.

The Idaho Formation, well-exposed in Payette County, is composed of clay, shale, ash, silt, sandstone, oolitic limestone, impure diatomite, and fine gravel (Fig. 6). Like the Poison Creek Formation(?) the Idaho Formation is principally a fluviatile deposit including local lacustrine-type sediments. As arkosic sand, it underlies much of Freezeout Hill south of Emmett. Clay Point, just southeast of Payette, and the upland area south of New Plymouth provide fine exposures of the variety of materials that compose the Idaho Formation.

The Idaho Formation in Gem and Payette Counties is similar to that of Ada and Canyon Counties on the south. Savage (1958, p. 25-26) described this series and concluded:

> There is a strong possibility that these sediments accumulated during a transition from a ponded basin (Lake Payette) environment to a piedmont plain environment with shrinking and fluctuating shallow lakes. Later Idaho sediments represent a badland-type topography and generally can be distinguished from other materials by this characteristic.... Toward the west, the Idaho Formation becomes finer grained... beds dip up to 5 degrees west, southwest, or south.... In many exposures the materials appear to be horizontal except for local crossbedding.

<u>Tenmile Gravel</u>

Tenmile Gravel consists of silt, sand, and gravel, generally nonconsolidated and locally containing caliche (Fig. 8). It is separated from the underlying Idaho Formation by a major unconformity. Essentially comparable to Lindgren's (1898a) Upper Mesa gravel, this deposit exhibits evidence of torrential stream deposition. Imbrication in most gravels indicates a source in the crystalline uplands of Boise Ridge. Locally some of the gravel contains basalt pebbles derived from upfaulted Columbia River lavas.

Tenmile Gravel seems to be related to torrential floods of meltwater resulting from an increase in moisture and rainfall during the Pleistocene. Derived from glaciated areas and from more local uplands, irregular eroded patches of Tenmile Gravel occur on the tops of broad divides, capping the Idaho Formation east of Payette (see geologic map, Fig. 4). These gravels also occur in high terraces around

Montour and along Squaw Creek Valley.

Caldwell and Nampa sediments

Shown as one unit on the geologic map (Fig. 4) the Caldwell and Nampa sediments are also related to increased rainfall, especially because of climatic changes in the late Pleistocene. These sediments seem to represent pluvial phases correlative with the Bonneville and Provo stages of Great Salt Lake (Savage, 1958, p. 27).

Caldwell and Nampa sediments are difficult to differentiate because of their similarity; both consist of clay, silt, sand and gravel. The gravel is composed of moderately rounded fragments of rhyolite, quartzite, quartz monzonite, quartz diorite, granodiorite, arkose, sandstone and basalt. Representative exposures may be found in the lower terraces north of Payette River floodplain, and around Montour. Near the Snake River these sediments, deposited in a ponded environment, are fine-grained and well-layered (Fig. 9). Present elevation of the fine silts is approximately 160 feet above the Snake River.

Recent deposits

Recent sediments are fluviatile and eolian and consist of clay, silt, sand, and gravel deposited by running water along modern floodplains; in the case of wind-transported materials, deposition also occurred on upland surfaces. Post-glacial climatic fluctuations have been responsible for innumerable changes in stream regimen: for one thing, low terraces have developed in the deposits along modern streams. Most recently, entrenchment has resulted in the exposure of from 6 to 12 feet of recent floodplain materials along such streams. Willow Creek and Little Willow Creek in northern Payette County are good examples of modern streams which have become entrenched.

Silt of wind-blown origin caps much of the surface in Gem and Payette Counties. This relatively thin loessial cover is not shown on the geologic map.

GEOLOGIC HISTORY

Pre-Cenozoic history

No Precambrian or Paleozoic rocks are exposed in the Gem-Payette area, but there is reason to believe that certain northwest trending structural features may be related to earlier Precambrian features. In post-Precambrian time, a shelf area probably developed on the easternmost margin of a Paleozoic seaway that lay over this region. Through the Paleozoic and into the early Mesozoic eras, orogeny and epeirogenic movements imposed additional structural trends upon the basement rocks. These structures were later effective in controlling the development of erosional patterns and some topographic features. By Early Jurassic, southwest Idaho had become part of a

Figure 8 Tenmile Gravel along Johnson Creek, southwest of Montour.

Figure 9 Fine-grained, laminated Caldwell-Nampa silts deposited in a pluvial ponded environment.

great upland undergoing extensive erosion. Thus abundant sediments were contributed to the California trough along an axis centered in Oregon and Washington (Eardley, 1951, p. 241-252).

Late Jurassic and Cretaceous orogenies were important in the geologic history of Idaho. Eardley (1951, p. 313) emphasized the relation to the Idaho batholith of the convergence of two arcuate segments of orogeny in eastern Idaho. According to Eardley, Laramide and Nevadian structures overlap in Central Idaho and their overall concordance is clear. He contended that the batholith was emplaced late in the Nevadian "revolution." The composite and complex nature of this batholith may be observed in the Pearl district.

Anderson (1948, p. 85) stated that the Idaho batholith was emplaced in late Jurassic or Cretaceous as "a significant part of the Laramide orogeny...in rocks more or less extensively disturbed by the Nevadian orogeny." Anderson (p. 91) implied orogeny extended into the Tertiary.

Jaffe and others (1959, p. 94) assigned an age of 114 million years to a rock of similar composition (biotite-hornblende-diorite) occurring near Horseshoe Bend. This age, based upon lead-alpha determination, suggests that some of Anderson's "Tertiary" intrusions may be Middle Cretaceous in age.

Uplift and erosion of unknown magnitude had prepared a surface of mature relief in southwest Idaho by the early Cenozoic; for example, Columbia River Basalt and Owyhee Rhyolite rest on such a maturely eroded surface. A considerable amount of erosion was necessary in order to unroof and expose the intrusive rocks of the Idaho batholith. The extensive erosion was accompanied by faulting and uplift.

Cenozoic geologic history

The geologic history of Gem and Payette Counties is closely related to the history of all southwest Idaho. Areas affected by the Nevadian-Laramide diastrophic phases show the effects of the relaxation of these major compressional stresses during the Cenozoic era. Block faulting, Tertiary basin filling and down-faulting, and subsidence of the great Snake River Plain in Idaho are the aftermath of late Laramide orogeny, igneous activity, and thrust-faulting. These post-Laramide geological processes exerted at depth and on the earth's surface during the Tertiary and early Quaternary, influenced the accumulation of potentially valuable metallic and non-metallic mineral resources in southwestern Idaho.

Because Savage (1958, p. 32-45) described the Cenozoic geologic history of southwestern Idaho in some detail, the same discussion will not be fully repeated here; however, it should be noted that major drainage changes associated with geologic crustal phenomena are important in the late history of this area (Fig. 10).

Columbia River volcanic flows and pyroclastic rocks represent early Cenozoic volcanism followed by silicic flows, and subsequently by pyroclastics and mafic flows. These volcanic rocks were erupted from both central and fissure-type vents.

Temporarily blocking major surface-water drainage, lava flows and fault-block dams caused extensive deposits of piedmont alluvial and lacustrine sediments now referred to as the Payette, Poison Creek(?), and Idaho formations. These sediments span a Miocene to Pleistocene interval. Squaw Mountain, a principal contributor to drainage changes, represents a major block of Columbia River Basalt upfaulted at least 2,000 to 2,800 feet along its eastern margin. A similar huge upfaulted block of lava occurs on the east side of Squaw Creek Valley.

Malde (1959, p. 272) adduces seismic evidence to support his conclusion that "...13,000 to 38,000 feet of rocks about as dense as Columbia River basalt have been dropped down against the Idaho batholith" in the King Hill area, 80 miles southeast of Gem County. An important belt of faulting that strikes northwest across Gem and Payette counties on the same general strike as Malde's fault zone near King Hill, is probably a continuation of Malde's fault. The Squaw Creek Valley fault zone mentioned above represents a second major fault zone which trends north and resembles the Basin and Range system of northern Nevada (Fig. 10).

Woollard (1958, p. 1136-1137) noted that the location of earthquake epicenters, among others in the United States, shows one frequency alignment trending from Puget Sount in Washington southeast across Idaho through the Gem-Payette area and into northwestern Utah. This alignment "...conforms in position and strike with structural axes crossing the Columbia River Plateau." Woollard also contended that "...there has been considerable epeirogenic uplift of all the northwestern states." He also points out that this uplift is still going on, and that regional movement is chiefly the result of "...considerable adjustment of crustal blocks along old fracture lines developed at different times in the geologic past under varying stress conditions" (p. 1152). Woollard logically suggests the probability that considerable crustal subsidence occurred in connection with the outpouring of Tertiary and Quaternary lavas in this region. Undoubtedly this event was accompanied by faulting.

In reference to the situation in the King Hill area, Malde (1959, p. 272) said:

> Geologic evidence of intermittent crustal adjustment has been found near King Hill along the zone of faulting inferred from the geological observations, indicating that rocks of early Pliocene and younger age are dropped downward toward the Snake River Plain in progressively diminishing amounts.

Malde then points out that silicic rocks of Pliocene age (similar to the Owyhee Rhyolite south of Pearl) form the escarpment bounding the King Hill fault zone, while adjacent basalt of middle Pliocene age is not displaced as much. Near the Snake Plain, sedimentary rocks of late Pliocene age are displaced to a lesser degree by faulting. Deposits of early Pleistocene age in the King Hill area, which are probably equivalent to Tenmile Gravel in Ada, Canyon, Gem, and Payette Counties, appear to be displaced only a few hundred feet by faulting. Middle and late Pleistocene sediments are only slightly displaced. Malde (1959) concluded:

As the sum of all the measurable displacements in rocks younger than the silicic volcanics (4,000 feet) accounts for less than half the minimum total displacement along the fault zone (9,000 feet), most of the movement must have occurred before deposition of the middle Pliocene and younger rocks, but after eruption of the early Pliocene silicic volcanics.

Stearns (1961, p. 389-390) thought Malde's figures for the thickness of Columbia River Basalt were too high; if so, the estimated amount of total fault displacement based upon geophysical interpretation may be too great. I concur with Stearns' figures, that is, 3,000 to 4,000 feet of actual thickness of Columbia River lava in Southwest Idaho. This figure should be considered in the interpretation of gravity anomaly surveys.

Baldwin and Hill (1960, p. 3-20) conducted such a gravity survey of the western Snake River Plain and found two high gravity anomalies "...with closure in excess of 10 milligals." The anomalies were elongate along a northwest strike (Fig. 10). The larger anomaly extends from Glenns Ferry, Idaho (southeast of Boise) about 80 miles to a point northwest of Swan Falls. The smaller high anomaly is offset to the northeast about 10 miles extending from a point just southeast of Nampa to Nyssa, Oregon on the northwest. These two highs are associated with two low gravity anomalies: one occurs southeast and one northwest of Boise. The latter extends into the Pearl district toward Emmett and is probably caused by the presence of a southwestern bulge of the less dense batholith into this area.

The high anomalies are attributed to thick basalt layers occurring at some depth and parallel to the axes of the gravity anomalies. Baldwin and Hill (1960, p. 20) suggest two possible explanations of the anomalies: (1) faulting along the margin of the batholith; or (2) downwarping of the Snake River Plain, as proposed by Kirkham (1931b, p. 456). The steepness of the gradient associated with these gravity highs may be observed where silica-rich rocks are closest to the northeast side of the anomaly axes. Baldwin and Hill consider "...most plausible" the theory of downfaulting of the basalt flows in the plains area; faulting at the surface as noted by Malde (1959) is cited to support their conclusions. A third possible explanation of the gravity highs, based upon erosion and basalt fill, is feasible. A large river representing drainage during the early Tertiary Deep Stage (Savage, 1958, p. 43) seems to have excavated a major valley north of the present Snake River, while a later system, the Idaho River, followed the same axis. This deep valley was subsequently filled with intercalated sediments and dense basalt and must account for at least some of the measured gravity anomalies.

The extension of Malde's King Hill fault zone seems to be somewhat north of the main gravity anomaly, and of the present Snake River Valley in southwest Idaho, for the river was forced to shift south by late lava flows. The principal fault belt is probably parallel to the belt of Poison Creek(?) or Boise Sandstone outcrops that trend northwest across Gem and Payette counties (Fig. 10).

In 1900 Lindgren (p. 80) stated:

> The lake beds filling the valley to a great depth are divided into an older Miocene series...the Payette formation...containing abundant plant remains, and a younger Pliocene division...the Idaho formation, ...which carries mammalian remains and fresh water mollusks.

The valley referred to by Lindgren is the Tertiary Deep Stage valley; broad and deep, it probably occupied much of the present area drained by Payette, Boise and Snake River valleys. Some conception of the valley's probable depth can be gained from Kirkham's (1931b, p. 477-479) report that a well drilled at Ontario, Oregon, remained in the Idaho Formation to a depth of 2,300 feet below sea level. Such great depth probably resulted from a combination of subsidence (including some faulting) and excavation by the Deep Stage River.

The Deep Stage Valley parallels the axes of the main gravity highs discovered by Baldwin and Hill (Fig. 10). Subsequently filled with basalt flows this buried valley contributed to the present positioning of gravity highs.

A final alternative explanation may be that the axes of gravity highs observed by Baldwin and Hill parallel a large lava-filled rift fault, for example, an elongated vent, now filled with either or both Columbia River and younger Snake River volcanic rocks. Conceivably, less vertical displacement would have been necessary to produce the observed gravity phenomena if the rift were also associated with a Deep Stage drainage valley subsequently filled with dense basalt.

Erosional outliers of the so-called Poison Creek Formation (Fig. 10) may represent coarse detritus deposited by rejuvenated streams along the southwest margin of the principal northwest fault zone. This scarp developed in late Miocene or early Pliocene times. It probably was parallel to the north boundary of an earlier northwest-trending ancestor of the Snake River. The silicification and cementation of the Poison Creek Formation(?) may be attributed to the rise and lateral spreading of silica-laden water along such a fault zone.

The Payette Formation, consisting of clay, ash, silt, and sand, underlies the Gem-Payette map area but appears only in restricted, faulted areas where the formation has been upfaulted. Deep wells should penetrate the Payette, but its identification would be difficult because it resembles the Idaho Formation.

The Payette is equivalent in age to part of the Salt Lake Formation in southeastern Idaho and to the Latah Formation in northern Idaho.

The Idaho Formation occurs widespread in Gem and Payette Counties as a great blanket of piedmont fluviatile clay, silt, sand, and gravel that was spilled over the rim of a Miocene-Pliocene fault scarp by early stream systems in southwest Idaho.

The Idaho Formation is probably of the same age as Stearns' Hagerman Lake beds along the Snake Valley to the east (Stearns, Crandall, and Steward, 1938, p. 43). Possibly, it is also equivalent to Anderson's Oreana Formation (preliminary unpublished stratigraphic section).

In 1954 Corcoran (p. 79-84) reviewed the controversial issues related to subdivision of the Payette and Idaho formations. In many places, these two horizons are demonstrably almost inseparable because the Idaho Formation represents reworked Payette material. Savage (1958, p. 36-37) stated:

> During the Mio-Pliocene phase aggradation was taking place first in the Payette basin; later as the basin evolved into a piedmont alluvial plain, the Idaho beds accumulated. Eventually a major river, here called the Idaho River for convenience, probably meandered across the plain from the southeast corner of Ada County to the northwest corner of Canyon County.... The principal evidence for this river is the greater thicknesses of fluviatile sediment along such an axis as noted on drillers' logs. Lithologic and structural evidence also substantiate this idea...
>
> The Idaho River evolved into drainage herein designated as the Dry-Kuna River system when the Idaho beds were uplifted.... The resulting surface was a southwest-sloping plain tilted slightly away from the rising crystalline highlands to the north and northeast. Segments of the plain may have been upfaulted at this time, for example, Table Rock southeast of Boise [and also Little Butte east of Emmett].

In northeastern Ada County and southern Gem County, local limestone, oolitic limestone and diatomite deposits are associated with the base of the Idaho Formation. These materials probably accumulated in local elongate ponded areas. Savage (1958, p. 37) said:

> Some of the long-pre-existing valleys, which were eroded into the older Payette sediments as the margin of Boise Ridge was elevated were probably occupied in their early stages by temporary elongate ponds in which...limy sediments accumulated.

Sediments comprising the Idaho Formation locally were indurated and converted to limestone, shale, sandstone, conglomerate, arkose, and orthoquartzite. Just east and southeast of Payette, however, the Idaho Formation is nonconsolidated sand and clayey silt. The finely laminated character of the beds suggests a lacustrine environment; yet a few fluviatile characteristics may be noted. Delicate crossbedding and channel fillings are not uncommon, and local lenses of stream gravel are frequently exposed in fresh bank cuts. Possibly some coarse sediment may represent shoaling conditions in shallow ponded waters.

All sedimentary materials tend to become coarser from east to west, that is, from areas adjacent to the crystalline uplands toward areas near the Snake River on the west. Arkosic sands are coarse on Freezeout Hill south of Emmett because their probable source was the crystalline rocks of the batholith exposed nearby in the Pearl district. Older and younger sedimentary facies all suggest an origin from rising upland areas; a decrease in particle size towards the piedmont plain areas on the southwest and west suggests a decrease in the transporting capacity of eroding and depositing streams. Even the Pleistocene sediments show this tendency to become finer toward the west.

In 1900 Lindgren (p, 93-99) described evidence of "shorelines" of a "Miocene lake" (Payette Lake) as high as 4,200 feet above the sea level (near Boise); a "terrace of shore gravels at 3,000 feet" (also near Boise); and shorelines at 2,800 feet (north of Emmett). Lindgren thought these were formed by a lake in the Pliocene or at a somewhat earlier date. In some instances he may have interpreted fault-line scarps and their fans as modified shore line deposits.

Both the Idaho and the Payette formations have suffered deformation. Variable dips may be measured in the field; generally the resulting dip is toward the axis of the Snake River Valley, but minor folds in northwestern Payette County, for example, have produced local open synclines and anticlines. Some of the dips may be initial dips resulting from deposition on an inclined slope. Earlier deformation may have been compensated for by faulting and uplift; thus some Poison Creek beds are nearly horizontal. Again, extremely high local dips (some almost vertical) may be the result of local faulting.

Undoubtedly Pleistocene glaciation had occurred in the uplands of central Idaho by the time the last of the Idaho beds were being deposited. Later, large volumes of meltwater were finding their way down toward the ancestral Boise and Payette valleys. Clay, silt, sand, cobbles, and boulders spilled onto the piedmont alluvial plain building up a blanket of Tenmile Gravel by the early Pleistocene.

The Pleistocene was a time of climatic fluctuations that produced complex changes in stream regimens. Increased runoff, the result of melting ice or rainfall during a pluvial climatic phase, eroded and transported large quantities of rock debris. Thus, areas far removed from actual accumulation of glacial ice were indirectly affected by the changeable glacial climates.

Tenmile Gravel deposits (Savage, 1958, p. 38) of about the same age as those Lindgren (1898b) called Upper and Lower Mesa gravels are correlated with the Pleistocene drainage systems. The gravel is not quite as extensive in Gem and Payette counties as in Ada and Canyon; however, it is rather thick. Many of the gravel pits shown on Figure 4 are excavated in Tenmile Gravel (Fig. 16). This gravel also occurs at fairly high elevations along interfluves east of Payette; the gravel is a remaining part of a once more extensive accumulation.

Tenmile Gravel represents more or less torrential deposition and consists largely of well-rounded to subangular silicic and mafic crystalline rock floats. This gravel is a combination of piedmont plain mantle and valley train eroded to form the present prominent terraces along the Payette Valley. These terraces were modified by late deposits of Caldwell and Nampa sediments during the pluvial floods of the Wisconsin stage.

Seemingly, Snake River lava flows are not present in Gem and Payette counties. However, broad lava flows and pyroclastics of Snake River lava from fissure eruptions appear to have interferred with surface drainage farther south in the Boise and Snake valleys. These eruptions served to increase the complexity of surface drainage during the Pleistocene pluvial floods which, in turn, affected the Payette River system and its tributaries. Savage (1958, p. 40-41) said:

> Overflow from Pluvial Lake Bonneville in Utah appears to have produced flood conditions all along the Snake River lowland in late Pleistocene.... At times this water must have come in great floods.... Rising flood waters appear to have streamed north over the divide between the present Boise Valley and the Snake Valley to the south.... The overflowing Snake River caused a rise in the Boise River by back-flooding into Boise Valley.

Big Whitney Gulch in southwest Gem County appears to be associated with some kind of "spillover" stream channel, which, at some early date, carried water from the Boise Valley northwest into the Snake Valley south of Payette (Fig. 4). The complex terrace systems in Little Willow Creek, Willow Creek and other streams in Payette and Gem counties probably were eroded when earlier streams developed flood conditions during the late pluvial stage.

Because they are similar to each other, Caldwell and Nampa sediments are only locally separable into two formations. Caldwell sediments are generally finer than Nampa deposits. Both more typically occur at lower elevations from 2,300 to 2,500 feet (Fig. 9). They are both important sources of commercial gravel.

Recent geologic events in Gem and Payette counties include the formation of the lowest terraces, attributed to more recent flooding and erosion. The present stream entrenchment--as much as 8 to 12 feet on lower stream course--may be the result of overgrazing on slopes. This entrenchment is common along tributaries on the north side of Payette River Valley. Construction of extensive irrigation canals and drainage ditches, slight crustal uplift, and lowering of regional base level may also have aided more recent entrenchment of stream systems.

Recent fluviatile and eolian deposits are associated with a dry, warm post-glacial or hypsithermal climatic phase (Table 1). Wind-blown deposits of variable thickness occur over most of Gem and Payette counties. In most instances these eolian deposits have not been shown on Figure 4. Recent climatic events which have had an effect upon the contemporary landscape features may be correlated with the following climatic phases:

Phase	Number of years before the present (approximate)
Hypothermal (arid to semiarid)	2,600 (started)
Hypsithermal (subhumid, becoming arid)	2,600 - 9,500
Anathermal (Moist)	9,500 -10,700
Late Pluvial Floods (very moist)	11,000 - ?

ECONOMIC GEOLOGY

INTRODUCTION

There are mineral commodities of current and future economic value in Gem and Payette counties (Table 2). Most important among these are the nonmetallic deposits, for example, extensive accumulations of sand and gravel, and silica sand. The sand and gravel are used principally for aggregate and road base; the silica sand is used for plaster sand, glass sand, blasting sand, molding sand and minor miscellaneous purposes.

Water resources are generally plentiful in the two-county area, although lack of development may result in short supply locally. Water resources appear ample for present and immediate future needs including power and irrigation for public, private, and industrial supplies; and for recreational use.

Widely scattered clay and relatively small outcrops of limestone, silty pumice and silty diatomite occur locally. They are not currently being exploited but some of these commodities may have potential value.

In Gem and Payette counties, known metallic mineral resources are limited. The West View (Pearl) district in southern Gem County yields gold, silver, lead, and zinc; the Squaw Creek district (Fig. 2) reportedly yields copper and silver. Considering present conditions, including the price of gold, the known quantity of these metallic minerals does not constitute a major mineral resource. Any future increase in the value of gold, however, could produce renewed interest in the Pearl district.

According to Baber, Fulkerson, and Petersen (1959, p. 16 and 1960, p. 3 and 10), sand and gravel, and gold and silver produced in Gem County in 1957 had a combined value of $95,000. Gold, silver, lead, and zinc production in Gem County for 1958 and 1959 was valued at $44,000 and $12,000 respectively. In 1959, three lode mines in the district reported the following total production values:

Gold - $8,000 Silver - $2,000 Lead - $1,000 Zinc - $1,000

The same source reported that the total value of sand and gravel production in Payette County for 1959 was $106,000: sand and gravel production in 1959 in Payette County was worth almost nine times the value of gold, silver, lead, and zinc produced over the same period in Gem County.

Table 2

Mineral Resources

Gem and Payette Counties, Idaho

Geologic Age			Formation or unit	Mineral Resources
QUATERNARY	RECENT		Fluviatile and eolian deposits (Qfe)	Fine placer gold in West View (Pearl) district; placer sand and gravel replaced by annual flooding. Fairly clean aggregate. Local clay deposits in lower stream courses.
	PLEISTOCENE	LATE	Caldwell-Nampa sediments (Qcn)	Good source of sand and gravel. Some clay in Payette County.
			Unconformity	
		EARLY	Tenmile Gravel (Qtg)	Fine to coarse sand and gravel, many commercial pits. May contain caliche and rotten disintegrated crystalline rock. Screening and some classification generally necessary.
			Unconformity	
TERTIARY to QUATERNARY	PLIOCENE to PLEISTOCENE		Idaho Formation (QTi) Poison Creek Formation(?) or Boise Sandstone (QTpc)	Abundant silica sand particularly at Freezeout Hill, and also east and west of this hill. Some limestone locally. Local clay beds, e.g. hills east of Payette. Diatomite (rare). Sandstone has been used for building stone.
			Unconformity	
			Owyhee Rhyolite and related rocks (QTsv)	Gem material of low value, e.g. colored breccia and flow rock.

Table 2
(Continued)

Geologic Age		Formation or Unit	Mineral Resources
TERTIARY	MIOCENE to PLIOCENE	Late Columbia River volcanic rocks (Tcr)	Suitable for crushed rock aggregate. Some pumicite(?) in Squaw Valley area.
		Unconformity	
		Payette Formation (Tp)	Not common in map area.
		Unconformity	
		Early Columbia River volcanic rocks (Tcr)	May or may not be present in map area.
		Unconformity	
CRETAC-EOUS to TERT-IARY	MID-CRETACEOUS to MIOCENE	Diorite and related porphyry belt rocks (Td)	Related to mineralization in West View (Pearl district). Principal economic mineral is gold; some sphalerite, galena, stibnite and argentite.
		Idaho Batholith (Kg)	Also contains same economic minerals similar to porphyry belt (above)

METALLIC MINERALS

West View (Pearl) district

Early development

Gold discoveries were made in the vicinity of Pearl shortly after the rush to Boise Basin; placers along Willow Creek were probably worked in the 1860's. The first lode development was the Red Warrior Mine operated in 1870. No important lode deposits were developed until 1894 and 1895 (Lindgren, 1898b, p. 708). Major developments occurred in the period 1900-07, which seems to have been one of the most important in the history of the district. Unfortunately, past production figures are so incomplete and so variable as to be of little value in assessing past activity.

General rock types

There are important similarities between the Pearl district and Boise Basin: geologically in the two areas the nature of the terrain, the rock types, and the geologic history are similar. The principal rocks of the Pearl district (described earlier) are quartz diorite and granodiorite of the Idaho batholith (Fig. 7). They have been sheared, fractured, and intruded by dikes of the "porphyry belt." Varying in composition, these dikes include dacite, andesite, diorite, syenite, granite, and rhyolite porphyries, and some lamprophyres. A stock-like pluton composed of the diorite is younger than the main batholith.

Basalt and rhyolite flows and the Payette and Idaho sedimentary formations are also present in the general vicinity of Pearl. Anderson (1934, p. 5-12) described the rocks of this district in detail.

Ore deposits

Lindgren (1898b, p.712) referred to the gold deposits of the Pearl district as "...fissure veins of somewhat varying character...in a belt parallel to that of the porphyry dikes." He pointed out that the gold-bearing veins follow porphyry dikes or cut through dikes in the faulted or sheared zones.

In the Willow Creek area, veins tend to strike east and dips are 45° to 80° to the north. In the Rock Creek area the strike swings around toward the northeast. Narrow veins are common in the Willow Creek lodes, while broader ones occur along Rock Creek. None of the veins can be traced for long distances.

Ores, principally sulfides, include pyrite, sphalerite, arsenopyrite, and galena. Chalcopyrite is uncommon but ruby silver has been recovered from some ores. Much of the altered country rock is full of pyrite crystals that contain low gold values; higher values are found in solid sulfides. A few of the sulfides contain a very low percentage of free gold. Gangue consists of country rock, quartz, dolomite, and calcite. Lindgren (1898b,p. 713) said:

> Shipping ore often contains 5 ounces of gold and 5 ounces of silver to the ton. A sample of pyrite, arsenopyrite, and galena from one of the best mines gave 0.85 ounces of gold and 28.35 ounces of silver per ton.... Some galena carries 60 to 70 ounces of silver, and generally also much gold--high-grade shoots are not of great lateral extent and...they are rather irregular.

According to Anderson (1934, p. 18-20) the ore consists of sulphides deposited after shearing and fracturing. The shearing continued even after ore emplacement, as evidenced by outcrops containing sheared ore. The disturbed and fractured lodes are complex but mineral assemblages are simple. Two ore bands are not uncommon: a second band of ore is sometimes found in the hanging wall with swarms of stringers between it and the original fracture or fissure zone. A disturbed zone may be entirely ore.

Anderson (1934, p. 21) stated:

> The concentration of the lodes along the dike zone, in some cases in and along the dikes themselves, and their distribution along fissure zones of the same trend as those that directed the intrusion of the dikes suggest a close relation of the lodes and dikes to the controlling structural forces and to each other.

Anderson inferred a genetic relation between a parent magma of deep-seated origin and the Tertiary dikes and mineralization. Bleached and sericitized, altered wall rock seems to be a guide to ore zones. The sericite resembles a "gouge or talc" in the lodes, while the richest areas seem to be located in zones exhibiting the highest degree of sericitization. Mineralogic and textural characteristics suggest that the ore deposits are of mesothermal origin; hence they were formed at intermediate temperatures and depths.

In respect to the potential of this area, Anderson in 1934 (p. 22) postulated that early mining operations were closed down because ore dressing methods were then inadequate to make good recoveries, and also because of lack of good technologic and financial management. Experience has proved the area's ore grade is fairly consistent, averaging, for example, 0.25 to 0.50 ounces of gold per ton. Because of the type of mineralization, this yield should persist at depths. Furthermore, past operations indicate that the ore is neither richer nor leaner at greater depths.

Both Lindgren (1898b) and Anderson (1934) described mine operations in the Pearl area during their periods of investigation; however, most of these mines are now

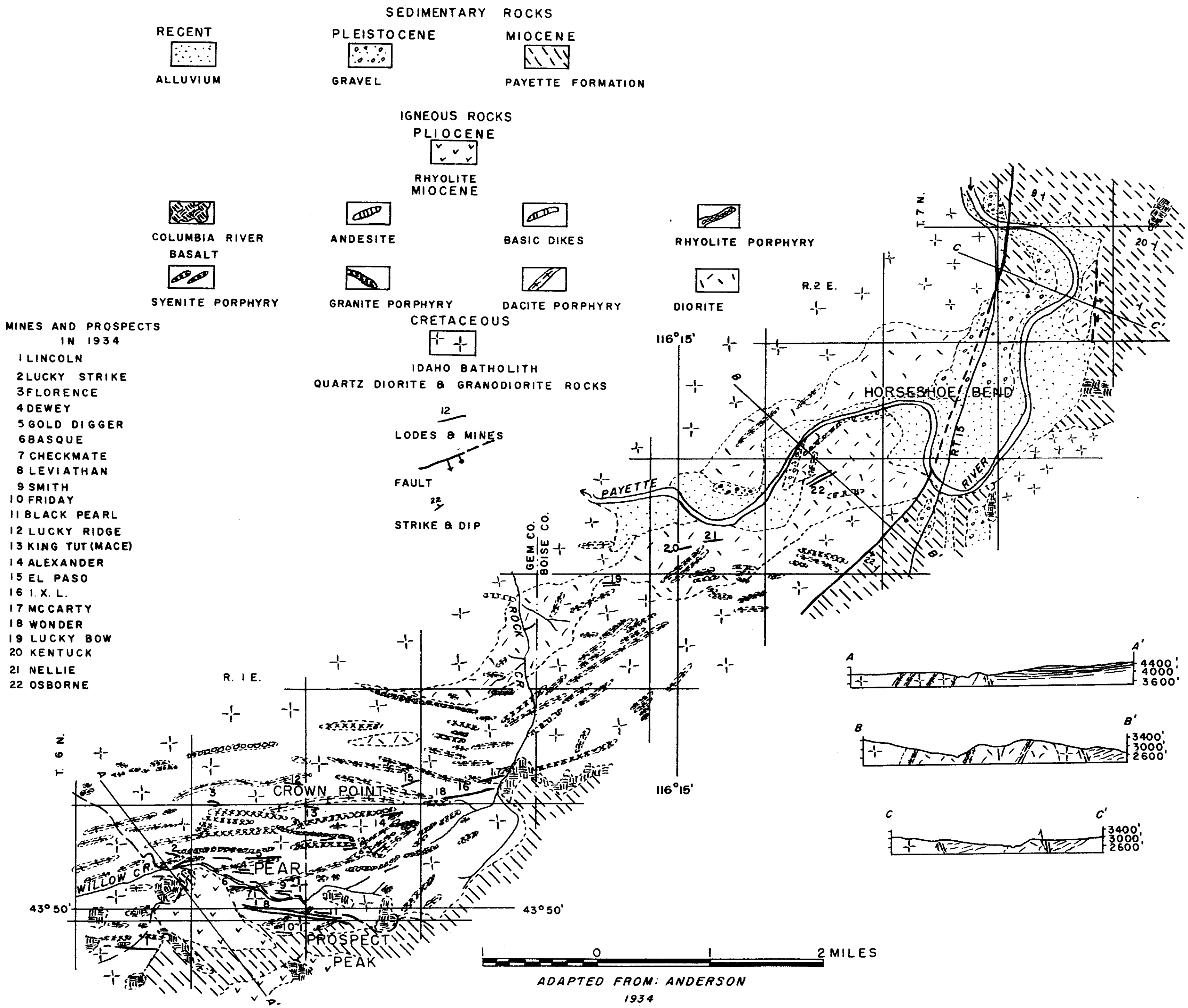


FIG. 7 GEOLOGIC MAP PEARL-HORSESHOE BEND AREA

completely caved and long abandoned. Mine locations (in 1934) are shown on the adaptation of Anderson's map (Fig. 7). In more recent years three or four mineralized areas in the Pearl district have received some attention. For example, Gem State Consolidated Mines (Fig. 11), located on the North Fork of Willow Creek, is still active (near the center of sec. 15, T 6 N, R 1 E), in the same location as the old Dewey mine described by Anderson in 1934 (p.29).

McDowell (1955, p. 102) reported activity by Gem State Consolidated Mines Inc. in his 57th Annual Report of the mining industry of Idaho. Mr. T. R. Baugh is president and manager and George E. McKenney is the agent. The property consists of five patented and seven unpatented claims developed by two principal tunnels, one 1500 feet in length. Ore consists of gold, silver, lead, and zinc. During the fall of 1959 ore was being stockpiled (McKenney, oral communication) for processing, while near-by a 50-ton capacity Hardinge ball mill and a flotation plant were being installed.

A few hundred feet downstream from the Gem State Consolidated Mines, Inc. on the North Fork of Willow Creek, H. H. Estill and Sons were constructing, in 1959, a 50-ton capacity ball mill and flotation system. This mill anticipates the processing of ore from the leased Lucky Ridge Property located near the northwest corner of sec. 14, T 6 N, R 1 E, the general location of the former Monroe Mine.

Don Elmquist (written communication) manager of Eagle Talon Mines, reported in 1959, holdings comprising some 1576 acres of patented and unpatented land in the Pearl district. He indicated that 73,000 tons of ore had been blocked out. A 30-ton capacity ball mill, tables, and flotation cells were to be included in a processing plant in the near future, according to Elmquist. The ore reportedly yields minerals valued at $31.00 per ton.

In 1958, McDowell (p. 104) recorded that the Lucky Gem Mining and Milling Co., Inc. had seven unpatented claims in Gem County. These claims supposedly yield gold, silver, and lead values. Earl J. Adkins of Emmett, Idaho is president, manager, and agent.

The above described properties are the only ones known to have been active when the Pearl district was investigated during 1958 and 1959.

In the past, rather extensive placering operations have taken place along the canyons that extend down the north slope of Crown Point. The North Fork of Willow Creek also has been placered. Data on these placer recoveries are not available.

Squaw Creek district

Silver and copper have been reported to occur in Squaw Creek district a few miles north of Montour. This report was not verified and no signs of mining activity were detected during the field investigation of this so-called mining district.

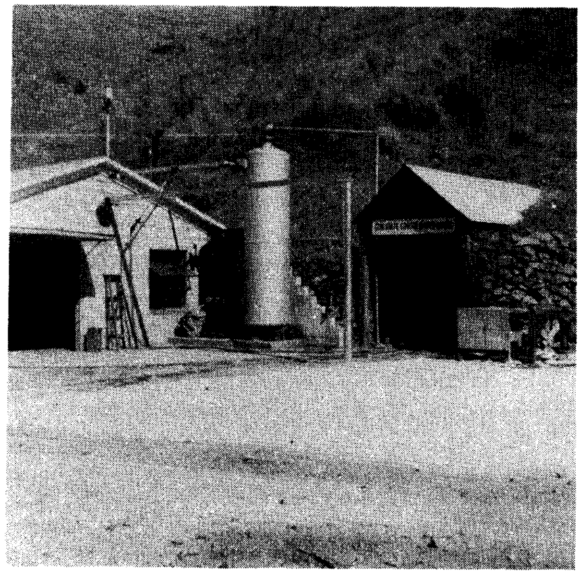


Figure 11 Portal, compressor, and shop at Gem State Consolidated Mines, Pearl district.

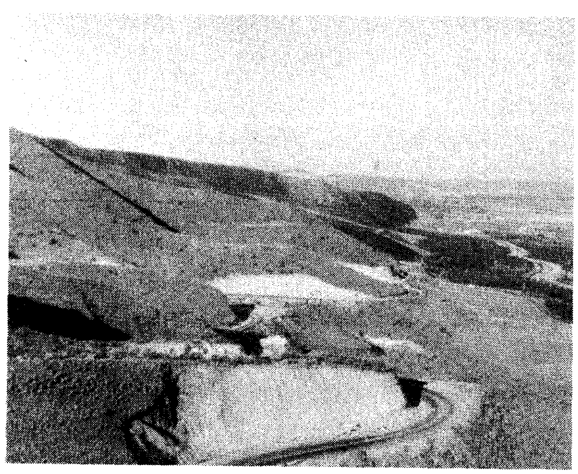


Figure 12 Freezeout Hill on State Route 16 south of Emmett.

Sand Hollow

Prater (1947) conducted metallurgical tests on manganese-bearing sands from Sand Hollow in Payette County. The samples were collected approximately 15 miles southeast of Weiser and reportedly were from the Payette Formation (probably the Poison Creek(?).

The sample was described as "...black colored friable sandstone..." and it contained a cement of manganese oxide, which constituted the principal source of manganese.

Prater (1947, p. 9) concluded:

> Beneficiation of this ore to a grade of commercial value by any method of concentration appears impossible...technically it is possible to obtain satisfactory extraction of the manganese from these sands. From the economic side, however, exploitation of a deposit of such low grade would require a very low cost operation.

Past production

Metallic mineral production in the past has been largely from the West View or Pearl district in southeastern Gem County (Tables 3 and 4). The greatest economic production was through the years 1938-1942 inclusive. The years 1923, 1952, and 1958 were also comparatively good years.

Total value of gold in Gem County from 1915 to 1959 (excluding 1924, 1945, 1950, 1957, and 1958 for which no figures are available) was slightly more than $534,000.

Total value of gold, silver, copper, lead, and zinc produced in Gem County from 1943 to 1959 (excluding 1945, 1950, and 1957 for which records are unavailable) amounted to $140,192.

There is no record of metallic mineral production in Payette County except for 10 ounces of gold reportedly produced in 1933-34. This gold undoubtedly was flour gold recovered from Snake River alluvium.

Potential

Future metallic mineral production in Gem and Payette counties will probably be limited to the region around Pearl. In this metallogenic area the volume of ore minerals is not great but experience suggests that values seem reasonably steady. If the work of earlier investigators is accepted, values, though low, will remain consistent to an unknown depth.

Table 3
Gold Production

Gem County*
1915-1942

Year	Production (ounces)	Value (Dollars)	Year	Production (ounces)	Value (Dollars)
1915	132	2,728	1929	60	1,240
1916	77	1,592	1930	8	165
1917	2	41	1931	4	83
1918	14	289	1932	456	9,424
1919	54	1,116	1933	144	2,976
1920	15	310	1934	91	3,185
1921	1	21	1935	61	2,135
1922	22	455	1936	183	6,405
1923	19	393	1937	759	26,565
---	---	---	1938	4,049	141,715
1925	19	393	1939	151	5,285
1926	4	82	1940	1,401	49,035
1927	640	13,229	1941	3,232	113,120
1928	283	5,850	1942	2,917	102,095
				TOTAL	$489,927

Payette County

1933 - 1934 (Probably from Snake River)	10 ounces	$360

*Principally from West View (Pearl) district. Data adapted from Staley (1946, p. 20 and 26.)

Table 4

Metallic Minerals Production

Gem County*
1943-1959

Year	Gold (ounces)	Silver (ounces)	Copper (Pounds)	Lead (Pounds)	Zinc (Pounds)	Total Value of Gold (Dollars)	Total Value All Minerals (Dollars)
1943	60	1,956	--	23,000	19,000	2,100	7,268
1944	70	1,142	200	11,000	8,500	2,450	5,138
1945	--	--	--	--	--	--	--
1946	54	1,354	--	600	1,600	1,890	3,244
1947	118	2,505	700	4,200	3,400	4,130	7,560
1948	34	526	200	7,800	3,700	1,190	3,597
1949	151	242	--	1,800	--	5,285	5,788
1950	--	--	--	--	--	-	--
1951	185	1,053	2,000	12,000	6,000	6,475	11,099
1952	164	4,383	2,000	74,000	44,000	5,740	29,409
1953	65	783	--	14,000	8,000	2,275	5,738
1954	119	284	--	2,000	--	4,165	4,696
1955	2	1	--	--	--	70	71
1956	13	143	--	--	--	455	584
1957	--	--	--	--	--	--	--
1958	--	--	--	--	--	--	44,000
1959	215	1,909	--	12,000	8,000	8,000	12,000
					Total	$44,225	$140,192

*Principally from West View (Pearl) district. Data obtained from U. S. Bureau of Mines Minerals Yearbooks.

It seems reasonable to assume that small quantities of gold, silver, copper, lead, and zinc will continue to be produced in this area; furthermore, any appreciable increase over the present price of gold will produce a marked increase in production activity in southeastern Gem County.

NONMETALLIC MINERALS

Building stone

Building stone probably will never be produced in large quantities in Gem and Payette counties, although sandstone, arkose, and orthoquartzite have been exploited for local use. The Poison Creek Formation(?), just below the Idaho Formation, contains a sandstone-arkose-orthoquartzite member which is correlative with the so-called Boise Sandstone southeast of Boise. Boise Sandstone from Table Rock is rather widely used as a dimension stone (Savage, 1958, p. 56-58). Some exposures of this sandstone in Gem and Payette counties are equally suitable for use as dimension stone.

Sand and gravel

Sand and gravel resources are widely distributed over Gem and Payette counties. Numerous borrow pits are located adjacent to easily accessible roads. Frequently this local gravel needs some beneficiation to meet rigid specifications. Fluvial and glaciofluvial sand and gravel deposits are more than adequate in quantity and quality to meet the demand for such materials for some years to come. In general, the situation is similar to that of Ada and Canyon counties (Savage, 1958, p. 58-62).

The total value of sand and gravel produced in Gem County for the past few years for construction purposes is not available; however, Baber, Fulkerson, and Petersen (1960, p. 4) revealed that sand and gravel valued at $106,000 was produced in Payette County in 1959. There are a number of state and county-owned pits in addition to the privately owned pits. Expansion is possible as future needs increase for many local sand and gravel deposits still remain to be developed.

Silica sand

High silica, arkosic sands are widely distributed in the Idaho Formation in Gem and Payette counties. This commodity has already been exploited by the Gem Silica Co. of Emmett. Average samples of the silica sand product when washed and screened to about 0.6 mm size yield:

85	percent SiO_2
9	percent Al_2O_3
0.15-1.14	percent Fe_2O_3
4.86-5.90	percent miscellaneous minerals and impurities

Principal minerals present are quartz, feldspar, and mica (both biotite and muscovite). At least part of the feldspar is in the albite-anorthite series.

Prater (1952) conducted flotation tests on these silica sands. His results and conclusions were recorded in: Flotation Tests on quartz sand from the Gem Silica Co., an open-file report of the Idaho Bureau of Mines and Geology.

A screen analysis of a pit-run sand sample is as follows:

Table 5

Screen Analysis Silica Sand from Freezeout Hill

Size (mm)	Mesh	% Weight	Cumulative % Weight
+2.8	(+6)	10.2	10.2
2.4	(6/8)	15.3	25.5
1.5	(8/10)	18.0	43.5
1.2	(10/14)	25.1	68.6
0.8	(14/20)	15.4	84.0
0.6	(20/28)	8.35	92.4
0.4	(28/35)	4.75	97.1
-0.4	(-35)	2.9	100.0

These data indicate the sand is 84 percent coarse-to-very-coarse sand.

Individual mineral liberation appears to be nearly complete in sizes below 0.6 mm; at that size the individual grains are composed entirely of one mineral type.

Prater (1952, p. 8-10) concluded:

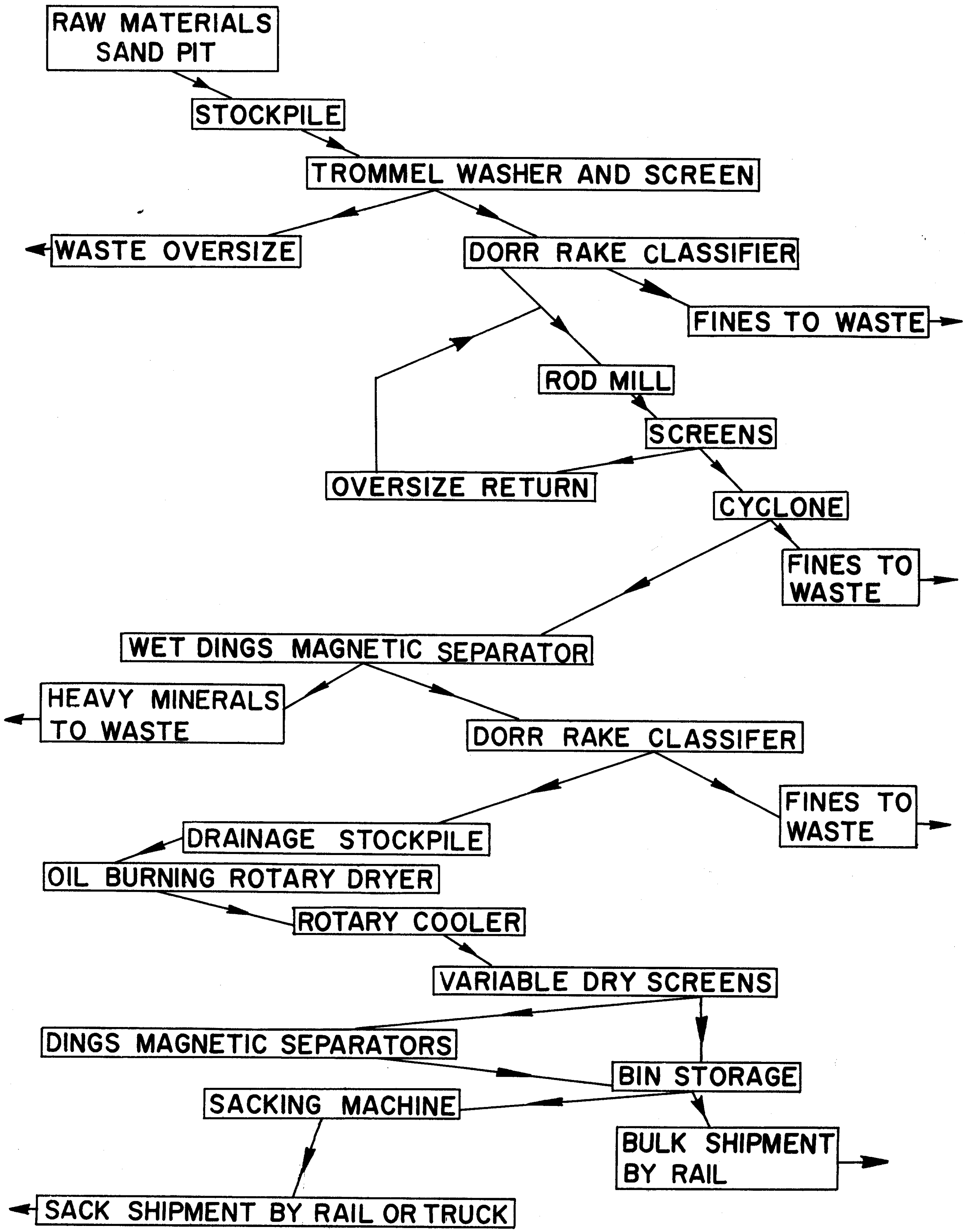
> ...tests would indicate that the feldspar and a minor amount of mica in this sand can be quite selectively floated from the quartz... qualitative examination of the products indicated fairly clean separation.

It is pointed out that best flotation occurs when the material is ground to a size ranging from approximately 0.2 to 0.06 mm and when the pulp is deslimed. Desliming seems to eliminate much of the iron content.

Classification of the feed also seems to be necessary. Furthermore, there is reason to believe that continuous operation might improve metallurgical results over those achieved under laboratory testing conditions.

FIGURE 13 PROCESSING PLANT FLOW DIAGRAM

DEL MONTE PROPERTIES CO.
EMMETT, IDAHO



The properties of the Gem Silica Company mentioned above were leased by Del Monte Properties Company, Sand Division, about 1956 (Fig. 12). These silica pits, 3 to 4 miles south of Emmett on Freezeout Hill, include 16 claims covering approximately 2 1/8 square miles.

Raw materials are recovered by open pit methods and transported to the processing plant at Emmett. Figure 13 is a flow sheet representing the nature of the processing operations. Mr. George Hellerich of Del Monte Properties Company who kindly supplied these data, reported at the same time that sand production averages 1500 tons per month (1959).

Gem County silica sand is produced for glass making, the roofing industry, plasterers' sand, and sand blasting.

In the future, technological improvements in processing should permit consumption of even greater quantities of silica sand from southwest Idaho. Future markets might include the silicon carbide industry and the use of silica in cermets for high temperature applications. If a market could be developed for the feldspar product which is separated from the silica sand as a part of the processing operations, the result would be more profitable use of the entire sand commodity.

Clay

The presence of silty clay in the Idaho Formation has long been known. Locally, clayey portions of the Idaho Formation have been reworked by running water and impure clay products have been concentrated at lower elevations, particularly in western Payette County. The Jenson Brick Company of Payette utilized local clay of this type for many years; however, the firm is no longer in business, reportedly because the clay supply has been exhausted in the immediate vicinity of the plant.

Clay deposits intercalated with Caldwell-Nampa sediments and the Idaho Formation could conceivably continue to supply reasonable quantities of raw material for a brick industry. Such clay of potential economic value occurs in the hills east of Payette and also in the southwest portions of Payette County.

Limestone, diatomite, and pumicite

Among other nonmetallic minerals of unknown economic potential one might include the small quantity of limy rock occurring in southern Gem County (Idaho Formation); locally, it is oolitic limestone. Also impure ashy diatomite occurs locally intercalated with Idaho Formation ash and silt layers, although no sizeable deposit of major potential economic value was located during the present field investigation. Powers (1947, p. 15) said:

> One outcrop of diatomite 3 feet thick with 4 feet of soil overburden is located 1 1/2 miles southeast of Marsh. The bed strikes N 45° W

and dips 25° northeast. About 25 percent of the sample is quartz, clay, and volcanic ash. This material is too impure for commercial use.

Any future use of diatomite from this area is uncertain. Development of a local market and technological methods of beneficiation would probably be necessary.

Ashy pumicite is sometimes found intercalated with Idaho Formation beds; again, however, no deposit of great economic potential was located in the region investigated. The possibility that enough volcanic ash and lime rock may be found in this area to provide raw materials for a small pozzolanic cement industry, is worth investigation. A more extensive field investigation and rock drilling program should be carried out to ascertain the actual quantities of available raw materials present in the area before any major development program is undertaken.

Gem stones

Agatized and opalized wood are found in some of the volcanic materials of northern Gem County and also near Squaw Butte. The North Fork of Willow Creek yields some interesting banded rhyolite, rhyolite breccia, and agate. Some individuals have successfully cut and polished this material for gem stones. Also, several claims have been staked out in the North Fork area by "rockhounds."

NATURAL GAS AND OIL

Six or eight wells drilled in Gem County and 13 wells drilled in Payette County have failed to produce commercial quantities of gas or oil. Washburne (1911) was one of the first geologists to examine the possibilities of gas and oil accumulation in the Vale-Payette district. He noted the presence of sedimentary strata and partly deformed structures, both favorable to the accumulation of gas and oil provided hydrocarbons were present in the rock pores. Washburne's published optimistic conclusions are probably responsible for recurrent promotion of oil and gas exploration. He postulated:

> The logical conclusion is that the chances for developing a gas field are good and the chances for developing an oil field are slight, though not to be wholly disregarded.

Plans for exploiting such envisioned reserves of natural gasand oil have waxed and waned sporadically in southwest Idaho for about 55 years. As early as 1904, excitement over the possibility of drilling wells for oil "of volcanic origin" swept through Boise Valley. In 1908 Henry and O. A. Cox drilled a well 10 miles north and three miles west of Emmett in Sand Hollow. Reportedly, some natural gas was produced (Prater, 1958).

Additional wells were drilled in Payette and Gem counties over the periods 1926-35 and 1955-56. As recently as August 26, 1959, the Statesman (Boise, Idaho) published a report that test drilling for oil and gas would "...start in the near future" a few miles southwest of Payette near Vale, Oregon, where the geologic situation is similar to that near Payette.

Buwalda (1923, p. 6) pointed out that the gas rising from wells in the Payette region was marsh gas that accumulates as the result of the decay of fresh water organisms in marshy areas. He comments that "...a considerable abundance of such material is known to be present in the Payette Formation."

Buwalda (1923, p. 6-7) concluded:

> So far as the petroleum possibilities of this district are concerned the writer is forced to express an unfavorable opinion...and it must be confessed that the chances of securing a paying gas well do not appear to be good, even if somewhat better than the chances for securing a producing oil well.

Kirkham (1935, p. 236) examined the southwest Idaho region and commented on the potential of natural gas production from the district:

> Many of the wells are gushers, reported to have blown sand, water, and gravel in a continuous stream 100-150 feet into the air for a period lasting from several hours to several days...but all have had the same history. After a few days almost every well ceased flowing...

Many of the water wells drilled in the Payette area yield gas from small pocket accumulations. It is reported that one well produced 75 million cubic feet of gas per day for a short period then ceased to flow.

Youngquist and Kiilsgaard (1951, p. 95) conducted one of the most recent geological investigations of oil and gas possibilities in southwestern Idaho. They concluded:

> The Cenozoic rocks of the Snake Plains do not constitute a source of oil. They probably are not potential reservoir rocks because of the many thick impervious extrusives, and a general lack of proper regular structure in both the sedimentary and volcanic rocks.

Table 6 is a list of the known locations of these wells, but these data may not be wholly reliable (Prater, 1958).

Table 6

Oil and Gas Wells Gem and Payette Counties

Gem County

Company or Property Owner	Location	Depth (Ft.)	Status
C. A. Berglund	sec. 3, T 6 N, R 3 W	576	Used for artesian water
C. A. Berglund	sec. 3, T 6 N, R 3 W	693	Abandoned
Bergdahl Oil Co.	sec. 35, T 6 N, R 1 W	175	Abandoned
Bergdahl Oil Co.	sec. 25, T 6 N, R 1 W	295?	Abandoned
Bergdahl Oil Co.	sec. 25, T 6 N, R 1 W	600?	Unknown
R. H. Lent Co.	Letha, Idaho	758?	Probably abandoned
Henry & O. A. Cox	NW of Emmett, Sand Hollow	879	Unknown
Ida.-Ore. Pet. Co.	City of Payette	1,830	Unknown
Idaho Canning Co. (?)	sec. 33, T 9 N, R 5 W	1,730	Abandoned
Payette Exploration	sec. 12, T 8 N, R 5 W	892	Abandoned
Ohio Oil Co.	sec. 5, T 9 N, R 4 W	4,011	Unknown
Consolidated Oil Co.	sec. 2, T 8 N, R 5 W	?	Unknown
Idaho Canning Co. (?)	sec. 33, T 9 N, R 5 W	2,000	Abandoned
Idaho Canning Co. (?)	sec. 33, T 9 N, R 5 W	2,500?	Unknown
Oroco Oil & Gas Co.	sec. 4, T 8 N, R 5 W	2,775	Abandoned
Oroco Oil & Gas Co.	sec. 27, T 8 N, R 4 W	4,040	Abandoned
Oroco Oil & Gas Co.	sec. 34, T 8 N, R 4 W	1,685	Abandoned
El Paso Natural Gas	sec. 27, T 8 N, R 4 W	3,521	Abandoned
El Paso Natural Gas	sec. 8, T 9 N, R 3 W	4,017	Abandoned

WATER RESOURCES

General availability

General water supply in Gem and Payette counties is very good in quantity and quality, although subject to some minor fluctuations. The situation is similar to that described in nearby Ada and Canyon counties (Savage, 1958, p. 70):

> Except for poor distribution of seasonal runoff, there is ample water in the streams and rivers of southwestern Idaho to constitute a major resource in this semiarid region.

Streams both past and present have deposited clay, silt, sand, and gravel layers that constitute excellent aquifers and ground water storage beds. Intercalated clastic sediments and lava flows are also important to natural water storage. Some lavas are quite pervious because of the presence of angular fragments and gas vesicles. Intercalated ash and scoria layers also play a part in underground water storage and movement, either as impervious or pervious horizons.

Developed water resources

Irrigation

Water resources include the Payette and Snake rivers and their tributaries, which supply large quantities of water used for irrigation purposes; subsurface or ground water is a source of well water used for additional supplies for irrigation; and wells are also the main source of municipal water supplies.

Large tracts of land in this two-county area have been under irrigation for a long time, and canals and ditches form an intricate part of surface water distribution and runoff. Important agricultural pursuits, including a major fruit growing industry, are practicable only because adequate irrigation water is available.

Irrigation in the Payette River Valley, however, as in the Boise River Valley to the south, has produced serious ground water problems such as soil saturation and poor drainage. Troeh and others (1958, p. 453 and 834) agreed that a generally high water table is indicated by ponds and marshy patches within gravel pits. The local ponding of rainwater on the soil surface during and shortly after precipitation also indicates poor subsurface drainage, in this case the result of a high water table.

Reservoir storage

There are two reservoirs of major importance within Gem County, none in Payette County. One storage area, Sage Hen Reservoir, is located on the northeast near the headwaters of the Second Fork of Squaw Creek. The other, Black Canyon Reservoir, is on Payette River east of Emmett.

Sage Hen Reservoir is used largely for recreational purposes and for regulation of the flow in Squaw Creek.

Black Canyon Reservoir is used principally for irrigation; however, two power units generate electricity from the stored water at certain times during the year. This power is sold to Idaho Power Company. Water storage capacity upon completion of the reservoir was 37,659 acre-feet.

In 1936 Hough and Flaxman (1937) conducted a sedimentation survey of the Black Canyon Reservoir and discovered a loss of 10.72 percent in the original storage capacity. If the rate of storage loss due to sedimentation is assumed to have continued at the same rate, then one might project the loss in storage as follows:

Original storage capacity 1924	37,659 acre-feet
Storage capacity 1936	33,622 acre-feet
Estimated capacity 1960	25,609 acre-feet

According to Hough and Flaxman (p. 11), inflow at the Black Canyon Reservoir from the Payette River averages 2,207,000 acre-feet per year. Inflow from Squaw Creek is estimated at 28,000 acre-feet per year.

Just north of the northeast corner of Payette County a dam on Little Willow Creek forms a reservoir. This reservoir is in Washington County but it regulates flow and irrigation water supply in Willow Creek Valley in Payette County.

Municipal and rural water supply

Municipal and rural water supplies are obtained principally from wells or ground water sources. As mentioned earlier, there seems to be no immediate danger of water shortage from this source because of the favorable nature of subsurface geology in the area.

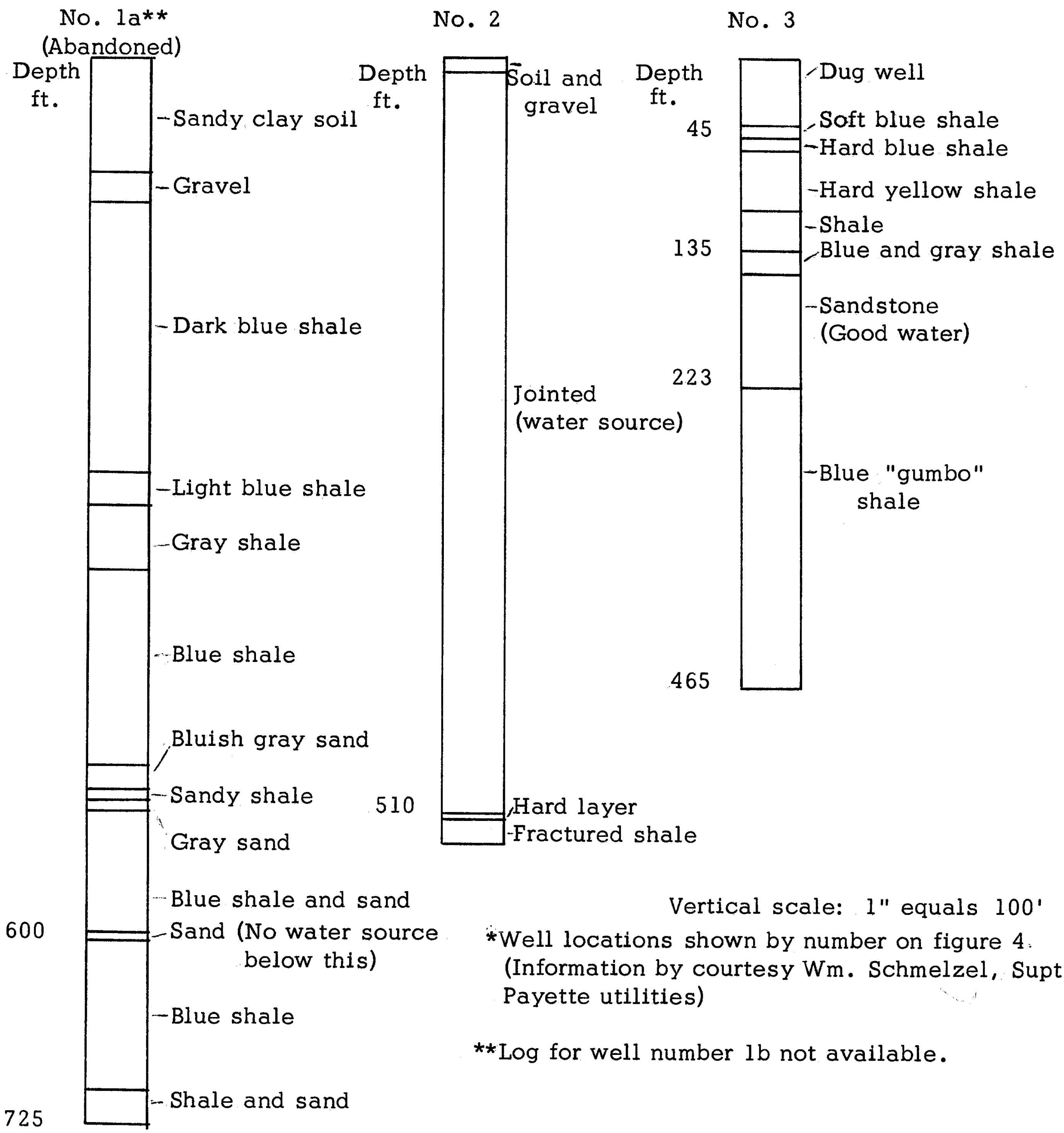
Water supply data were not obtained from all settlements in the map area; however, a few statistics will be cited for Payette and Emmett. In order to demonstrate the nature of subsurface water origin and storage in the Payette Valley, logs of the Payette water wells were obtained and are included in this report (Table 7).

At Emmett the municipal water supply system has delivered as much as 1,700,000 gpd (gallons per day). The system is reportedly capable of producing as much as 3,744,000 gpd. The water is of good quality, does not require treatment at the present time, and is suitable for boiler use.

Payette municipal water system has six wells (Table 7) which produce from 125 gpm (gallons per minute) to 600 gpm; reportedly this system averages 963,500 gpd. Water quality is good and treatment is not required at the present time.

Table 7

WATER WELL LOGS PAYETTE, IDAHO*

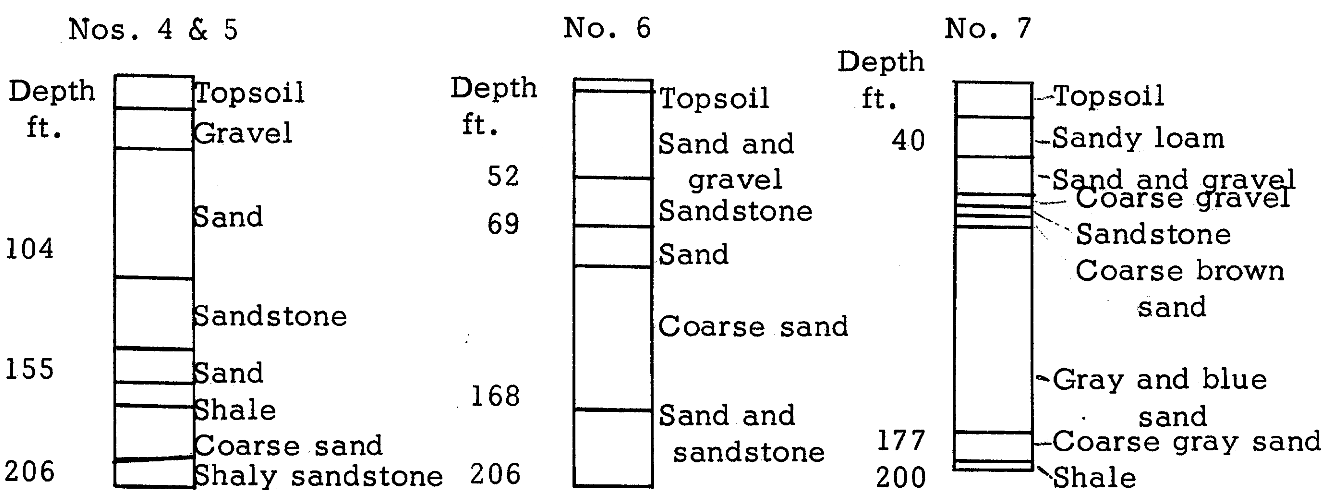


Vertical scale: 1" equals 100'

*Well locations shown by number on figure 4. (Information by courtesy Wm. Schmelzel, Supt. Payette utilities)

**Log for well number 1b not available.

Table 7
(Continued)



Vertical scale: 1" equals 100'

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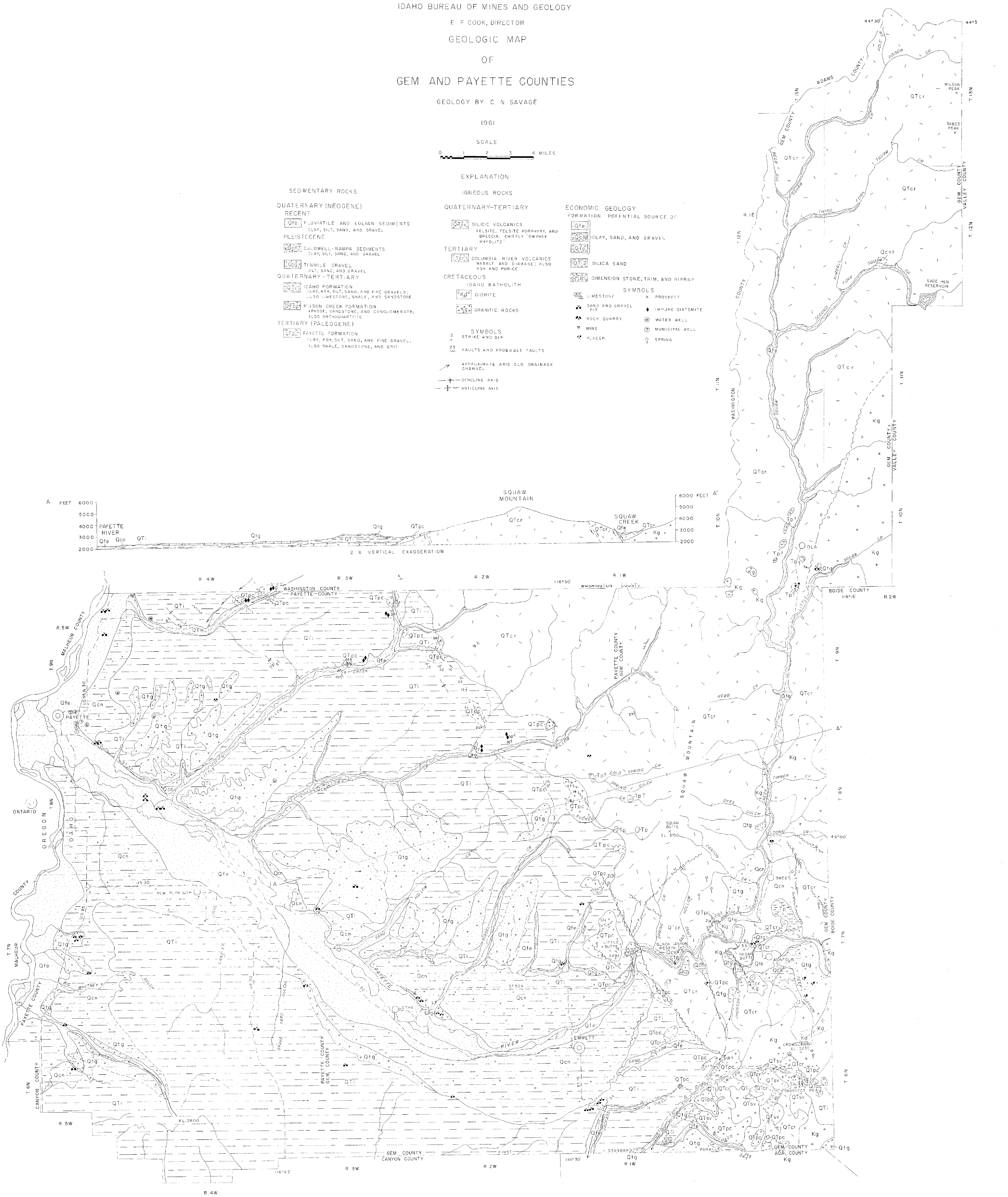
IDAHO BUREAU OF MINES AND GEOLOGY
E. F. COOK, DIRECTOR
GEOLOGIC MAP
OF
GEM AND PAYETTE COUNTIES
GEOLOGY BY C. N. SAVAGE
1961
SCALE
0 1 2 3 4 MILES
EXPLANATION
SEDIMENTARY ROCKS
QUATERNARY (NEOGENE)
RECENT
Qfe FLUVIATILE AND EOLIAN SEDIMENTS
CLAY, SILT, SAND, AND GRAVEL
PLEISTOCENE
Qcn CALDWELL-NAMPA SEDIMENTS
CLAY, SILT, SAND, AND GRAVEL
Qtg TENMILE GRAVEL
SILT, SAND, AND GRAVEL
QUATERNARY-TERTIARY
QTi IDAHO FORMATION
CLAY, ASH, SILT, SAND, AND FINE GRAVELS; ALSO LIMESTONE, SHALE, AND SANDSTONE
QTpc POISON CREEK FORMATION
ARKOSE, SANDSTONE, AND CONGLOMERATE; ALSO ORTHOQUARTZITE
TERTIARY (PALEOGENE)
Tp PAYETTE FORMATION
CLAY, ASH, SILT, SAND, AND FINE GRAVEL; ALSO SHALE, SANDSTONE, AND GRIT
IGNEOUS ROCKS
QUATERNARY-TERTIARY
QTsv SILICIC VOLCANICS
FELSITE, FELSITE PORPHYRY, AND BRECCIA. CHIEFLY "OWYHEE RHYOLITE"
TERTIARY
Tcr COLUMBIA RIVER VOLCANICS
BASALT AND DIABASE; ALSO ASH AND PUMICE
CRETACEOUS
IDAHO BATHOLITH
Kd DIORITE
Kg GRANITIC ROCKS
SYMBOLS
STRIKE AND DIP
FAULTS AND PROBABLE FAULTS
APPROXIMATE AXIS OLD DRAINAGE CHANNEL
SYNCLINE AXIS
ANTICLINE AXIS
ECONOMIC GEOLOGY
FORMATION POTENTIAL SOURCE OF
Qfe Qcn Qtg CLAY, SAND, AND GRAVEL
QTi SILICA SAND
QTpc DIMENSION STONE, TRIM, AND RIPRAP
SYMBOLS
LIMESTONE
PROSPECT
SAND AND GRAVEL PIT
IMPURE DIATOMITE
ROCK QUARRY
WATER WELL
MINE
MUNICIPAL WELL
PLACER
SPRING
A FEET 6000 5000 4000 3000 2000
PAYETTE RIVER
SQUAW MOUNTAIN
SQUAW CREEK
6000 FEET A'
2 X VERTICAL EXAGGERATION
WASHINGTON COUNTY
PAYETTE COUNTY
GEM COUNTY
ADAMS COUNTY
VALLEY COUNTY
BOISE COUNTY
ADA COUNTY
CANYON COUNTY
MALHEUR COUNTY
IDAHO
OREGON
PAYETTE
ONTARIO
NEW PLYMOUTH
EMMETT
LETHA
OLA
SWEET
MONTOUR
SQUAW BUTTE EL. 5150
LITTLE BUTTE
REGAN BUTTE
CROWN POINT EL. 3230
PROSPECT PEAK
WILSON PEAK
GABES PEAK
SAGE HEN RESERVOIR
BLACK CANYON RESERVOIR
SQUAW MOUNTAIN
PAYETTE RIVER
WILLOW CREEK
SAND HOLLOW
COLD SPRING CR.
SPRING GULCH
TIMBER CR.
DYES GULCH
WEBB CR.
BIG WHITNEY GULCH
FIRST STANDARD PARALLEL
R. 5W R. 4W R. 3W R. 2W R. 1W R. 1E R. 2W
T. 6N T. 7N T. 8N T. 9N T. 10N T. 11N T. 12N T. 13N
44°30' 44°00' 116°45' 116°30' 116°15'
EL. 2800

COUNTY REPORT 4
FIGURE 10

Idaho Bureau of Mines and Geology

FIGURE 10 TECTONICS AND EVOLUTION OF THE WESTERN SECTOR OF THE PLIOCENE-PLEISTOCENE PIEDMONT BASIN, SOUTHWEST IDAHO