Ore Deposits in Rocks of Paleozoic and Tertiary Age of the Northern Black Hills, South Dakota

by

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NOTE

STEWART GULCH (SEC. 7, T. 4 N., R. 3 E.) IS MISLABELED ON THE U.S.G.S. 7 1/2 MIN. LEAD QUADRANGLE TOPOGRAPHIC SHEET, WHICH APPEARS AS PLATE 5 IN THIS REPORT. STEWART GULCH IS THE NEXT UNNAMED GULCH TO THE NORTH, ON THE LINE BETWEEN SECTIONS 6 AND 7 OF THE ABOVE TOWNSHIP. THE MISLABELED GULCH SHOULD BE THE NORTH FORK OF WHITETAIL CREEK. THE CORRECT TERMS ARE USED IN THIS TEXT AND IN ALL EARLIER LITERATURE ON THE RUBY BASIN DISTRICT.

COLOR KEY FOR ALL MAPS IN THIS REPORT

Rock Unit	Mongol Number
Q	817
Twr	867
IPml	883
Cp	845
Ce	819
Ow	813
Owr	862
Owl	848
Fd	803
Tp	866
Tph	864
Precambrian	868

TABLE OF CONTENTS

Page

TABLE OF CONTENTS - Con't.

TABLE OF CONTENTS - Con't.

TABLE OF CONTENTS - Con't. Page

TABLE OF CONTENTS - Con't. Page

LIST OF FIGURES

LIST OF PLATES

LIST OF TABLES

1. INTRODUCTION

The northern Black Hills of South Dakota has long been famous as a gold producing area. The colorful history of the early placer mines in Deadwood Gulch and the extensive operations of the Homestake Mining Company in the Precambrian rocks of the area are well known. In addition to these, however, numerous Tertiary deposits of gold and silver were found in the Cambrian, Ordovician and Mississippian sedimentary rocks which surround the Precambrian window in the Lead-Deadwood area. With minor interruptions, these deposits were mined continuously from 1877 to 1959, with a total production well in excess of $75,000,000 in gold and silver.

1.1 Objectives

The present study has had two objectives. First, to assemble the pertinent literature, both published and unpublished, regarding ore deposits in Paleozoic sedimentary rocks in the northern Black Hills, and second, to conduct field investigations in selected areas.

In a sense, the first objective provides a supplement to the Black Hills Mineral Atlas (U. S. Bureau of Mines I. C. 7688, referred to in other sections of this report as "Atlas") which provides information on the location, history, mining operations, production and references for most of the known ore deposits in the area. However, geologic descriptions in the Atlas were limited to only a few sentences for each deposit. This was sufficient for those deposits about which little is known, but in general much more data was available than could be included under such a restriction. Descriptions of properties not mentioned in the Atlas have been included in this report and locations given in the Atlas have been refined where possible. All known properties from which ores of Tertiary age were produced and shown on Plate 1.

As a result of the literature study, it was decided that the Bald Mountain, Ragged Top and Carbonate Mining Districts would be the most fruitful areas for field study, and these areas were subsequently mapped and a program of geochemical sampling conducted concurrently.

1.2 Location

The mining districts discussed in this report are all within an area of about 125 square miles centered at the city of Lead, South Dakota (Fig. 1). The mapped area (Plates 2, 3, 4, 5, 6) lies northwest and west of Lead, in T. 5 N., R. 2 E., and T. 4 N., R. 2 and 3 E.

Sedimentary rocks in the area are gently dipping except where affected by the emplacement of younger intrusive rocks. The topographic relief is nearly 3,000 feet, with flat upland areas and steep walled canyons which are often separated by areas of moderate slope. The north-facing slopes and flat areas are generally covered by dense growths of pine or aspen while the vegetation tends to decrease on the south-facing slopes. In areas where the topographically high points are covered with intrusive rocks, the slopes are obscured by heavy scree. Old mine dumps, townsites and railroad grades cover many critical areas because these are obviously associated with the heavily mineralized zones.

Numerous county roads, logging trails, mine roads and railroad grades provide access to these areas away from the paved highways which serve the northern Black Hills.

1.3 Acknowledgments

Numerous graduate and undergraduate students of this institution assisted in all phases of the project. During the summer of 1968 Mr. John

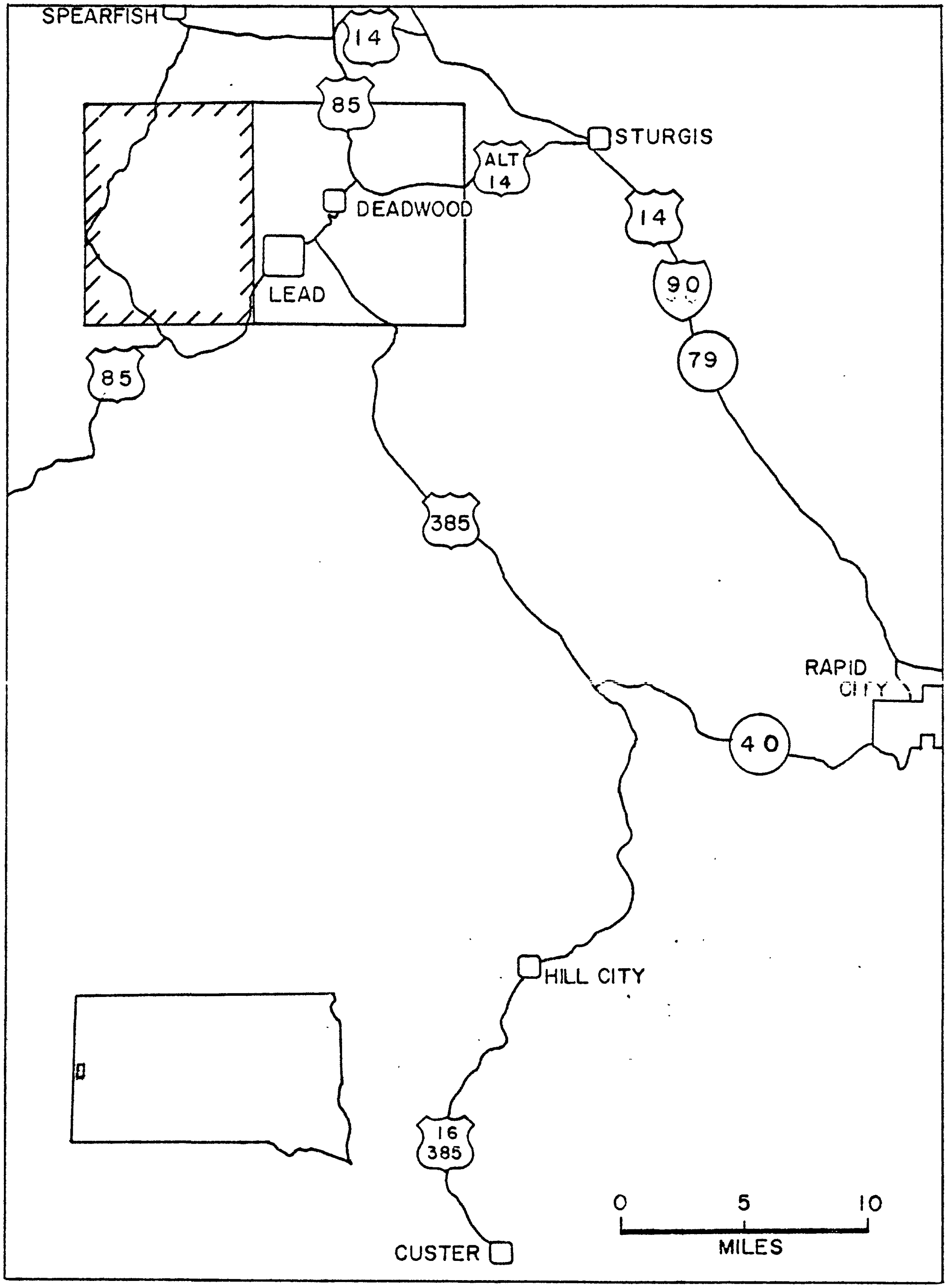


Figure 1. Location of Study Area. Hatching Shows Mapped Area

K. Fisher led a field party in the Citadel Rock area. Mr. Amos Lingard of the South Dakota Mining and Engineering Experiment Station supervised the laboratory work during the summer of 1969.

Acknowledgments are due to several members of the U. S. Geological Survey, especially to Mr. Richard W. Bayley who supervised the project and to Mr. A. Maranzino and Miss E. Martinez who gave valuable assistance in setting up analytical procedures. The Homestake Mining Company and Anaconda Copper Company kindly permitted the examination of cores from the Ruby Basin District and publication of the logs.

1.4 Methods and Procedures

Geologic mapping was done on the 7 1/2-minute Maurice, Savoy, Lead and Spearfish topographic sheets, enlarged to a scale of one inch equals one thousand feet.

A map of the Portland District on that scale has been done by Miller, Harder, and Slaughter (*in* Miller, 1962) though not on a topographic base. During the present project, the map was field checked and topographic control was established, and that part of the map south and east of a line from the head of Annie Creek to War Eagle Hill was used with only minor revisions. The area north and west of that line was remapped and the mapping extended to the Ragged Top and Carbonate Districts. The mapping credits are shown in Figure 2.

Aerial photo coverage was used in the few areas where forest cover was not too heavy. Five mining camps in the Ragged Top and Carbonate Districts were mapped with plane table and alidade on a scale of one inch equals one hundred feet.

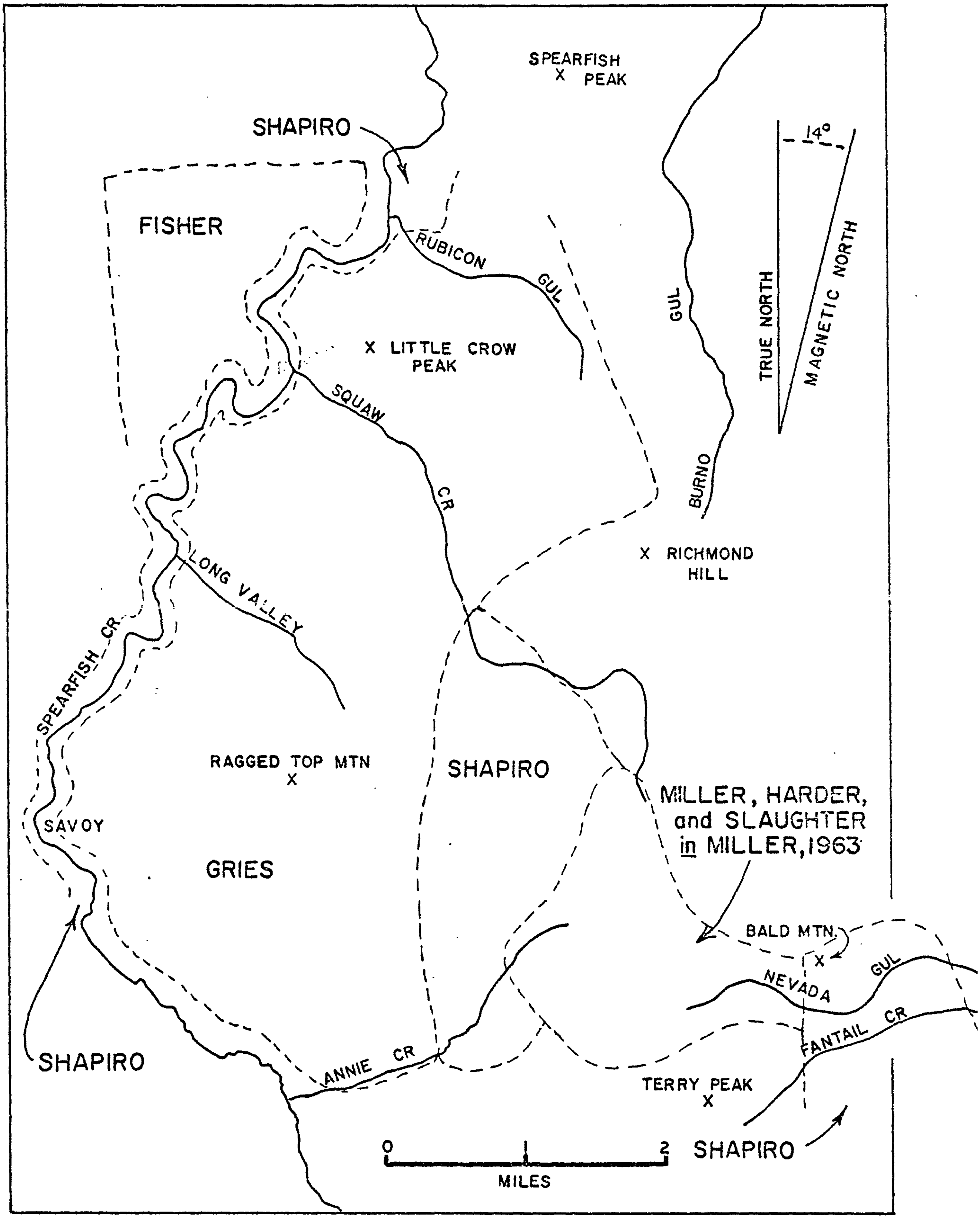


Figure 2. Mapping Credits

The intimate relationship between joints and ore shoots in the area required that the major joint systems be identified. This was accomplished by systematically measuring every joint in a single outcrop at each of several localities. The joint strikes (dip of the joint planes were near vertical in almost all cases) were then plotted separately for each locality. The number of joints measured varied from 44 to 200 per outcrop.

The samples collected for the geochemical program during mapping were primarily taken from prospect pits, mine dumps and workings, and scattered outcrops which showed evidence of alteration. In addition, a few areas were systematically sampled either on traverses across specific parts of the sedimentary section, or on a series of grid points to sample a particular area. The results of the analysis of samples taken in connection with the mapping program or on a specific mining property are described in the text. Other results are given in Appendix VII.

Preparation and analysis of the samples were done by following the procedures given by Ward, et. al., (1963) for all elements other than gold. The latter element was determined by the method given by Huffman, Mensik and Riley (1967). All samples were analyzed for gold and silver, and determination of arsenic and mercury was done in some cases. In a few instances, the results of analysis by the above methods were checked by comparison with the results of fire assays on the same samples. The values generally were in fair agreement. However, the personnel employed in this phase of the work changed several times during the course of the project and modifications in equipment and procedures were occasionally introduced. For these reasons, it is suggested that the results of the sampling project be accepted with the realization that some error, possibly as high as 50%, is present in some of the results.

1.5 Previous Work

The most comprehensive study of the northern Black Hills mining districts available is that of Irving (1904) who had the opportunity to examine the area while many of the mines were still operating. Connolly (1927) examined some of the properties which were still accessible, and made additional contributions based upon analytical, petrographic and polished surface work on materials which he collected and on those found in collections at this institution. Miller (1962) presented a complete discussion of the geology and operations of the Bald Mountain Mining Company, much of which was from unpublished sources.

A program of sampling and chemical analysis of sediments from several streams in the northern Black Hills was conducted under the sponsorship of the South Dakota Industrial and Expansion Agency. The results were summarized by Miller (1964). Lingard and Roberts (1969) presented the results of a project sponsored by the U. S. Bureau of Mines, involving sampling and chemical analysis of old mine dumps in the Black Hills. Included were dumps in the Galena, Portland and Carbonate Mining Districts.

Mukherjee (1967, 1968a, 1968b) has investigated the porphyry gold deposits on Strawberry Creek, west of Galena, and Grunwald (Ph.D. thesis, South Dakota School of Mines and Technology, in progress) is currently studying the stratigraphy, structure, and mineral deposits of the Galena Mining District under a National Science Foundation grant.

2. GENERAL GEOLOGY

2.1 Regional Setting

2.11 Regional Structural Geology

Darton (1904) described the Black Hills Uplift as an " . . . irregular dome rising on the northern end of an anticlinal axis extending northward from the Laramie or Front Range of the Rocky Mountains. It is elongated to the south and northwest, has steep slopes on the sides, is nearly flat on top and is subordinately fluted." Noble (1952; in Noble, Harder and Slaughter, 1949) recognized that the uplift is divided into two blocks which are in contact along a lineament which trends north from just east of Newcastle, Wyoming. The eastern block is about 100 miles long and 50 miles wide, with its axis trending north-south. The western block is about 100 miles long and 70 miles wide and its axis trends northwest. The eastern block is uplifted relative to the western block. These relationships are shown in Figure 3.

The lineament was studied in the vicinity of Newcastle, Wyoming by Wulf (1955) who showed that it consists of a series of high-angle faults, which pass into monoclines along their strikes. Brobst and Epstein (1963) remapped the area and named the structure the Fanny Peak Monocline. Shapiro (Ph.D. thesis, University of Minnesota, in progress) mapped the lineament north for about 40 miles from the northern limit of Wulf's mapping, and showed that it passes into the igneous complex near Iron Creek Lake on the eastern boundary of the Tinton Uplift. Regional structure contour maps (Darton, 1904, Dobbin & Others, 1957) clearly show that south of Newcastle, Wyoming the Fanny Peak Monocline marks the eastern boundary of the Powder River Basin, and can be traced as far south as the Hartville Uplift.

Just north of Iron Creek Lake, a monocline striking northeast and dipping northwest, was mapped by Shapiro (Ph.D. thesis, University of Minnesota, in

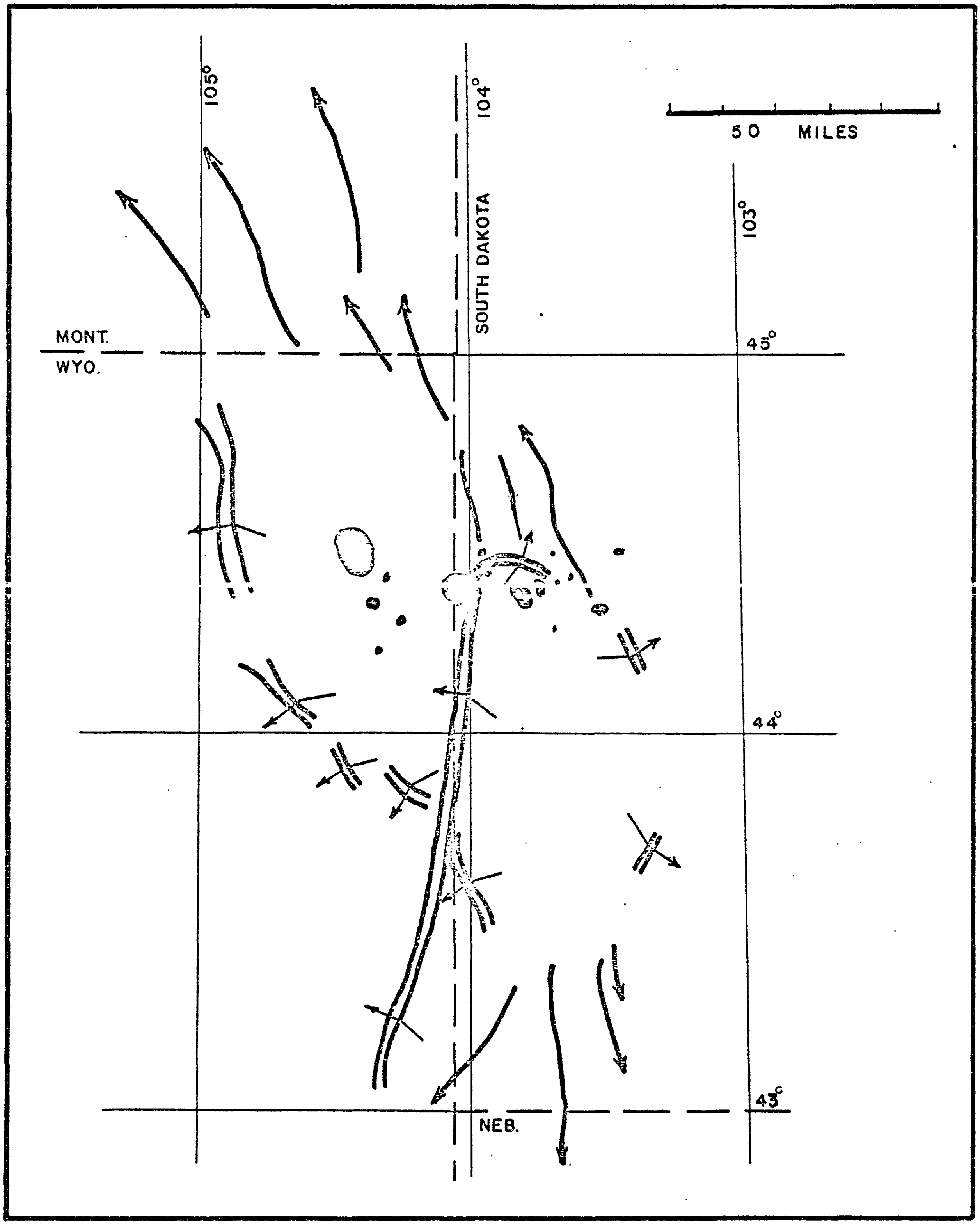


Figure 3. Regional Tectonic Map. Double Lines Show Well-Developed Monoclines; Arrows are Plunging Folds, Black Areas are Tertiary Igneous Rocks.

progress). Additional mapping to the northeast for the present project demonstrated that the strike of the fold turns gradually from northeast to east at Spearfish Peak. The fold has not been mapped further east than this point, but existing maps suggest that it bends to the southeast and forms the structural front of the northern boundary of the eastern block. The connection between the Fanny Peak and the second monocline seems probable from the map pattern, but has not been demonstrated in the field.

2.12 Tertiary Intrusive Belt

Noble (1952) and Brown (1954) both noted the fact that the Tertiary intrusive rocks in the northern Black Hills occur in a well-defined belt which crosses the uplift in a N. 70°-75° W. direction. A "best fit" center line for the belt is parallel to the Lake Basin Fault zone and is almost an extension of the Nye-Bowler fault zone (see map in Stone, 1969). It would also be parallel to and just south of the northern boundary of the eastern block of the Black Hills Uplift. With the exception of a few isolated intrusive bodies, all of the Tertiary igneous rocks are found within 5 miles of the center line of the belt.

Brown (1954) recognized four major centers of intrusive activity aligned along the belt. These are: (1) at the eastern edge of the belt in the Kirk Hill-Deadman Mountain-Vanocker Laccolith complex southeast of Sturgis, South Dakota; (2) the Lead-Deadwood dome which lies northwest of those two cities; (3) the Tinton Uplift on the Wyoming-South Dakota boundary, and; (4) the Bear Lodge Mountains north of Sundance, Wyoming. In addition, numerous small igneous bodies are found outside of these centers and in no apparent association with them.

Only two of the centers, Tinton and Lead-Deadwood, have large areas of Precambrian rocks exposed within them. Darton (1905) mapped small bodies of granitic rocks which he considered to be of Precambrian age, surrounded by Tertiary igneous rocks in the Bear Lodge Mountains. The area was later restudied by Brown (1952) who considered these "granites" to be metamorphosed sediments of the lower Deadwood formation.

2.13 Distribution of Mineralized Areas in Paleozoic Rocks of the Northern Black Hills

Brown (1952) reviewed the economic geology of the Bear Lodge area and noted that there is no record of gold production from that locality, nor any indication that some might be forthcoming, although numerous claims have been filed in the area. The same is true of the igneous center southeast of Sturgis.

Gold was produced from placer deposits in the creeks draining the Tinton area as early as 1876, and cassiterite was soon identified in these deposits (Smith and Page, 1941). The source of the tin was determined to be the pegmatites of Precambrian age which are intruded into schists exposed in the center of the Tinton Uplift, and production of tin began in 1903 and continued intermittently until about 1941. Gold has been found in the Tinton District in both Precambrian schists and Tertiary intrusives, and fairly extensive underground workings were developed in the intrusive rocks of the Mineral Hill area (Allsman, 1940) though there is no record of any resulting production of gold. In addition, though numerous small prospects are present in the Cambrian, Ordovician and Mississippian rocks surrounding the dome, there is no indication of any production from these sources either.

The bulk of the Tertiary mineralization in the northern Black Hills is concentrated around the Lead-Deadwood dome and in a zone that extends east from the south end of the dome to Galena, a distance of about six miles. The relationship between the dome and the mining districts which surround it is clear, but there is no deformation of the Cambrian-Precambrian contact which suggests structural control on the distribution of the remaining deposits (Plate 7, Fig. 4).

In the present study, most of the work was concentrated along the west flank of the Lead-Deadwood dome, although reconnaisance and some sampling was done in all the other districts.

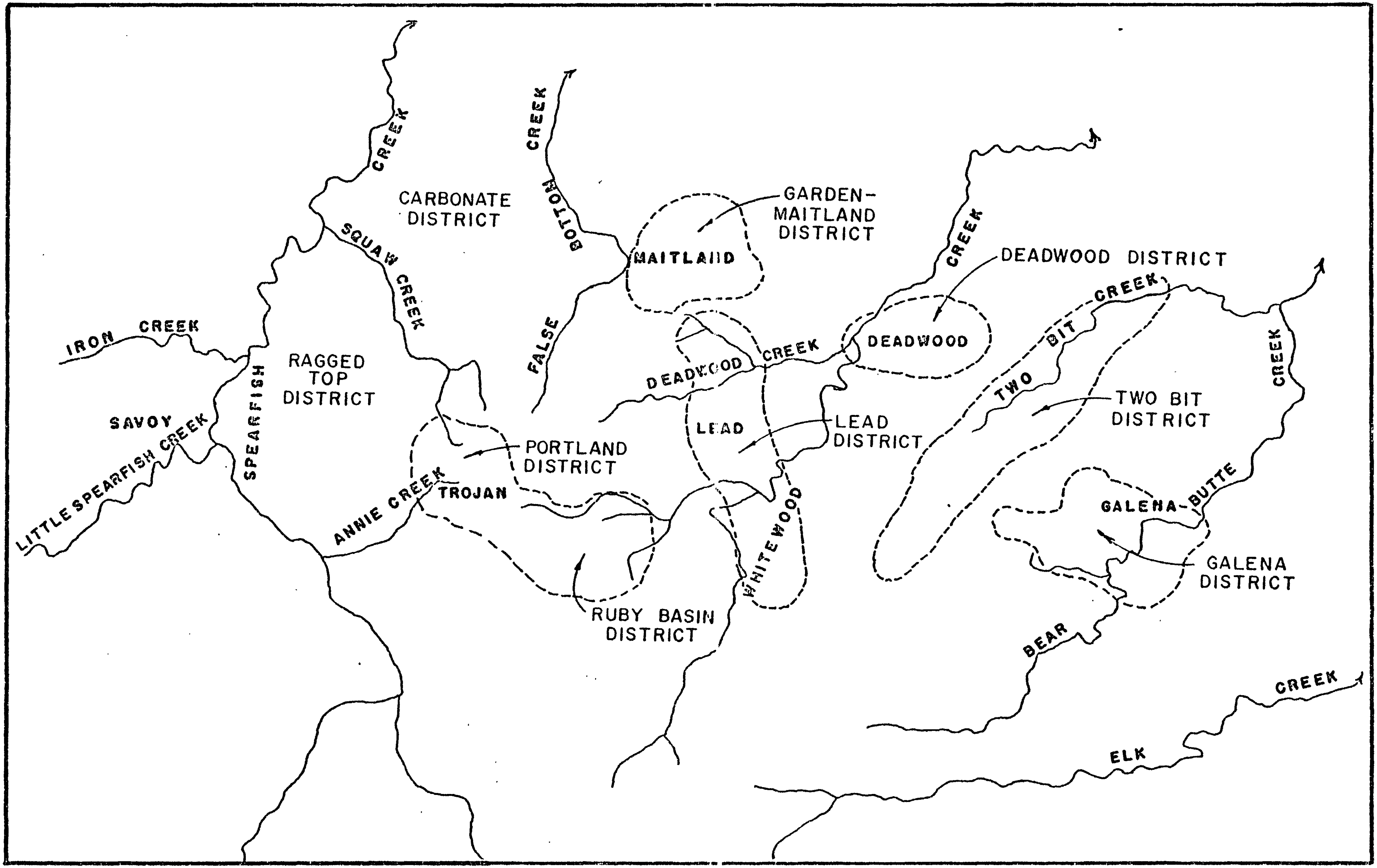


Figure 4. Location of Mining Districts

2.2 STRATIGRAPHY

2.21 Introduction

Sedimentary rocks exposed in the Black Hills uplift range in age from Cambrian to Tertiary with only the Silurian unrepresented. Ore deposits of Tertiary age occur in the northern Black Hills in rocks of Cambrian, Ordovician and Mississippian age, and it is with these units that this report is concerned. The regional aspects of the pre-Pennsylvanian stratigraphy of the northern Black Hills have been reviewed by Mickelson and Kulik (1963), and the reader is referred to that paper for more detailed information. The discussion which follows applies only to the Paleozoic section around the Precambrian window in the area of Lead and Deadwood. A generalized stratigraphic column appears in Figure 5.

2.22 Deadwood Formation.

The stratigraphy of the Deadwood formation in the Black Hills has recently been studied by Kulik (1962, 1963, 1965) and the following discussion is based on these papers.

The Deadwood formation includes rocks ranging in age from Late Cambrian to Early Ordovician. Its thickness on the outcrop in the study area varies from about 350 feet at Galena to 429 feet at the type section north of Deadwood. A drill hole at Dacy cut 426 feet of Deadwood. The formation can be subdivided into three members. The lower member includes a basal conglomerate which varies in thickness from zero to 36 feet overlain by a buff sandstone or quartzite about 25-30 feet thick. Beds of almost pure hematitic shale up to 25 feet thick have been observed below the conglomerate in drill cores from south of the Ruby Basin. A few feet of green shale is found at this horizon in the bed of Squaw Creek in SW 1/4 SW 1/4 sec. 22, T. 5 N., R. 2 E. The

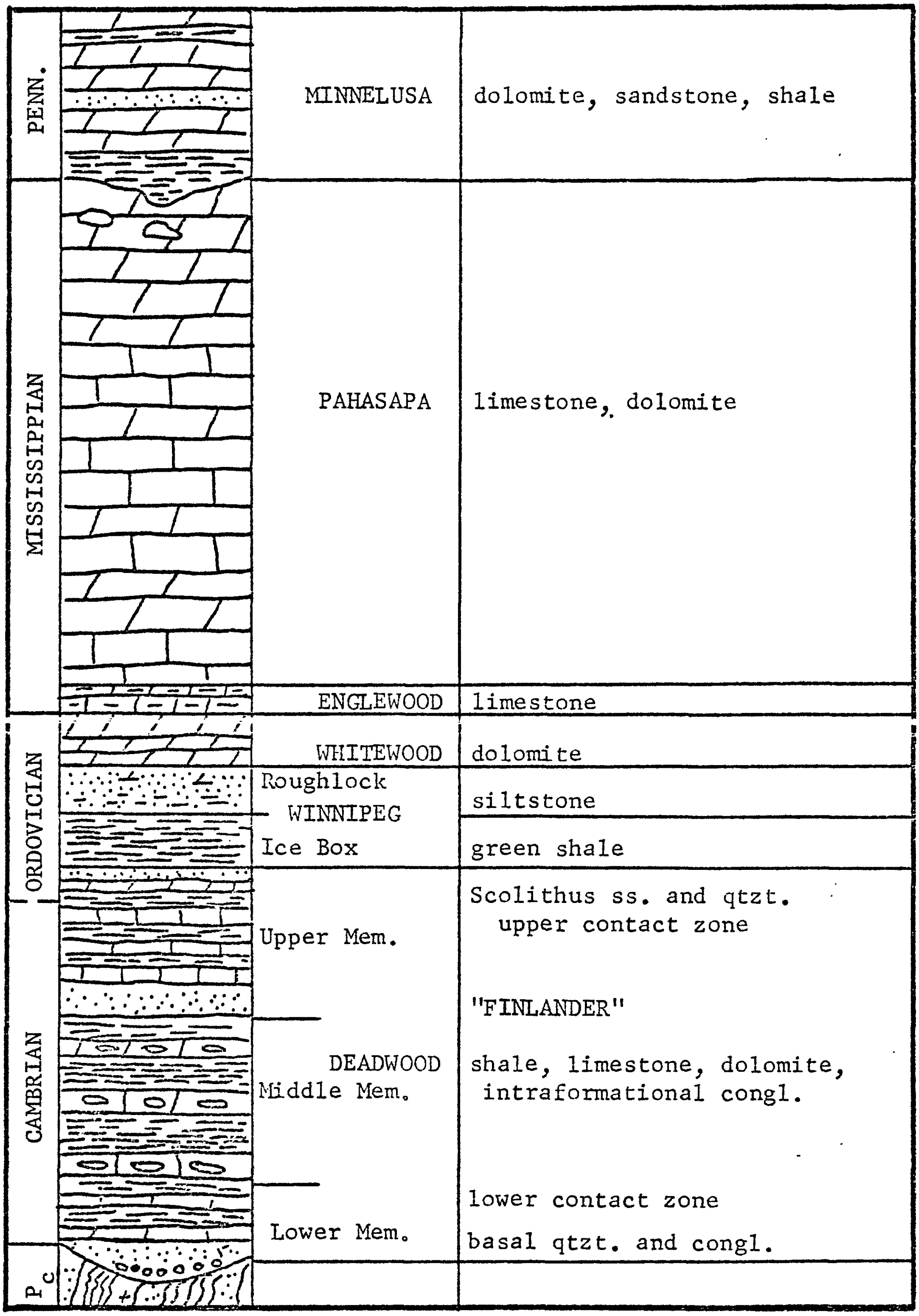


Figure 5. Stratigraphic Section, Northern Black Hills

quartzite is followed by up to 50 feet of thin to medium bedded argillaceous limestones, dolomitic limestones and limestone pebble conglomerates interbedded with thin layers of shale.

The middle member consists largely of interbedded shale and limestone pebble conglomerates, and is 156 feet thick at the type section. The upper member is dominantly flaggy sandstones and limestones, limestone and siltstone pebble conglomerates and a massive red sandstone. Its thickness at the type section is about 160 feet. The Scolithus sandstone (Aladdin formation of McCoy, 1962) is included in this member (Kulik, 1965).

2.23 Winnipeg Formation.

The Winnipeg formation disconformably overlies the Deadwood formation. It is represented by two members which were described, named, and given formation rank by McCoy (1962). However, more recent work (Carlson, 1960; Kulik, 1963) has reduced them to member status. The lower unit is the Ice Box Member consisting of 25 to 60 feet of greenish gray silty shale. It is of Middle Ordovician age, as demonstrated by the included microfauna (Furnish, et. al., 1960). Overlying the Ice Box is the Roughlock member, 25 to 50 feet in thickness. This unit ranges from a soft argillaceous siltstone, often calcareous, to a clean white siltstone, and frequently to a hard granular quartzite. The siltstone facies is usually stained with diffusion banding of reds and yellows on the outcrop, but is pale green to white in subsurface. The quartzite is generally white.

No fossils have been found in the Roughlock. The writers anticipate that ultimately the unit will be shown to be more closely related to the overlying Whitewood than to the underlying shale. For further discussion of the Winnipeg Group, the reader is referred to the review and summary by Carlson (1960), or the thesis by Kulik (1965).

2.24 Whitewood Formation.

The Whitewood formation of Late Ordovician age is equivalent to part of the Red River formation of the Williston Basin, and the Bighorn formation of Wyoming and Montana. Its thickness in the area ranges from 36 to 56 feet. The upper part is generally thick bedded to massive, but it becomes more thin bedded, and often silty, near the base. The lower member is gradational, with perhaps a slight break in sedimentation, with the underlying Roughlock member. On outcrops, the Whitewood consists of mottled buff to red granular dolomite, and contains characteristic chain corals, straight orthocone cephalopods, and a *Maclurites*-like gastropod.

Its potential as a host horizon for mineralization is discussed in the section of this report concerning the Carbonate Mining District.

2.25 Englewood Formation.

The Englewood formation consists of 35 to 50 feet of pink to lavender calcareous siltsone and slabby argillaceous carbonates. It grades conformably into the overlying Pahasapa formation, but is disconformable with the Whitewood formation. A lower gray shale unit, present along Whitewood Creek below the city of Deadwood, has not been recognized along Spearfish Canyon.

Although the Englewood formation was deposited by a transgressive Mississippian sea, Klapper and Furnish (1962, p. 2071) have pointed out that the basal few feet contain conodonts which are regarded as of Late Devonian age in Europe. On the basis of corals and brachiopods, Darton (1925) considered the entire formation to be Lower Mississippian in age.

2.26 Pahasapa Formation.

The Pahasapa formation is a carbonate unit which averages between 500 and 600 feet in thickness over most of the northern Black Hills. It is a major cliff forming unit and also forms a wide plateau along the western border of the area. On the outcrop it is a crystalline carbonate, light gray to buff in color with composition varying from pure limestone to pure dolomite including various combinations of the two. The lower contact is conformable with the Englewood formation, while at the top, a red clay of variable thickness, probably a fossil soil, occurs irregularly around the area. There is also some evidence of the development of pre-Pennsylvanian karst topography on the Mississippian surface. No Tertiary ore deposits are known any higher in the section than the top of the Pahasapa, although there is a potential host zone in the carbonate part of the lower Minnelusa formation which immediately overlies the Pahasapa.

2.27 Minnelusa Formation.

The Minnelusa formation consists of three units, a lower red shale, a middle section which is dominantly carbonates, and an upper, sandstone unit. Only the basal shale unit has been seen in the mapped area east of Spearfish Canyon. The entire formation reaches a total thickness of 500 feet in northern Black Hills outcrops.

2.3 Tertiary Igneous Rocks

2.31 Introduction

No comprehensive study of the petrology and petrography of the northern Black Hills Tertiary igneous province has been completed, and the profusion of rock types described in the literature combined with the generally inadequate locations given for the sample sites, make generalizations regarding the intrusives difficult. Paige (in Darton and Paige, 1925) summarized the results of earlier investigations with the observation that rhyolites, rhyolite porphyry, monzonite and quartz monzonite porphyries comprise over 80% of the igneous rocks in the province, while phonolite and grorudite contribute an additional 6% each. He further notes that "there is evidence that the monzonites were the earliest intrusive rocks and that they were followed by the rhyolite and quartz monzonite porphyries and these in turn by the phonolites," and that no evidence is available regarding the grorudites and rhyolite porphyries.

2.32 Age of the Igneous Rocks

The age of the intrusives has been determined, from geologic evidence, to be pre-Oligocene but post-Cretaceous (Darton and Paige, 1925). Drake (1967) reviewed the available data and concluded that the intrusives are all of Eocene age. Two radioactive ages have been established for the Tertiary igneous rocks, one from each end of the belt. At the east end, a K-Ar age on hornblends from the intrusive at the Gilt Edge mine just north of Galena gave 60.5±3 m.y. (Mukherjee, 1968). At the west end of the belt, a K-Ar age on orthoclase from the phonolite mass of Devils Tower, Wyoming gave 40±4% (Bassett, 1961). Comparison of these ages with the time scale of Kulp (1961) shows that they bracket the Eocene. Earlier workers in this area usually assumed that the period of igneous activity was of relatively short duration (Brown, 1954, suggested one million years), and that all the Tertiary porphyries were derived from a single parent magma. However, the time boundaries established by the ages above casts serious doubt on the validity of that assumption.

2.33 Mechanics of Intrusion and Geometry of the Igneous Bodies

In general, the form of the individual igneous bodies is closely controlled by the presence of planar elements in the country rock, represented by nearly horizontal bedding planes and unconformities in the sedimentary section and near vertical foliation planes in the Precambrian schist. Such control is not absolute, however, because individual igneous bodies do change position in the stratigraphic section by breaking out of the plane in which they were initially emplaced and moving to one higher in the section.

Noble (1952) studied the mechanism of intrusion of the Tertiary igneous rocks and concluded that forcible injection of the magma is the most likely explanation. No contradictory evidence to this suggestion was discovered during the present study, nor has any such evidence been presented in the literature since the time of Noble's publication. In general, there is little evidence of magmatic stoping or of assimilation of country rock by the magma (Fisher, 1969; Brown, 1952, 1954; Noble, 1952).

The general structural features and the controlling factors on the form of the intrusives are probably very similar to those described by Hunt (1953) and Pollard and Johnson (1969) from the Henry Mountains. Lack of good outcrops, however, prohibited sufficient data to be gathered to completely confirm this conclusion, but the similarity is certainly strong in view of the available data.

Discussions of the form of the intrusives which appear in the literature have, to some extent, become involved in unnecessary controversy which stem from attempts to classify the intrusives. In particular, the fact that many of the intrusive masses are small domes in various states of erosion has led to disagreements with regard to whether these domes are stocks or laccoliths in the sense of the definitions in the AGI Glossary. According to those definitions, no igneous body intruded into the Precambrian schists can possibly be a laccolith, because the foliations are vertical, hence a near-horizontal floor for the intrusive seems highly unlikely. The central question is thus whether or not a particular intrusive body is a stock projecting up from the Precambrian schists, a laccolith with a floor either in the Paleozoic section or at the Cambrian-Precambrian contact, or finally, a bysmalith, floored as a laccolith, but elongated vertically to give a stock-like aspect to its form at the surface. Noble (1952, <u>in</u> Noble, Harder and Slaughter, 1949) suggests that most of the northern Black Hills intrusives are stocks, based on the study of the form of the igneous bodies exposed in the Lead-Deadwood dome.

Within the Lead-Deadwood dome, the Precambrian schists have been intruded by numerous igneous bodies of Tertiary age which various authors have identified as stocks and dikes. The term "dike" as used here is not in accord with the definition given in the AGI Glossary which specifies that a dike must cut across the structure of the adjacent rocks. However, it is in accord with that given by Jagger (1900) whereby a dike is simply a tabular body whose walls were closer to the vertical than the horizontal at the time of intrusion. The usage of the term "stock" is the commonly accepted one of an igneous body covering less than 40 square miles and having steeply dipping sides. Noble (1952) referring to the northern Black Hills notes that " . . . most stocks are made up of several intrusions of porphyry of different kinds and parting screens of schist are fairly common." According to H. D. Carlson (written comm., 1966) the largest of the stocks, the Cutting Stock, which occupies much of the exposed core of the Lead-Deadwood dome, is a multiple intrusive consisting of at least four different igneous rock types. It is evident from larger scale maps of the Lead-Deadwood dome (see, for example Noble, 1952, Fig. 9) that the form of the stocks is dominated by linear elements which reflect the geometry of the schists into which the magma was intruded. The dikes vary widely in thickness and are found in profusion throughout the exposed core of the dome. Irving (1899) counted 22 dikes varying in thickness from 10 to 100 feet within one mile along Deadwood Gulch, west of the Cutting Stock. These were accompanied by "innumerable" smaller dikes.

The uplift of the Lead-Deadwood dome has been attributed to the increase in volume of the basement due to the emplacement of the Tertiary porphyries (Noble, in Noble, Harder and Slaughter, 1949), a conclusion which seems entirely reasonable in view of the lack of evidence of assimilation of the schist by the intruding magma. In addition, this conclusion can probably be extended to the Tinton Uplift as well. A rough estimate of the thickness of porphyry dikes in the eastern part of that dome, taken from the map in Smith and Page (1941) shows that roughly 10% of the surface area within the core of the uplift, is occupied by porphyry, and the major intrusive center within the uplift is west of the mapped area in the Welcome-Mineral Hill area. If the 10% of surface area can be translated to an equal volume increase, then, a degree of uplift certainly follows. The percentage of the core of the Lead-Deadwood dome which is occupied by porphyry is probably closer to 30%, estimating from the 1:62,500 scale map in Darton and Paige (1925). Noble further suggests that the smaller, outlying domes away from the intrusive centers, such as Elkhorn Peak, Citadel Rock, Crow Peak and others, are similar to the Lead-Deadwood dome in that the uplift is due to an increase in volume of the Precambrian basement which in turn was brought about by the emplacement of a stock. Fisher's (1969) study of the Citadel Rock area, however, casts doubt upon this interpretation of the origin of the smaller domes.

Citadel Rock is a mass of quartz monzonite porphyry intruded near the base of the Deadwood formation, with part of the body crosscutting the stratigraphic section up to the lower Minnelusa formation. The floor of the intrusive is nowhere exposed so that direct evidence of the laccolithic or stock character of the igneous body is not available. However, field studies show that the attitude of the beds in the sedimentary section changes from steeply dipping off the flanks of the intrusive to relatively flat in a very short distance away from Citadel Rock. Further, a structure contour map of the area shows no recognizable bulging of the Precambrian surface (Fisher, oral comm., 1968) showing that the volume of igneous rock intruded into the basement is negligible. Other considerations, such as the geometry of the igneous mass, probable temperatures, volatile content, and viscosity of the magma at the time of intrusion, and comparison with other areas (Hunt, 1953; Mudge, 1968) led to the conclusion that the intrusive is probably floored, and that the feeder was either a dike or pipe. The former alternative seems more acceptable in view of the mapped geometry of the intrusive bodies at the Tinton District five miles to the southwest (Smith and Page, 1941).

Within the area in which this study was concentrated, that is, on the western flank of the Lead-Deadwood dome, the dominant form of the intrusive bodies is the sill. They intruded primarily on the same preferred planes of intrusion in the Paleozoic section as are recognized in other parts of the northern Black Hills. These are: (1) just below or above the basal conglomerate or basal quartzite of the Deadwood formation; (2) in the shaly middle member of the Deadwood; (3) just below the top of the Deadwood; (4) in the Ice Box member of the Winnipeg formation; (5) just below or above the Englewood formation and; (6) at the top of the Pahasapa formation. In addition, any given sill can be expected to change its position in the section by crossing to a higher horizon. This is particularly true in the lower and middle members of the Deadwood formation where relatively thin layers of hard and soft material are interbedded. The total thickness of the sills, and their distribution relative to the Lead-Deadwood dome can be estimated from the structure contour maps (Plate 7).

Individual sills range in thickness from a few inches to several hundred feet and partings of sedimentary rocks up to several tens of feet thick, are often found within the sills. In some cases these are badly distorted and altered, but in others, neither of these effects is noticeable.

Many of the sills end abruptly against the sedimentary rocks at vertical contacts. In these cases, the stresses caused by the flexure of the beds over the leading edge of the advancing magma were relieved by movement on vertical or near vertical fracture surfaces. The data available is insufficient to permit determination of whether the fractures were newly created or whether the motion occurred on pre-existing joint planes. There is some indication that both types of surfaces were involved. Plate 8 shows measurements of joints taken at several localities around the dome superimposed on a tectonic map of the area. Some correspondence between the strike of the offsets and the strike of the joint sets is apparent, but in other cases the analogy fails.

The structures which result from the movements discussed above are small bysmaliths, known locally as "porphyry offsets". The lack of good outcrops, coupled with the presence of these structures lead to uncertainties in mapping as to whether a particular offset was due to faulting which cut the entire section or to lifting of part of the section due to the emplacement of a sill at depth. Where no certain evidence of faulting is available, these features were recorded as offsets (Plate 8).

One igneous body which provides examples of most of the structural features associated with the sills is the large igneous mass which includes War Eagle Hill (NE 1/4 sec. 34, T. 5 N., R. 2 E.), the area north of Crown Hill (W 1/2 sec. 34, T. 5 N., R. 2 E.) as far as Squaw Creek and then west to the porphyry-Pahasapa formation contact west of Redpath Creek (Plate 6, cross-section C-C'). This intrusive mass separates the Deadwood formation along three planes leaving the Deadwood only slightly altered at a few localities. Dips within the Deadwood are generally low and nearly continuous between ridges. The porphyry-Pahasapa contact west of Redpath Creek is vertical, and the cross-section shows that the entire section above the Ice Box member of the Winnipeg formation has been raised at least 250 feet and removed by erosion. The change from one horizon to another within the Deadwood is clearly shown in the divide west of Labrador Gulch.

Crosscutting igneous bodies are also common in the area, both as dikes, which tend to follow the joint directions, and as irregular masses. The latter are more common in the Pahasapa formation than in other units.

3. THE ORES

3.1 Ores of the Deadwood Formation

3.11 Basal Conglomerate (Cement Ore)

The basal conglomerate of the Deadwood formation occurs as numerous lenticular beds irregularly distributed along a belt about two miles wide extending from the vicinity of Roubaix to Blacktail Gulch (Darton, 1909; Kulik, 1965). In the area north of Lead along Blacktail Gulch the conglomerate is thickest in a zone parallel to the outcrop of the Homestake formation, and it is in this area that gold has been produced from this horizon.

Lithologically the basal conglomerate of the Deadwood formation consists of pebbles and small, rounded boulders of detrital material derived from the underlying Precambrian rocks. The matrix is generally fine sand. In unmineralized areas, the cement is usually silica, carbonate or, in a few cases, hematite. Irving (1904) reports that in mineralized areas, weathered conglomerate is cemented by limonite and where unweathered it is cemented by pyrite. The physical appearance of the rock has caused it to be known locally as "cement rock" and, where it is mineralized, as "cement ore".

The cement ore mines have been closed since shortly after 1900, and the only publications by investigators who had the opportunity to study the deposits are those of Devereux (1882) and Irving (1904). Their work was reviewed and summarized in some detail by Connolly (1927). Noble (1950) reported his opinion of the origin of these deposits after the Homestake Mining Company reopened all the portals to the mines so that the deposits could be re-examined. A brief summary of the results of all these investigations is given below.

Irving and Devereux agree that much of the gold in the cement ores is detrital, weathered from the outcrop of the Homestake formation which, because of the pinch out of the conglomerate, is taken as having formed a local high on the sub-Cambrian surface. Irving (1904, p. 101) describes the gold as being ". . . a mechanical deposit of water-worn scales and "shot" gold, richer near the base of the conglomerates . . . " and occurring in "pay streaks" as if concentrated along channels by currents. The gold in these deposits is much coarser and lower in silver content than that of either the Homestake lode or the proven Tertiary ores which occur higher in the section. According to Irving (1904, p. 102) and Connolly (1927, p. 57) the low silver content is due to solution of the silver in the water of the Cambrian sea. Enrichment of the lower part of the conglomerate is attributed to settling of the gold particles under gravity and by solution and redeposition of gold by descending water at some unspecified time after mechanical deposition. Evidence for the latter point is provided by the occurrence of gold values in the top few feet of the Precambrian rocks underlying the conglomerate which are attributed to downward migration of dissolved gold from the conglomerate (Irving, 1904, p. 110).

It is concluded by the above authors that some gold was added to the conglomerate with the emplacement of the pyrite during the period of Tertiary igneous activity and that some solution and reprecipitation of detrital gold may have occurred in this period by the action of the mineralizing solutions.

Noble (1950) disagrees with the interpretation offered above. Referring to his investigation of the deposits he states (p. 246):

> "This study casts so much doubt on the placer origin that this line of evidence can have little weight. The mineable portions of the deposits are the oxidized portions of leaner pyritic replacements of the conglomerate, and the space distribution of the gold which originally suggested a placer origin is probably attributable to a small amount of solution and redeposition of gold during oxidation. These pyritic replacements are identical with the pyritic replacements of Cambrian dolomite in the Tertiary ores of the Bald Mountain district, a few miles to the west."

This summarizes the current state of knowledge regarding the origin and nature of the ores of the basal conglomerates in the Lead-Blacktail Gulch area. It seems unlikely that any new data bearing on this problem will be forthcoming in the immediate future.

Prospects for the development of new deposits of gold in the basal conglomerate seem remote at the present time. The limited thickness and areal extent of this horizon makes it improbable that it has not been extensively prospected in past years. According to Allsman (1940, p. 23) the area north of Blacktail Gulch, where the basal conglomerate dips north under younger rocks, appears to offer the best opportunity for locating new deposits. Mining operations were less extensive in this locality than in others around the area, and water problems were encountered in many mines which further limited exploitation.

3.12 Gold-Silver Replacement Deposits.

Gold-silver deposits occur in several zones in the Deadwood formation above the basal conglomerate. They are replacement deposits in dolomitic horizons localized by high-angle fractures which provided access for the ore forming solutions. Most of the deposits which have been discovered thus far are in one of two zones: the "lower contact" zone or the "upper contact" zone. The first use of these terms was by Crosby (1888) and referred specifically to the Ruby Basin District where numerous deposits were found above and below the Sugarloaf sill (see p. 53). The terms indicated whether the deposit was at the upper or lower contact of the sill. Later usage of the terms describes the position of the deposits in the upper or lower parts of the Deadwood formation as described below. Under this usage, all of the mines in contact with the sill are in the lower contact zone.

The lower contact zone rests directly on the basal quartzite, while the upper contact zone is about 15 feet below the *Scolithus* sandstone, roughly 350 feet stratigraphically above the lower contact zone. Both zones consists of interbedded layers of pure to sandy dolomite and impervious shales. The thickness of the lower contact zone ranges from 6 to 30 feet, while the upper contact zone is generally about 10 feet thick. The ratio of dolomitic to shaly beds in the two zones varies throughout the region, because the dolomites tend to occur as lenticular beds of variable thickness rather than as continuous sheets. This also leads to variations in the position of the ore within the zones. In some of the lower contact mines the ore rests directly on the basal quartzite, while in others the ore is separated from the quartzite by several feet of shale.

The host beds consist of interlocking masses of anhedral, or euhedral dolomite crystals with variable amounts of detrital quartz. Glauconite is a common constituent of the rock, although it is usually present in only small amounts. In general, anhedral dolomite is more common in the lower contact zone and the euhedral variety on the upper contact zone. However, both types occur in each zone and grade into each other.

Mineable ore bodies have been discovered in two other zones in the Deadwood formation. These are the basal quartzite and the "intermediate zone". The latter is a series of thin-bedded dolomites, dolomitic shales and flat-pebble conglomerates capped by a coarse-grained, glauconitic, massive quartzite known locally as the "Finlander". The zone ranges in thickness from 50 to 150 feet, and occurs just below the upper contact zone.

The ore bodies of the basal quartzite were generally of irregular shape, varying from 20 to 500 feet in length, 6 to 40 feet in width and from 2 to 30 feet in thickness. The deposits formed as the result of replacement of carbonate cement in the quartzite by silica, pyrite and argentiferous galena. The latter was most common near the top of the quartzite, occurring in pockets and filling pore spaces. At the top of the quartzite, a yellow clay was often found which was similar to the "carbonate ore" of the Galena District. Assays of this material often showed values of up to 30 ounces of gold and 500 ounces of silver per ton, as well as high values of lead (Miller, 1962, p. 29). All of the ores from the basal quartzite were rich in silver, and large quantities of the ore were mined in the lower Clinton mine of the Portland District, and from the Alpha Plutus and Tornado mines of the Ruby Basin District. Examination of workings suggest that much of the ore mined from the Stewart and Golden Reward was also from this zone.

The ore bodies of the lower contact, intermediate, and upper contact zones are similar in many respects. Most were long, relatively narrow shoots ranging in length from a few feet to almost 5000 feet, in width up to 300 feet, and in thickness up to about 20 feet. The shoots of the lower contact zone were generally longer than those of the other zones, while those of the intermediate zone were often much thicker than the average.

The ores can be divided into two obvious catagories: unweathered or "primary" ores and weathered or "secondary" ores. By far, the most conspicuous of the primary ores were the "blue ores", described by Miller (1962, pp. 34-35) as:

> "It is highly siliceous, dense and hard, blue to blue gray in color. Pyrite is abundant and the ore is highly refractory. Many drusy cavities are seen which are lined with minute, euhedral quartz crystals or are filled with selenite, fluorite and calcite. Fluorite is also present scattered throughout the ore in small irregular masses. The original texture of the sediments, such as bedding, fossil remnants and dolomite rhombohedrons, are pseudomorphously preserved in the ore. Upon careful examination, considerable unreplaced wall rock is seen as small islands in the silicified material. Replacement boundaries are very sharp."

In addition to the blue ores, the dolomites are often mineralized without the accompanying silicification, and thus must also be classed as primary. A well exposed example is the upper contact beds exposed in an open cut just north of Trojan in the NE 1/4 sec. 2, T. 4 N., R. 2 E. A measured section of these with assay results is shown in Figure 7. As noted, a rusty color, probably from decomposition of pyrite, is common to the beds, but thin-section studies show no indication of silicification.

Other primary ores were described by Miller (1962, pp. 35-36) and Irving (1904, pp. 143-144). However, these are of minor importance.

Quartz is the most common mineral in the blue ores. It occurs as replacements of dolomite crystals or carbonate cement, as overgrowths on detrital quartz grains and as fillings in fractures and vugs. Pyrite is the second most abundant mineral in the blue ores, occurring as euhedral crystals or irregular masses ranging down to sub-microscopic in size. It commonly was deposited around, or replaced primary grains of glauconite.

Arsenopyrite has been identified in many of the lower contact ores and was particularly abundant in the ore from the Two Johns mine. Arsenic has been detected by chemical tests in the ores of most of the mines in the region, even where no arsenic minerals have been observed.

Sylvanite has been identified in many of the primary ores. It was probably more abundant in the lower contact ores than in the upper contact (Connolly, 1927, p. 75). In a few mines, small bodies of exceptionally rich telluride ores have been mined. The largest of these was in the lower Clinton mine. The total amount of the ore is not known, but its value is reported to have been over $5,000 per ton in gold and silver.

In the early years of mining in the northern Black Hills, it was generally accepted that the major part of the gold and silver in the Deadwood formation occurred in the form of telluride minerals, predominately sylvanite (Smith, 1896, 1897; Irving, 1904; O'Harra, 1902; Zeigler, 1914). This view was based on the results of a series of chemical analyses done by Smith (1896, 1897) of samples of ore from a few mines in the Ruby Basin District, rather than by direct observation of tellurides in the ore. However, Connolly (1927) later showed that the major portion of the gold in the primary ores is held in fine grains of pyrite. The later experiences of the Bald Mountain Mining Company in treating the primary ore tends to substantiate Connolly's conclusions.

Fluorite is widespread in the ores as fine particles and occasionally filling vugs and fractures. Selenite occurs in the same manner. Barite, stibnite, sphalerite, hubnerite, meta-autunite, rhodochrosite and other minerals have also been identified in the ores, although they occur in minor quantities.

Paragenetic relations were discussed by Miller (1962, pp. 38-39) as follows:

> "The principal mineralizing processes which acted both independ- and simultaneously, were silicification and pyritization. The variations in types of the primary ores suggest more than one stage of mineralization. The first was probably pyritization of certain of the sediments at which time pyrite was introduced as the finely disseminated type. The second state of mineralization resulted in silica-pyrite replacement superimposed on the first stage. During the second period the existing pyrite was not appreciably attacked but was included in the introduced silica. Pyrite of the later stage was the coarse, automorphic variety containing lesser quantities of gold and silver. The reason for the greater affinity of the silver and galena for the basal quartzite host is unknown . . . it is possible that this represents still another stage of mineralization."

In addition, Hummel (1952, p. 61) presented evidence which indicates that the sylvanite and selenite were introduced during a period of mineralization following those mentioned above.

In most stratigraphic studies of the Deadwood formation, in areas other than those in which Tertiary mineralization was introduced, the carbonates are predominately limestones, with only rare occurrences of dolomite (see, for example Kulik, 1964). In the mineralized areas, however, the host beds are invariably described as dolomites (Irving, 1899, 1904; Connolly, 1927). In the Homestake-Anaconda cores unsilicified carbonates with abundant pyrite tend to be dolomitic, while in cores where pyrite is less abundant or absent, the carbonates are limestones. The implication is that the first episode of mineralization involved the introduction of pyrite and dolomitization of the limestones of the contact zones, followed by silicification and addition of more pyrite.

The secondary or "brown" ore is the weathering product of the primary ore. In the weathering process the hardness and compactness of the primary ore are reduced, and the ore is stained brown by weathering of the pyrite. The degree of change depends entirely on the pyrite content of the rock since the silica of the primary ore is unaffected by the weathering process. Ores of this type were observed in association with blue ores at the Big Bonanza mine and at the head of Stewart Gulch. It should be noted that many of the dolomitic ores mentioned above have previously been considered as secondary.

3.13 Lead-Silver Ores

The lead-silver ores of the Galena District were described in brief by Irving (1904, pp. 169-171). Connolly later investigated the ores in more detail, and the results of his work appeared in identical form in two publications (Connolly, 1927, pp. 98-109; Connolly and O'Harra, 1929, pp. 188-198). The discussion which follows is based largely on Connolly's work.

The lead-silver deposits in the district occur only in the Deadwood formation and primarily in two zones, one near the base of the unit and the other near the top. These correspond to the stratigraphic position of the mineralized zones of the Bald Mountain District and therefore the terms "upper contact zone" and "lower contact zone" are also applied in the Galena District. The host horizons for the mineralization in the Galena District are dolomitic sandstones for the lower contact zone and sandy dolomite for the upper contact zone, in contrast to the purer dolomites of the Bald Mountain District.

Mineralized fractures influence the position and orientation of ore bodies in the Galena District as they do in other mining districts in the northern Black Hills. However the strike of the fractures appears to be more variable in the Galena District than elsewhere. Ore shoots tend to be narrow and closely follow the fractures. According to Connolly (1927, pp. 99-100, 102-103), on the lower contact in the Silver Queen and Cora mines the fractures vary in strike from N. 30° E. to east-west, with most clustered around N. 50° E. On the upper contact east-west is the most common trend, although in the Florence and Branch Mint mines the dominant fracture system trends northeast. A second fracture set has been observed intersecting the main verticals in a few places on the upper contact zone. The ore bodies tend to be enlarged at these intersections.

Information regarding the ores of the lower contact zone is limited to the results of Connolly's work in the Silver Queen mine and his investigation of samples of ore from the Horseshoe-Comet mine. The ore bodies in the Silver Queen mine are lenticular in cross-section with dimensions varying from one inch to two feet in thickness and up to 18 feet in width. They are replacements in a layer of dolomitic quartzite which rests between other quartzite layers. The latter contain very little dolomite and they are heavily impregnated with pyrite.

The ore is deeply weathered to a soft, yellow material which is rich in silver and lead, and contains vanadium in amounts varying up to 5%. A series of 15 analyses of the ore given by Connolly (1927, p. 100) shows lead values ranging from 8.74% to 49.9% and silver from 3 to 455.5 ounces per ton. Vanadinite and scorodite are the only minerals which have been identified in the ore. The name "carbonate ore" which was used by local miners to refer to the weathered material is a misnomer because little lead carbonate occurs in it. Pyrite in all stages of oxidation is abundant in the ore, and occurs fresh in the quartzites above and below. Galena is reported to be rare in the weathered ore, but there is little doubt that it was the source of the lead and silver (Connolly, 1927, p. 101).

A polished section of the ore from the Horseshoe-Comet mine was described by Connolly (1927, p. 102) as follows:

> ". . . the ore minerals are pyrite, galena, tetrahedrite and a very little spalerite and chalcopyrite. Pyrite is the earliest formed mineral. In some polished sections it appears to have been crushed and brecciated, and the later ore minerals were then deposited around and among the crushed pyrite grains, partly replacing them."

Garske (1968) identified arsenopyrite, chalcopyrite, galena, pyrite, pyrrhotite, siderite, sphalerite and tetrahedrite in ore samples from the lower contact zone of the Double Rainbow mine.

The ores of the upper contact zone occur in a very sandy dolomite, overlain by a calcareous shale and resting on a quartzite which is usually impregnated with iron and manganese oxides. The thickness of the ore shoots is variable, averaging between 18 and 30 inches. The thickest shoot reported was in the Richmond Mine (Double Rainbow) where one stope was mined to a height of 14 feet and still had galena both in the floor and the back (Connolly, 1927, p. 102).

In thin section the country rock is seen to consist of rounded sand grains with silica overgrowths, in a dolomitic cement. Glauconite is also a common constituent of the rock. Adjacent to the verticals, much of the carbonate cement is replaced by silica or shows evidence of recrystallization. Rock alteration due to the mineralization is generally slight.

The suite of ore minerals from the upper contact zone consists of pyrite and lollingite, deposited contemporaneously and followed closely by galena and chalcopyrite, also deposited contemporaneously. The pyrite is widespread and less massive than in the lower contact zone. It occurs in euhedral crystals replacing dolomite and occasionally replacing quartz. Galena is found replacing the same minerals as pyrite, as well as in cavities and seams. Chalcopyrite is rare and occurs in small blebs contained in pyrite and galena. Lollingite occurs in small grains scattered throughout the ore.

All of the ores of the upper contact zone have been oxidized to some degree and in the Florence, Branch Mint and Red Cloud Mines oxidation is complete. The weathering product of the galena is a fairly hard, fine-grained, yellow-white material which is always high in lead and often high in silver. Connolly concludes that, "It is probably that this product is a mixture of lead oxides with some carbonate and sulphate, and probably silver chloride, cerargyrite" (Connolly, 1927, p. 108). Covellite is often present, probably derived from the weathering of chalcopyrite. The weathering product of lollingite was not identified. It should be noted also that vanadium, in contrast to its presence in abundance in the ores of the lower contact zone, is absent in the oxidized upper contact zone ore.

The greatest production of lead-silver ores came during the years 1881, 1882 and 1883 when about $750,000 worth of these metals were produced. Irving listed the producing mines in order of their importance through 1902 as:

Richmond-Sitting Bull, Florence, Hester A, Coletta, Merritt No. 2, Cora, Carpenter, Alexander, Romeo, El Refugio and Washington.

3.14 Tungsten Ores

Tungsten ores have been found in the northern Black Hills in the following localities:

1. In the Durango, Harrison and other mines in the NE 1/4 sec. 33 and the NW 1/4 sec. 32 of T. 5 N., R. 3 E. These are referred to in the literature as the Homestake tungsten deposits.
2. In the Etta mine in the SW 1/4 NE 1/4 sec. 4, T. 4 N., R. 3 E., high on the divide between Yellow and Whitewood Creeks.
3. In the Bismarck and Wasp #2 mines in the NE 1/4 sec. 9, T. 4 N., R. 3 E., on the divide between Yellow and Whitewood Creeks. Irving (1902) refers to this as the Yellow Creek area.
4. On the north slope of Deadwood Gulch between City and Spring Creeks near the center of sec. 22, T. 5 N., R. 3 E.
5. At the Denis Henault claims in the E 1/2 sec. 35, T. 5 N., R. 3 E.
6. At the S. R. Smith mine and adjacent properties on Two Bit Creek near the center of sec. 1, T. 4 N., R. 3 E.

Tungsten ores occur as wolframite with minor amounts of scheelite in association with siliceous gold ores replacing the dolomites of the lower contact zone at the Homestake deposits and the Etta and Wasp #2 mines. In the Wasp #2 and Bismarck mines and at the Deadwood Gulch locality, wolframite replaces carbonate cement in the basal quartzite, while at the Henault claims, wolframite is found in association with pyrite, sphalerite and gold in cracks and cavities in rhyolite porphyry dikes which cut the Precambrian schists (Runner, 1918, p. 78).

At the S. R. Smith mine tungsten occurs as hubnerite in irregular masses of bladed crystals lining cavities in what is probably dolomite of the lower contact zone. In addition, hubnerite occurs as well-formed crystals along the contacts of a rhyolite porphyry sill intruded into the Deadwood formation, and in thin seams cutting quartzite. Runner (1918, pp. 79, 81) was of the opinion that these were veins and not replacement deposits but later work by Connolly (1927, p. 97) has indicated that some replacement has occurred. Pyrite and clear quartz crystals are associated with the hubnerite.

The tungsten ores of the Homestake deposits range from dense, heavy masses of small crystals (less than 1/32 inches across) of wolframite to scattered grains of wolframite in a groundmass of silicified dolomite. Few of the crystals are well-formed. Commonly the tungsten ores capped or bounded the margins of (but never occurred below) masses of silicified gold ore. The contact between the ores was usually gradational.

The wolframite masses were generally irregular, tabular bodies up to two feet thick with extensive pinching and swelling. The width of the ore bodies varied up to about 50 feet. The ore tended to follow mineralized fractures although in general it was not distributed symetrically across the fracture as was commonly the case with the gold ores. One shoot in the Harrison mine was mined for over 500 feet with widths varying up to 30 feet.

Barite was common in the ores as tabular crystals and as drusy masses associated with quartz and secondary scheelite. Minor amounts of tin, copper and antimony were found with the Homestake ores, while malachite, and antimony, in large crystals of stibnite, were common in the leaner ores of the Wasp #2 mine.

3.2 Ores of the Pahasapa Formation

3.21 Gold-Silver Ores of the Pahasapa Formation

Gold and silver ores have been found in the Pahasapa formation in two areas in the northern Black Hills. By far the most important of these occurrences are the ores of the Ragged Top mining district. In addition, Irving (1904, p. 172) reported the existence of a small prospect in the Pahasapa formation near Galena, but its exact location is unknown and no information is available about it.

Most of the production from the Ragged Top District came from replacement deposits developed along verticals cutting the Pahasapa formation. The ore consisted largely of brecciated fragments of carbonate rock which were completely replaced by silica. Near the surface the ore was weathered into boulders of breccia which were stained red or brown by iron oxides, but at depth, it was light-buff colored which, according to Irving (1904, p. 173),

> " . . . is so nearly the color of the surrounding limestone and so perfectly preserves the structure that by the eye alone it can be distinguished from the unmineralized country rock only by superior hardness and slight yellow tinge. Nevertheless the lines of demarcation at either side of the ore body, if examined closely, are sharp and somewhat undulating."

Angular cavities occur throughout the ore and these are usually lined with quartz crystals or occasionally with calcite crystals. Chemical analyses show that the gold and silver occur in the mineral sylvanite but this mineral has never been observed in hand specimen, and Irving (1904, p. 174) reports observing only a single speck of a mineral resembling sylvanite under the microscope. Pyrite and other sulfides were absent from the ores. Two published assays (Irving, 1904, p. 175) show gold values of 17.34 and 15.25 ounces of gold per ton.

In addition to the ores associated with the verticals, ore occurred as irregular masses or blanket deposits, of brecciated and/or silicified carbonate rock at several localities in the Ragged Top District. Purple fluorite was associated with these ores and sulfides were absent. The high gold and low silver content of the ores (up to 100 ounces of gold per ton) suggests that the primary ore mineral was probably sylvanite.

3.22 Lead-Silver Ores of the Pahasapa Formation

Lead-silver ores have been produced from the Pahasapa formation only in the Carbonate mining district. Two apparently distinct types of ore were found.

The first type of ore partially filled a N 85° E vertical fissure along which most of the mines in the district were located. It consisted of a soft, ferruginous gouge, pinkish red in color, which is reported to have contained galena, lead carbonate, and cerargyrite. The adjacent country rock was extensively replaced to a depth of several feet with ferruginous jasper carrying lower values of gold, silver, lead, and manganese. The ore-bearing fissure was traced for an east-west distance of 2,700 feet. It was explored to a maximum depth of 460 feet, and is reported to have been from two to twenty-five feet in width.

A second type of ore body is reported to have consisted of irregular shoots apparently following old solution cavities within the limestone, and intimately associated with the porphyry dikes. The ore consisted of gold, silver, lead, and manganese. These ores were often very high in silver and were, in general, less siliceous than the jasperoid ores of the fissure zone. Other minor types of ore have been described, but are probably variations of the above two.

3.3 Gold and Silver Ores of the Tertiary Igneous Rocks

Gold ores have been mined from Tertiary igneous rocks in several areas in the northern Black Hills. The most important occurrences were located in the Galena Mining District. The gold mines of this district have never been thoroughly studied, although a paper on the area is currently in progress (Mukherjee, 1967, 1968, Ph.D. thesis; Colorado School of Mines). The mines are all located along the southern end of the quartz-monzonite mass of the Anchor Hill-Dome Mountain-Pillar Peak Laccolith described by Darton and Paige (1925, p. 21). Irving (in Darton and Paige, 1925, p. 29) reports that:

> "Much of the ore, some of it rich, occurs in thin sheets of auriferous limonite, filling small fractures or impregnates a decomposed portion of a large intrusive porphyry body. In general these deposits merge downward into unoxidized pyrite, but in a few places sphalerite and galena have been found."

Grout and Schwartz (1927) reported the presence of abundant alunite in the ore of the Rattlesnake Jack mine. Connolly, (1927, p. 112) showed that the gold in these mines is intimately associated with the pyrite, and also noted the presence of wire gold in some of the weathered porphyry.

3.4 Control on Ore Deposits

3.41 Introduction

As noted above, the areas where mining operations have been centered are all within the limits of the porphyry belt, and more specifically, along the flanks of the Lead-Deadwood dome and in a belt which extends east from the dome through the Two Bit District to Galena. The structure contour map (Plate 7) and the map of locations of mining districts (Fig. 4) clearly shows the relationship between the districts and the dome, but no relationship is apparent for the Two Bit and Galena Districts.

3.42 Stratigraphic Control

Stratigraphically, ore deposits tend to locate in particular zones in the Deadwood formation and this is well documented and apparently consistent between districts as discussed in the description of the ores and of the various districts. Some mining was apparently done in the Whitewood formation and possibly in the Roughlock as well although no studies of these deposits are reported, and no data is available on possible control within these units.

Within the Pahasapa formation mineralization appears to be related to dolomitization, but thus far no good correlation between position of the ore and the known stratigraphy of the formation has been found.

At Dacy Flat (Fig. 6), the Pahasapa is 430 feet thick, and most of the ore was produced within 60 feet of the surface.

At Carbonate Camp there seems to be less than 300 feet of Pahasapa formation present. Ore, associated with the great Iron Hill vertical, or with porphyry dikes cutting the Pahasapa, seems to have occurred in random positions throughout the entire 300-foot interval. Just to the west, at the Spanish R mine, all ore seems to have been taken from the lower 170 feet of the Pahasapa formation.

Southwest of Ragged Top, ore at the Metallic Streak property of the Spearfish Gold Mining Company was in horizontal beds about 440 feet above the base of the formation. On the Slavonian or Black Diamond property of the same company, the bedded ore appears to have been related to a sill-like intrusion of phonolite at a similar distance above the base of the Pahasapa (Plate 16). Half a mile farther south, at the Deadwood Standard, bedded deposits occur in a horizon about 490 feet above the base of the Pahasapa. The mineralized verticals at the Pottsdam property are about 570 feet above the base.

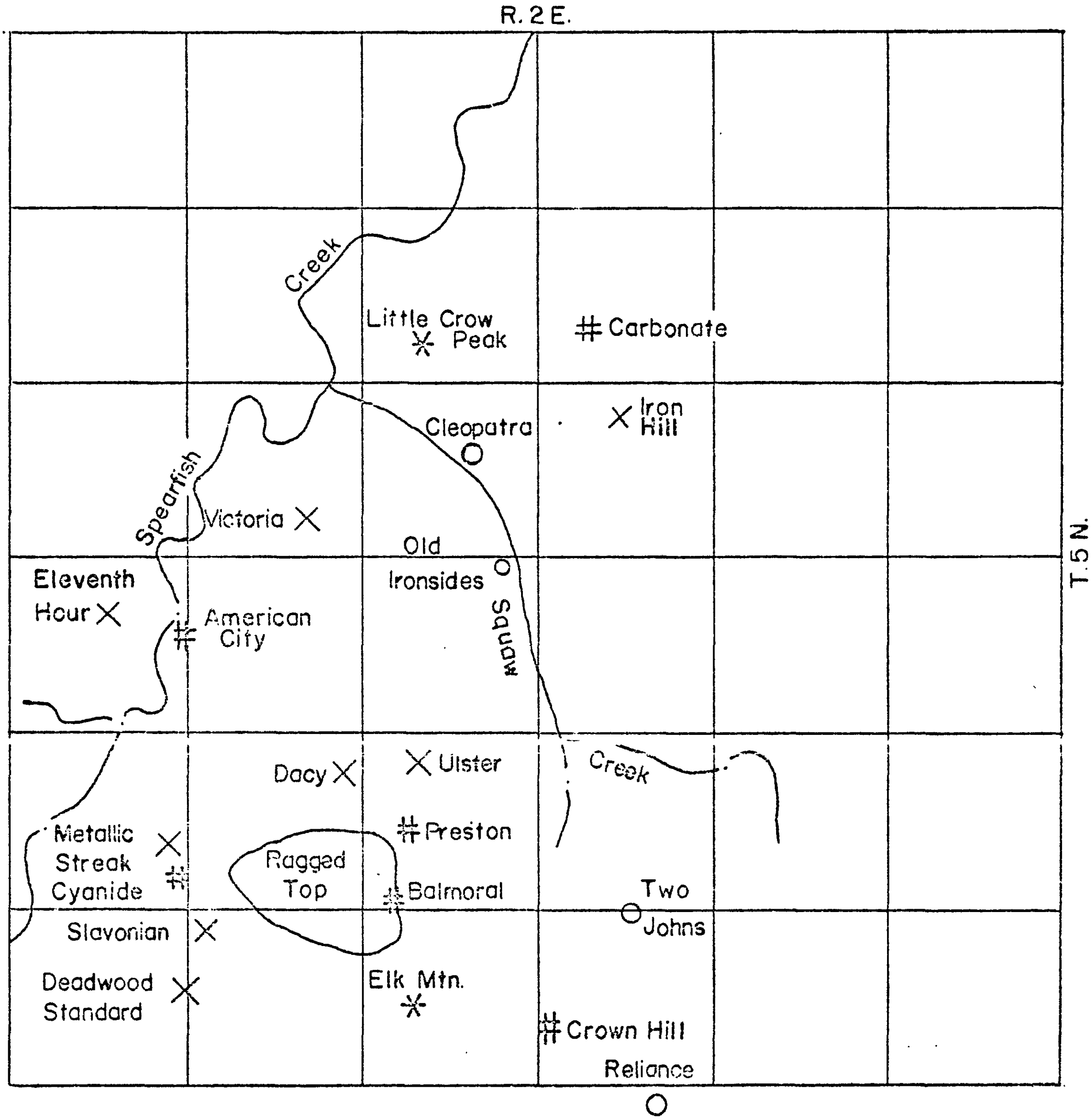


Figure 6. Location of Mineral Deposits in the Ragged Top, Squaw Creek and Carbonate Areas. Deposits in the Deadwood Formation Marked by Circles, and those in the Pahasapa Formation Marked by X's.

At Victoria, bedded deposits associated with a silicified layer within the Pahasapa, seem to occupy a position 570 feet above its base.

The workings at the 11th Hour appear to lie 470 to 500 feet above the base of the Pahasapa formation.

This apparently random distribution strongly indicates that other factors besides stratigraphy control the localization of the ores within the Pahasapa. Since all the above deposits were discovered on the outcrop, it suggests that many comparable deposits may await discovery by geophysics or by drilling. Except at Dacy and Carbonate, no attempt has been made to follow down beneath the known near-surface deposits.

3.43 Structural Control

Structural control on the deposits is indicated by the development of ore shoots along the intersection of fractures with the potential host horizons. It has been suggested (Miller, 1962) that the controlling fractures are part of a set of radial joints which developed in response to the uplift of the Lead-Deadwood Dome. However, data collected on fractures around the dome fails to support this.

Of particular interest in the present context are the three joint strike diagrams from points H-11, WS-3 and D-1, all of which are in the basal quartzite of the Deadwood formation (Plate 8). The strike of the northeast and northwest sets is nearly identical on each of the diagrams. Point H-11 shows a strong N. 5° E. set of joints, which, can be demonstrated in the field to be younger than the northeast and northwest sets. The position of this point on the Bald Mountain horst, close to the two north-south faults, strongly suggests that the N. 5° E. set was formed at the same time as the faults. The orientation of the longer ore shoots in the Ruby Basin District is dominantly in the north-south direction, following the joints and faults, with shorter connecting shoots in the directions of the remaining two sets (Plate 9).

The diagram for point WS-3, located on the axis of the Dome, shows no joints other than the same northeast and northwest sets found at the remaining points. Measurements at D-1 however, include a scatter of joints between N. 15° E. and N. 15° W. The structure contour map of the Cambrian-Precambrian contact (Plate 7) shows a sharp fold trending about N. 30° W. Control in the area is limited, however, and a fault could easily be present in place of the fold shown. It seems possible that the anomolous joints at this point are related to this structure, but no mapping is available to show this.

Significantly, the joints at point H-1 taken in the upper contact zone and Scolithus member of the Deadwood formation at Trojan show the same northeast and northwest sets as the three point just discussed, and the strikes are almost identical. However, the north-south set is missing and this is reflected in the orientation of ore shoots in the upper contact and intermediate zones of the Portland District (Plates 10 and 11). On the lower contact zone a few north-south shoots are found, and several north-south dikes are also reported. These probably reflect the presence of north-south faults of small displacement but the effect of these has not extended up into the section. The dominant direction of the shoots in the lower contact zone is however, the same as the strike directions of the joints.

The "radial" nature of the pattern of ore shoots in the Bald Mountain District is therefore seen to be due to the presence of the strong north-south joint set accompanying the faulting in the Ruby Basin District. In the absence of this set, the shoots in that district would have been expected to follow the northeast and northwest sets and in that event no difference in orientation between the shoots of the Ruby Basin and Portland Districts would have developed.

Further examination of Plate 8 indicates no regular sets of joints which could be interpreted as radial or concentric around the dome. In fact, the northeast and northwest sets appear to be rather consistent over the area. The only joint set in the area which can be related to the period of igneous activity with any degree of certainty is the north-south set at point H-11 in Nevada Gulch, the youngest set in the outcrop. This relationship follows from the understanding of the origin of the "paired faults" defined by Noble (1952). As will be pointed out later, the faulting is younger than the monzonite porphyry sill in the lower part of the Deadwood formation just east of the Tornado fault, while the fault is older than the phonolite dike intruded along it. Hence, the joints are bracketed in time by intrusives.

The persistence of the northwest and northeast sets to areas away from the monzonite porphyries precludes the possibility that they are related to those intrusives. Further evidence comes from studies by Noble (1952) and Getz (1966) at Elkhorn Peak, about eight miles northeast of the Lead-Deadwood Dome, and by Fisher (1969) at Citadel Rock about 3 miles northwest of the northern limit of the dome. Both structures are domes related to intrusive rocks. Joints in each of the areas are characteristically nearly normal to bedding, even where the beds dip steeply off the uplifts and, when rotated back to the horizontal, the joints show maxima to the northeast and northwest which the above authors concluded to be older than the intrusive which caused the uplift. No indication of radial or concentric joints formed by the emplacement of the intrusive were found.

On the basis of the above information, it can be surmised that well-developed northeast and northwest joint sets were present in the area prior to the initiation of the igneous activity. Further, no new joints were formed during the emplacement of the intrusives, with the exception of those associated with the uplift of the Bald Mountain Horst. Stresses developed in the sedimentary section around the intrusives were relieved by movement on pre-existing joint planes.

In addition to the shoots, several deposits in the Portland District have been mined from the contact zones between the porphyry and the Deadwood formation. In these cases it appears as if the access for the ore-bearing fluids was provided by shattering of the Deadwood formation as the porphyry was emplaced. Some deposits within the Pahasapa formation are also found at the contact of the porphyry and sedimentary rocks.

4. MINING DISTRICTS

4.1 Bald Mountain Mining District

4.11 Introduction

The Bald Mountain District is centered about 3 miles west-southwest of the city of Lead on the west flank of the Lead-Deadwood Dome. It is approximately 4 1/2 miles long and one mile wide, with the long axis parallel to the axis of the dome (Fig. 4). As defined here, the district includes all the mines of the Portland and Ruby Basin Districts of the older literature. The Ruby Basin District covers the southeastern one-third of the Bald Mountain District and includes the large group of mines in the lower reaches of Nevada Gulch and south across Fantail and Stewart Gulches to the North Fork of Whitetail Creek. The Portland District includes the mines clustered around the town of Trojan and those at the heads of Nevada Gulch, Squaw Creek and Annie Creek.

Locations of all known shafts and drill holes in the Bald Mountain Mining District are shown on Plate II. The logs are given in Appendices III, IV, V, VI.

4.12 History

The first claim in the Bald Mountain District was located near the site of the present town of Trojan in 1877 and rapid development of the remainder of the area followed. With the passage of time, the claims were slowly consolidated until two companies dominated the District. These are the Bald Mountain Mining Company and the Golden Reward Consolidated Mining and Milling Company.

The Bald Mountain Mining Company was formed in 1928 by reorganization of the Trojan Mining Company and several other, smaller properties. The Trojan had itself been organized in 1911 by a merger of the Clinton Mining and Mineral Company and the Portland Mining Company, which in turn had been consolidated from earlier operations. Other properties included in the Bald Mountain Mining Company's holdings are the American Eagle, Dakota, Mogul, Two Johns, Ofer, Imperial and American Mining Companies as well as several small operations. Total holdings of the Company consists of 2,250 acres of mining claims.

The Golden Reward Consolidated Mining and Milling Company was organized in 1887 by the consolidation of the Golden Reward, South Golden Reward, Double Standard, Little Bonanza, Stewart and Harmony Mines. In 1899, the Company acquired the Deadwood and Delaware Company's smelter and properties. Additional properties were added in the following years, the largest of which were the holdings of the Lundberg, Dorr and Wilson Company and, by the time operations ceased in 1918, the Golden Reward properties consisted of more than 440 mining claims encompassing most of the Ruby Basin District. The Company was purchased by the Anaconda Copper Company in 1940.

Production of ore from the Bald Mountain District has been almost entirely from the Deadwood formation. In a few mines mineralized verticals cross from the sedimentary rocks into the intrusives, and these latter have carried mineable values of gold and silver. In addition, some mining was done from the remnant of the Whitewood formation on the ridge in the center of the W 1/2 NW 1/4 sec. 34, T. 5 N., R. 2 E., but the extent of the remnant was small and the quantity of ore removed must also have been limited. In the Tornado Mine, in the Ruby Basin District, a silicified zone in the Precambrian schists was also mined. This zone occurred in a part of the mine where the basal conglomerate and quartzite of the Deadwood formation were absent, so that the dolomites and shales of the lower contact zone rest directly on the schist. In general however, production from sources other than the Deadwood formation has been minor.

4.13 Geology of the Bald Mountain District

The Bald Mountain District is cut by two major north-south faults which divide the area into three distinct segments. The faults are the Tornado fault which lies parallel to and close to the east edge of section 1, T. 4 N., R. 2 E. and the unnamed fault about one-half mile west, which trends through the saddle between Green and Bald Mountains. Both are dip-slip faults with dip separation on the order of 300 feet. However, the Tornado fault is up on its west side, while the second fault is up on the east side, thus making Bald Mountain a horst. The two faults also constitute an example of the "paired faults" described by Noble (1952) which he attributes to uplift over an intrusive at depth. The Tornado fault is accompanied by several faults of smaller displacement, all of which are found in a zone about 500 feet wide and just east of the fault. These smaller faults are almost all upthrown on the west, though the movement is opposite on a few. The combined displacement across the fault zone is at least 450'. No such complex is known to accompany the second fault, although the shoots in the Ben Hur mine just west trend parallel to the fault. Most of the faults in the zone adjacent to the Tornado fault were discovered in the workings of the many mines which were developed in the zone, and are virtually impossible to find on the surface. Mining operations near the second fault are far less extensive.

With the exception of a few mines to the west of the Tornado fault at the head of Fantail Gulch, the entire Ruby Basin District lies east of the fault. A few small prospects were developed on the horst block, and the Portland District lies west of the west fault of the pair.

The structure contour map of the Cambrian-Precambrian contact (Plate 7) shows that the dips at the contact are uniformly gentle and to the southwest throughout the District. The surface rocks over most of the district are either the Deadwood formation or one of the Tertiary intrusive bodies. The Ice Box member of the Winnipeg formation is present beneath the sills which cap Green and Foley Mountains, and along the western and northwestern sides of the District, the section up into the Pahasapa formation is present. In general, the age of the sedimentary rocks exposed on the surface becomes younger in proceeding from south to north across the area. The change is due more to topographic than structural causes.

Within the Ruby Basin District the Deadwood formation is the only sedimentary unit present, and it is not present in its entirety. The basal conglomerate is thin or absent on most of the surface outcrops, but is found in several drill holes. Its maximum thickness is 34 feet in drill hole HA-11. On the outcrop, the basal quartzite ranges in thickness from less than two feet at the Buxton mine to about 80 feet in Stewart Gulch. In the drill holes, the maximum thickness found was 115 feet in HA-4, while the minimum was 12 feet in GR-1. Its thickness around the district is thus very variable. The combined thickness of the conglomerate and quartzite probably reflect irregularities on the surface upon which they were deposited, rather than irregularities in source of sediments, etc.

The lower contact zone is exposed in the cuts of the Ross-Hannibal Golden Reward, Stewart, and Buxton Mines, where it is relatively unaltered, and in the Big Bonanza and Harmony Mines where it is completely silicified. The entire section is not exposed at any single locality. The remainder of the outcrops of the Deadwood formation in the District are primarily the shales, limestones and flat-pebble conglomerates of the middle member, though a small outcrop of the "Finlander", the thick glauconitic quartzite at the base of the upper member, outcrops on the ridge south of Fantail Gulch just east of the trace of the Tornado fault. It is probable that a few feet of the shales and dolomites of the upper contact zone are present up the slope to the west of the outcrop, but this could not be verified.

Three large porphyry bodies are present in the district: (1) the thick phonolite sill which forms the mass of Sugarloaf Mountain and outcrops along Whitetail Creek and the North Fork of Whitetail Creek, here named the Sugarloaf sill; (2) the sill in the lower part of the Deadwood formation in Nevada Gulch and the head of Fantail Gulch and; (3) the large mass of grorudite on the side of Terry Peak south of the Mogul and Troy shafts.

The phonolite sill is found in varying thicknesses and varying distances above the Precambrian-Cambrian contact in all of the Homestake-Anaconda drill holes and in the Fannie shaft. It is present in unknown thicknesses in the Sundance and Mogul shafts, but is absent in drill hole GR-1. The thickest section of the sill is 255 feet in drill hole HA-4, with sections of 250 feet in both the Astoria shaft and in drill hole HA-19. In the latter hole, a second phonolite sill 91 feet thick, overlying the thicker sill and separated from it by about 35 feet of the Deadwood formation, was also penetrated. Holes HA-10 and HA-11 cut 226 and 227 feet of the sill respectively, while in the Fannie shaft, one half mile to the north, the sill is 165 feet thick.

The sill is separated from the Precambrian schists by 110 feet of Deadwood in hole HA-1, 130 feet in HA-4, 80 feet in HA-10 and 40 feet in HA-19.

The Fannie shaft was bottomed in ore 22 feet below the sill, probably at the top of the basal quartzite. On the hill in the center of the SE 1/4 sec. 6, T. 4 N., R. 3 E., about 1/4 mile northeast of the Fannie, the sill rests directly on the Precambrian schists. Further north along the contact, the sill thins and curves down into the Precambrian schists as a dike.

It is thus apparent that the sill both thins and drops in the section from south to north across the Ruby Basin District. The effect on these changes on the ore deposits near the sill is most obvious from the position of the deposits aligned just west of Whitetail Creek (Plate 9). From south to north, the Astoria, Union, Ruby Bell and Billy workings are under the sill, while just north of the Billy, the Isadore lies on the sill. In Stewart Gulch, north of the Isadore, the Gladstone lies just under the sill, while a probable continuation of the same shoot was mined in the Stewart mine on top of the sill. Now workings are present below the sill north of the Gladstone.

About 1500 feet west of the mouth of the North Fork of Whitetail Creek, about 1200 feet west of the line of workings described above, the lower contact zone and a few feet of the basal quartzite of the Deadwood formation, both of which are mineralized, rest on the sill. The workings of the Ross-Hannibal mine are developed in these beds. The map of the lower contact workings (Plate 9) clearly shows that this deposit is closely related to the Union #3 shoot which is under the sill. On the north side of the creek, the mineralized quartzite is present at least as far north as Stewart Gulch. Further west along the North Fork of Whitetail Creek, about 1/4 mile from the Ross-Hannibal, the sill is overlain by Deadwood beds from the same horizon which crops out just above the sill east of the Astoria Mine. The lower contact zone and quartzite beds which overlie the sill in the vicinity of the Ross-

Hannibal there and occupy a narrow zone in which the sill has "sagged" about 30 feet down into the Deadwood. Irving (1904) noted that the long east-west crosscut in the Union mine between the #2 and #3 shoot penetrated about 500 feet of phonolite. The drift probably passed into and out of the base of the sill, cutting the entire width of the sag. The margin of the sag probably passes through the Fannie mine, because Irving noted that the ore zones in the mine were located both above and below the sill, about 150 feet apart vertically.

West of the line from hole HA-19 to the Fannie shaft, the only reliable information available is that the sill is present in the Sundance shaft, and that the Mogul shaft passes through a phonolite sill, the bottom of which is about 60 feet above the Cambrian-Precambrian contact (Irving, 1904, Plate 20). Unfortunately, Irving's description of the shaft states only that it ". . . penetrated two sills of porphyry separated by about 15 feet of Cambrian shales, the upper being relatively the thicker." The sill disappears between the Mogul shaft and drill hole GR-1, 1000 feet to the north, but no data are available to determine whether the sill pinches out gradually or abruptly. The sill is absent on the up side of the Tornado fault which passes about 1500 feet west of the Mogul, but nothing is known about its extent in that direction either.

The sill in Nevada Gulch and at the head of Fantail Gulch has been identified as monzonite porphyry by Darton and Paige (1925). North of Nevada Gulch, on the east slope of Bald Mountain, a large body of grorudite has been emplaced, probably through the monzonite porphyry, but relationships in the area could not be determined. On the south side of the Gulch, however, the sill can be seen to be intruded just above the basal quartzite of the

Deadwood formation, but it climbs rapidly in the section to the south, and in drill hole GR-1, it is 84 feet thick and separated from the Cambrian-Precambrian contact by 192 feet of the Deadwood formation. Projections of the sill to the south suggest that it may be the upper sill in the Mogul shaft. It is cut by the Tornado fault and can be mapped to the west of the horst block as far as the western fault (see cross-section A-A', Plate 6).

With the exception of the southwest boundary of the intrusive body, the contact relationships of the large grorudite mass in the side of Terry Peak are generally obscure. From the Troy shaft, the contact of the grorudite and Deadwood can be traced to the southwest for about 1000 feet as it climbs in the section. The top of the intrusive is then exposed and can be traced to the south at about the same position in the Deadwood formation, for about 2000 feet. An extension of the same mass forms the hill at the west edge of the SW 1/4 sec. 7.

A sample from this particular intrusive was described by Irving (1899) as the Sunset Mine type of grorudite. Megascopically, the rock is easily recognized, because of the presence of elongate, dark quartz phenocrysts, the ends of which are rounded by partial reabsorption. Irving cites a log of the Sunset shaft provided by F. C. Smith, which gives 160 feet of grorudite in the shaft. The sample described as the Sunset mine grorudite supposedly came from that sill. However, there is a major discrepancy in the depth of the shaft from the log (229 feet) and the value derived from unpublished sources (315 feet). The latter figure is in close agreement with the depth predicted by the structure contour map of the Cambrian-Precambrian contact, assuming that the shaft was sunk to the top of the basal quartzite. In addition, surface mapping suggests that the 160 feet of igneous rock in the shaft is an extension of the upper phonolite sill which was found in drill hole HA-19. The sample which Irving described probably did not come from the shaft, but rather from float from the slope south of the shaft. This slope is mantled to a depth of at least six feet by colluvium consisting of boulders of grorudite from the outcrop on the hill south of the shaft and from the fill along the old railroad grade on the slope.

Only a small part of the uplifted block between the two major faults has been mapped. On the north side of Nevada Gulch only a few feet of the lower part of the Deadwood formation is present, the bulk of Bald Mountain being comprised of a large porphyry mass. Several dikes pass across the Cambrian-Precambrian boundary on both sides of the Gulch and these are often marked by the presence of small faults which apparently controlled the position of the dikes. South of the Gulch, the monzonite porphyry sill is apparently thinning to the west.

Mining activities on the horst block were concentrated on the divide between Nevada and Fantail Gulches, just west of the Tornado fault, where the Boscobel, Double Standard, and Little Tornado mines were located. These were lower contact workings just below the monzonite porphyry sill. On the south side of Fantail Gulch, west of the fault the Harmony and Hardscrabble mines were developed in the lower contact zone, and west of these, the Welcome shaft was sunk in the floor of Fantail Gulch to the lower contact zone. Relationships in this area are obscured by the combination of faulting, intrusion of numerous small dikes, and the large grorudite dike which extends north-south just west of the Hardscrabble workings.

High on the slope on the west side of the north-south reach of upper Fantail Gulch are the workings of the Upper Welcome mine. Irving suggests that the deposits are in the upper contact zone, but examination of the area during the present investigation indicates that they are in the middle member and related to the porphyry bodies which are found in and near the workings. Just west of the Upper Welcome is a dike which roughly parallels the extension of the western fault of the Bald Mountain horst. Large open cuts were developed on both sides of the dike marking sites of earlier mining, and geochemical sampling during the present project indicates that the mineralized zone extends for some distance beyond the limits of the present workings (see Appendix VII).

West of the Bald Mountain horst the entire Deadwood section is present under Green Mountain, Foley Mountain and Crown Hill. Total thickness of the Deadwood formation is probably just over 400 feet, but the section is thickened to more than double that value by the intrusion of a number of sills. This is clearly shown in the logs of the shafts and drill holes (Plate 12, Appendices III, IV, V, VI) and is summarized in Table 1. The sills change position in the section as indicated on cross-section D-D', Plate 6.

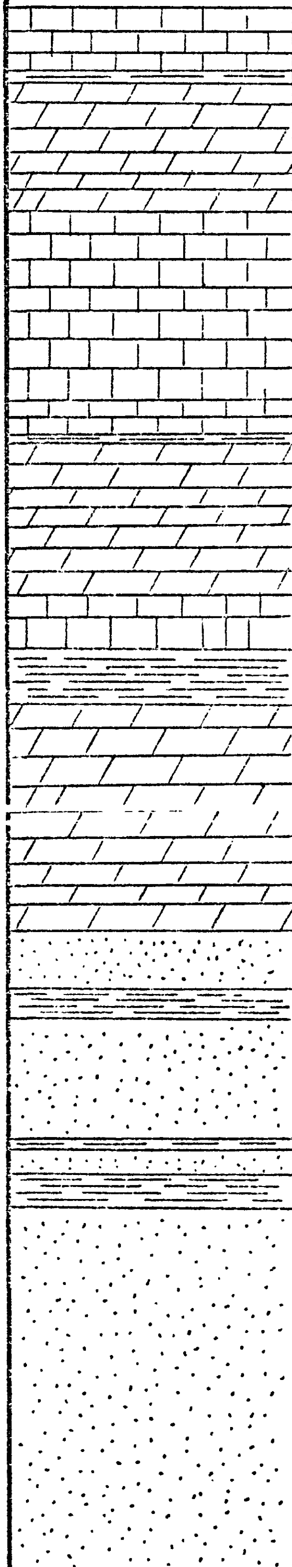
Table 1.—Thickness of Deadwood formation and sill in shafts and drill holes of the Portland District.

Hole	Depth to Precambrian	Deadwood thickness	Porphyry thickness
Portland #1	602	333	269
Portland #2	437	204	233
Reliance	753	225	528
Dakota shaft	860	400	460
Foley shaft (30 feet of talus at top)	793	172	591

An offset trends about west-northwest across the head of Nevada Gulch at the west edge of sec. 2, T. 4 N., R. 2 E. The Deadwood formation above the offset has not been explored to any extent, due to the thick cover of talus from porphyries higher up the slope, but a timbered shaft 10 to 12 feet deep which had penetrated the talus and reached the shales and carbonates of the Deadwood was found during the present investigation, at an elevation of approximately 6660 feet on the northwest slope of Terry Peak above the offset. It was not possible to ascertain whether this was the upper contact zone or the middle member of the Deadwood.

The majority of the mining operations in the area have been developed in the upper contact zone (a section in which is shown in Fig. 7) in the intermediate zone below Green and Foley Mountains. In addition, the lower contact zone has been mined in these areas, below the head of Nevada Gulch where access to the zone is through the Snowstorm and Baltimore shafts, and at the Two Johns mine on Squaw Creek. Additional upper contact workings were opened at the Annie Creek mine at the head of Annie Creek. The area was not mapped during the present investigation.

North of the saddle between Green and Foley Mountains, the Deadwood formation is in contact with a porphyry body which is the extension of the upper sill shown in cross-section E-A', Plate 6. When traced westward, however, the nature of this contact becomes somewhat problematical. East of the power line in the E 1/2 sec. 34 T. 5 N., R. 2 E., the contact is probably vertical and maintains this attitude to the west. The change from a vertical to a horizontal (sill) contact probably occurs at the fault in the SW 1/4 sec. 34.



	Inches Thick	Lithologic Description	Gold (ppm)
	10	Limestone, med. gr., rusty	trace
	2	Shale, calcareous, rusty on fracture faces	
	20	Dolomite, med. gr., glauconitic, glauconite increase to 30% of rock at top.	trace zero
	36	Limestone, dolomitic, fine gr., thin-bedded, becomes massive and glauconitic near top, shale partings in lower 12 inches.	trace
	1	Shale, green, hackly	
	24	Dolomite, med. gr., rusty, 2-3 inch beds in lower part, becomes more massive toward top	11.5 .36
	9	Limestone, med. gr., rusty, shale partings	trace
	9	Shale, siliceous, hackly, green	
	36	Dolomite, fine gr., glauconitic, rusty, becomes sandy toward top	1.1 41.0
	10	Sandstone, fine gr., rusty, shale partings	.42
	4	Shale, hackly, green	0.0
	20	Sandstone, fine gr., massive at base, becomes thin-bedded toward top, rusty at top	.23 2.3 2.3
	1	Shale, fissile, green	4.5
	4	Sandstone, fine gr., buff-brown	16.5
	5	Shale, brown	2.5
	51	Sandstone, fine gr., brown, rusty in spots	5.7 12.5 .23

Figure 7. Measured Section of Part of the Upper Contact Zone in Open Cut North of Trojan

West of the head of Labrador Gulch, remnants of the Roughlock member of the Winnipeg formation and the Whitewood formation are present resting on porphyry. This suggests that the plane of intrusion in the area is at the top of the Deadwood or in the Ice Box member of the Winnipeg formation. Outcrops at the east-west offset which crosses Labrador Gulch and the small, unnamed gulch to the west in secs. 22 and 27 clearly indicates this relationship. However, no information is available with regard to the eastward extent of the buried top of the Deadwood.

4.14 Mines of the Portland Mining District

Alameda (Bald Mountain Mining Company)

The Alameda mine was located on the south side of Green Mountain in the NW 1/4 NW 1/4 sec. 1, T. 4 N., R. 2 E. It was worked by means of an open cut.

The ore was mined from a two foot thick bed of dolomite overlain by 14 feet of interbedded glauconitic shale and dolomite of the upper contact zone. Most of the ore was developed by replacement of the thick dolomite layer but minor amounts were also taken from the dolomites interbedded with the shales. Fractures were oriented at about N. 35° E. The ore averaged about 1/2 ounce of gold per ton.

References: Allsman, 1940, p. 28; Atlas*, p. 47; Irving, 1904, pp. 203-204.

American Eagle (Bald Mountain Mining Company)

The American Eagle mine was located in the NE 1/4 sec. 35, T. 5 N., R. 2 E., just south of the Bald Mountain Mining Company mill. The present mill is located on the same site as the mill of the American Eagle Mining Company.

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* Atlas refers to U.S.B.M.I.C. 7688, see bibliography.

Information regarding the mine is sketchy. The workings were developed at the lower contact zone and the ore is known to have averaged about 1/2 ounce of gold and 5 ounces of silver per ton. The ore bodies were small and irregular. About 800 feet southwest of the portal, an offset has raised the Deadwood formation and most of the lower contact zone has been removed by erosion.

References: Allsman, 1940, p. 28; Atlas, p. 46; Miller, 1962, p. 69, Pl. 1, 5.

Apex (Bald Mountain Mining Company)

The Apex mine was located near the town of Trojan in the NE 1/4 sec. 2, T. 4 N., R. 2 E. Production was from the upper contact zone, but no details are available. The mine workings are now included in the upper Portland mine.

References: Allsman, 1940, p. 28; Atlas, p. 46; State Mine Inspector, 1891, p. 59.

Baltimore (Bald Mountain Mining Company)

The Baltimore mine was located in the W 1/2 sec. 1, T. 4 N., R. 2 E. in the bottom of Nevada Gulch south of the saddle between Bald and Green Mountains. The mine was opened by a 330 foot shaft to the lower contact zone. Three narrow shoots trending N. 20° E., N. 25° W. and N. 70° W. were worked. The log of the shaft is given in Appendix V and VI.

References: Atlas, pp. 46-47; Irving, 1904, p. 200.

Ben Hur (Bald Mountain Mining Company)

The Ben Hur mine was located in the SE 1/4 NW 1/4 sec. 1, T. 4 N., R. 2 E., just east of the mouth of the draw which heads at the saddle between Bald and Green Mountains. The mine was opened by an east-west inclined tunnel in the Precambrian schists. The tunnel was driven through a dike which followed the north-south fault on the west side of the Bald Mountain horst. The lower contact zone was intersected by the tunnel west of the fault.

The ore shoots were generally oriented parallel to the trend of the fault. The host dolomite bed was about 6 feet thick and was capped by a sill of unspecified composition. Fractures were observed to pass into the sill and these were lined with quartz crystals projecting into the open space of the fracture. The ore was oxidized and reportedly carried about 3 ounces of gold per ton.

References: Atlas, p. 47; Irving, 1904, p. 200; State Mine Inspector, 1898, 1899.

Burlington and Golden Sands (Bald Mountain Mining Company)

The Burlington and Golden Sands mine was located in the NE corner of sec. 2, T. 4 N., R. 2 E., on the north side of Green Mountain, just above the old railroad grade. The workings are now included in the upper Portland mine.

Ore was developed in the upper contact zone in a series of wide shoots trending about N. 35° E. The ore horizons ranged in thickness from 2 1/2 to 3 feet with interbedded shaly layers. Glauconitic shales occurred just above and below the ore, and in some cases these were mineralized for up to 6 inches away from the fractures. The fractures were dominantly oriented at N. 35° E., with others at N. 13° E. and N. 60° E. The shoots were best developed at the fracture intersections. At the southeast end of the mine, ore was located in a blanket above the shoots and separated from them by about 6 feet of glauconitic shale.

References: Atlas, p. 48; Irving, 1904, p. 205; State Mine Inspector, 1897, 1898.

Clinton

There are three distinct sets of workings in the Bald Mountain District which are referred to by the name "Clinton". One of these is a small mine on the lower contact zone in the Ruby Basin District which is discussed in the next section. The reamining two, the upper and lower Clinton mines, are part of the Bald Mountain mine.

The upper Clinton workings were located about 1500 feet west of the town of Trojan in the NW 1/4 NE 1/4 sec. 2, T. 4 N., R. 2 E. It was one of the original properties of the Clinton Mining Company and is now part of the upper Portland mine.

The ore occurred in three large shoots in the upper contact zone. The largest of these was 6 to 8 feet wide, 3 feet thick and 300 feet long trending N. 44° E. Major fractures in the shoot were at N. 25° E., N. 32° E., N. 44° E., and N. 50° E. and minor fractures at N. 86° E., N. 50°-85° W. and north-south. The mineralization appeared to be associated with the N. 32° E. and N. 44° E. major fractures and minor fractures from N. 50°-85° W. A second shoot was situated 30 feet northwest of the first, trending N. 32° E. along fractures of the same strike. The third shoot was 40 feet east of the main shoot and was oriented at N. 53° W. A series of parallel fractures striking N. 32° E. crossed this shoot.

Irving reported that the upper Clinton mine was quite productive.

The lower Clinton workings are opened by an 1800 foot inclined tunnel driven from the Ajax and Alaska claims in the SE 1/4 SE 1/4 sec. 35, T. 5 N., R. 2 E. The workings were developed beginning in 1935 for the purpose of prospecting the lower contact zone under the productive upper contact mines.

Several shoots were discovered in the lower contact zone, and in the basal quartzite, trending dominately between N. 20° E. and N. 50° E. following fractures in these directions. A second set of fractures strikes between N. 85° E. and S. 85° E. Both oxidized and unoxidized ores were produced. The grade was generally good.

A 100-230 foot thick sill of quartz monzonite porphyry underlies the basal quartzite in the mine. The sill ends abruptly on all but the southwest side of the workings, so that the lower Clinton workings are somewhat higher than other lower contact workings of the Bald Mountain mine. Many small, post mineralization dikes of quartz monzonite and diorite porphyry are found in the workings as well as several pre-mineralization faults of small displacement.

References: Allsman, 1940, p. 26-36; Atlas, pp. 48-49; Baldwin, 1904, Hummel, 1952, pp. 54-55, Pl. 6-A, B, 9; Irving, 1904, p. 206; Miller, 1962, pp. 63-65, Pl. 5.

Crown Hill (Bald Mountain Mining Company)

Information about the Crown Hill mine is limited to production data for a few years. The mine was probably located in sec. 34, T. 5 N., R. 2 E.

References: Allsman, 1940, p. 28; Atlas, p. 51.

Dakota Group (Bald Mountain Mining Company)

The name Dakota group refers to two separate groups of claims operated by the Dakota Mining and Milling Company during the years 1902-1907. The first group was located in secs. 34 and 35, T. 5 N., R. 2 E., and secs. 2 and 3, T. 4 N., R. 2 E., and included the Gunnison, Vulcan, Rehl, Lucy, Tiger, Mono and Peggy claims. Of these, the Gunnison was probably the most productive, although the ore taken from it was of low grade and came from a zone slightly below the usual position of the upper contact ores.

The second group of claims was located in the SW 1/4 sec. 35, T. 5 N., R. 2 E. and consisted of the Little Rock, Joseph, Jim and Wedge claims. No information is available regarding operations of any of these claims.

Between 1904 and 1907 a shaft (Dakota) was sunk, on the Lucy Claim, to the lower contact zone. The total depth was 584 feet, of which over 250 feet was in porphyry. A crosscut was then driven for a distance of about 2000 feet along a line trending N. 20° W. from the shaft and a few short lateral drifts were also run. A few small verticals were crossed and a minor amount of ore was produced from one of these. The workings were abandoned in 1921. However, the shaft was later renovated and used by the Bald Mountain Mining Company for access to the Dakota mine (see below).

Aside from the shaft and lower contact drifts, all of the workings of the Dakota group claims are now included in the upper Portland mine.

References: Atlas, p. 51; Baldwin, p. 172; Irving, 1904, p. 206; Miller, 1962, pp. 58-59, Pl. 4; State Mine Inspector, 1894, 1899.

Dakota (Bald Mountain Mining Company)

The Dakota mine is one of the workings of the intermediate zone, about 100 feet below the upper contact zone of the Deadwood formation, and slightly west of the upper Portland mine. The mine was opened off the Dakota shaft about 80 feet below the collar.

The shoots trended northeast, localized by fractures oriented at N. 35°-55° E. and N. 70°-90° W., and by a few northeast trending faults. East of the shaft, a fault has dropped the upper contact zone to the Dakota level, while to the west, the upper contact zone is over 120 feet higher.

In 1963, Miller reported that considerable ore remained in the mine in various stages of development.

References: Miller, 1962, pp. 58-61, Pl. 3; Hummel, pp. 54-55, Pl. 3-A, B, 9.

Decorah (Old or Upper) (Bald Mountain Mining Company)

The upper Decorah mine was located on the east side of Green Mountain in the northwest corner of sec. 1, T. 4 N., R. 2 E., and adjacent parts of sec. 35, T. 5 N., R. 2 E., about 50 feet above the old railroad grade.

The mine was opened by two tunnels following parallel shoots trending N. 35° E. The width of the shoots probably averaged about 20 feet with 100 feet as a maximum. The thickness of the ore corresponds to that of the host dolomite bed which is about 2 1/2 to 3 1/2 feet. In part of the mine the ore extends into the shales for a short distance on either side of the fractures.

The mine was worked independently until 1900 when it was acquired by the Portland Mining Company.

References: Atlas, pp. 51-52; Irving, 1902, p. 203.

Decorah (Lower) and Dividend (Bald Mountain Mining Company)

The lower Decorah and Dividend mines are located on the north slope of Green Mountain near the south edge of sec. 35, T. 5 N., R. 2 E. There is some confusion in nomenclature regarding these mines.

When Irving visited the area in 1899, he described the Dividend mine on the lower contact zone, and the upper Decorah mine on the upper contact zone. At a later time, the workings of the Dividend mine were extended under the upper Decorah and a new portal was opened. This portal and the workings under the Decorah claim on the lower contact zone were then referred to as the Lower Decorah mine. However, both Connolly (1927) and Salughter (1937) refer to these two lower contact mines combined as the Decorah mine and Miller (1962) uses the same name on his maps, although he refers to them as the Dividend and Decorah in his text.

Detailed descriptions are available only for the Dividend mine (Irving, 1902, pp. 201-202) which contained numerous ore shoots. At the northeast end of the mine were two small ore bodies about five to six feet thick and developed at the intersections of small fractures striking N. 25° E., N. 44° E., and N. 18° W. The ore was terminated on the west at a N. 78° W. fault which raised the Precambrian schists a few feet. The mineralized fractures crossed into the schist, and some ore was mined from these rocks. Another shoot in the southwest end of the mine was developed at the intersection of N. 30° E., N. 38° E. and N. 36° W. fractures.

The remaining shoots were generally less than 5 feet wide and followed open fractures which were mineralized for unusually large vertical distances above the basal quartzite (maximum 40 feet). The largest fracture was about 6 inches wide and was partially filled with fragments of schist. It was mineralized to minable grades for 743 feet along its N. 53° E. strike. Smaller shoots were developed along open fractures trending north-south, N. 15° E., N. 25° E., N. 44°-53° E. and N. 34°-40° W.

Three types of ore were taken from the mine. One was the usual unoxidized ore while the other two were oxidized. The first of these was a gouge-like material containing iron and manganese oxides and sandy fluorite, and the second was decomposed basal quartzite. The unoxidized ore carried from one to three ounces of gold per ton, while the values of the oxidized ores ranged from 1/2 to 1 1/2 ounces per ton.

Dikes, often with brecciated contacts, were common in the mine.

Miller (1963, p. 66) reported that much of the ore taken from these mines contained both sylvanite and free gold and that in the decomposed quartzite, much of the gold was in the free state.

The lower Decorah and Dividend mines were worked until 1918 when ore ran out and the owners were unable to acquire adjacent properties. The workings were examined briefly in 1952 by the Bald Mountain Mining Company geologists, and no new ore was discovered.

References: Atlas, p. 52; Connolly, 1927, pp. 65, 69; Connolly and O'Harra, 1929, pp. 150-171, 310-311; Irving, 1904, pp. 201-202; Miller, 1962, pp. 66-69, Pl. 1, 5; Slaughter, 1937, p. 137.

Empire and Empire State (Bald Mountain Mining Company)

The Empire State mine was an upper contact mine located on the north side of Green Mountain in the northeast corner of sec. 2, T. 4 N., R. 2 E. It was one of the first mines opened in the Portland District and was acquired by the Portland Mining Company, probably prior to 1900. The workings of the Empire State mine constitute the most easterly workings of the upper Portland mine.

The name "Empire mine" refers to workings in the intermediate zone slightly west of the Empire State mine. The Empire workings were probably opened about 1940.

The ore in the Empire State mine occurred in flat shoots ranging in thickness from 2 1/2 to 3 feet, and following fractures at N. 25° E. and N. 35° E. Usually glauconitic shales were located above and below the ore but in a few localities these were replaced by coarse-grained rhyolite porphyry. The mine was in operation as late as 1923.

The Empire mine is opened by a southwesterly-trending inclined tunnel driven on the base of the intermediate contact. Some ore was taken from the mine before 1942 and extensive development was planned. However, sometime during the 1942-45 close-down the mine workings caved and were never reopened.

References: Atlas, p. 50; Connolly, 1927, p. 60; Irving, 1904, p. 204; Miller, 1962, p. 61, Pl. 3, 4; Slaughter, 1937, p. 17.

Finlander, Foley and Trojan #4 (Bald Mountain Mining Company)

The Trojan #4 mine is located on the road up Nevada Gulch to Trojan in the S 1/2 NW 1/4 sec. 1, T. 4 N., R. 2 E. The Foley #1, #2, and #3 mines are located near the center of sec. 2, T. 4 N., R. 2 E. The location of the Finlander mine is unknown.

These workings were all opened to mine ore in a 30 foot thick quartzite bed, known locally as the "Finlander", which immediately underlies the upper contact zone. Most of the deposits in the Finlander were located directly below ore shoots in the upper contact zone and followed the same trends.

References: Miller, 1962, p. 56.

Folger (Bald Mountain Mining Company)

The Folger is an upper contact mine located on the south side of Green Mountain on the line between secs. 1 and 2, T. 4 N., R. 2 E., just west of the Alameda. The property was acquired by the Portland Mining Company in the early years of activity in the district.

The workings followed one small ore shoot trending N. 35° E. The roof was of uniform, unbroken shales.

References: Allsman, 1940, p. 28; Atlas, pp. 47-48; Irving, 1904, p. 204.

Golden Bottle (Bald Mountain Mining Company)

The Golden Bottle mine is located in the center of the S 1/2 NE 1/4 sec. 34, T. 5 N., R. 2 E. on the slope northeast of Squaw Creek. The deposit was localized along a N. 40° E. fracture in the porphyry mass of War Eagle Hill. The fracture was reportedly traceable on the surface for over 1500 feet.

Reference: Miller, 1962.

Gushurst and Manchester

The Gushurst and Manchester mine was probably located in the SW 1/4 sec. 35, T. 5 N., R. 2 E., near the head of Squaw Creek. A small amount of galena and cerussite in masses of jasperoid rock was produced from the Deadwood formation, probably the lower contact zone.

References: Irving, 1904, pp. 202-203.

Juno (Bald Mountain Mining Company)

The Juno mine was located in the center of the S 1/2 SE 1/4 sec. 34, T. 5 N., R. 2 E., just north of the Annie Creek road. The mine was a small producer, possibly from the upper contact zone.

References: Allsman, 1940, p. 28; Atlas, p. 54; State Mine Inspector, 1918, 1920.

Labrador

The Labrador mine was probably located in the E 1/2 sec. 27, T. 5 N., R. 2 E., in Labrador Gulch. A small amount of oxidized ore is reported to have been produced from beds of the Deadwood formation which were distorted by intrusive rocks.

References: Irving, 1902, p. 203.

Leopard and Jessie Lee (Bald Mountain Mining Company)

The Leopard and Jessie Lee mine was located on claims of the same name just west of the Empire State workings on the north side of Green Mountain in the northeast corner of sec. 2, T. 4 N., R. 2 E.

The ore was in flat, irregular masses varying up to 40 feet in width and about 2 feet thick. It was overlain by argillaceous shales, and rested on a 3 foot sill of coarse-grained rhyolite. Fractures were minor, and trended dominantly N. 20° E., north-south and N. 20° W.

The workings are now included in the upper Portland mine.

References: Allsman, 1940, p. 28; Atlas, p. 50; Irving, 1904, p. 205; Miller, 1962, Pl. 3.

Mark Twain (Bald Mountain Mining Company)

The Mark Twain mine was located in the town of Trojan in the NE 1/4 sec. 2, T. 4 N., R. 2 E. The mine was opened by a series of tunnels driven northwest into the hillside below the town.

The ore occurred as two masses separated vertically by about 5 feet of shale and replacing two dolomite layers, the lower of which was 3 feet thick and the upper 2-2 1/2 feet thick. Fractures were numerous and irregular with the most frequent trend at N. 35°-40° E. and others at N. 85° E., N. 60° E., N. 50° E., N. 80° W., N. 33° E., and N. 10° W. As a result the ore did not occur as a single shoot but as an irregular, channel-like body.

The workings are now part of the upper Portland mine.

References: Atlas, pp. 49-50; Irving, 1904, p. 204; Miller, 1962, Pl. 3; State Mine Inspector, 1891.

Monday Group (Bald Mountain Mining Company)

The Monday Group consisted of the Monday, Reindeer and Ofer claims located in the NE 1/4 sec. 2, T. 4 N., R. 2 E. just north of the Mark Twain. No geologic information is available concerning the ore deposits of these claims. They are currently part of the upper Portland mine.

References: Atlas, p. 49; State Mine Inspector, 1891, p. 58, 1892.

Perseverence (Bald Mountain Mining Company)

The Perseverence mine was located in the northeast corner of sec. 2, T. 4 N., R. 2 E., just southeast of the Empire State mine on the south side of Green Mountain. The Mine was operated by the Portland Mining Company during the early years of activity in the district.

The mine was opened by a tunnel driven N. 35° E. into the side of Green Mountain, following the trend of three ore shoots in the upper contact zone. In two of the shoots the ore occurred in one layer about 3 feet thick between layers of unmineralized shale. In the third shoot the ore was in two layers separated by shale. The widths of the shoots varied up to a maximum of 50 feet, but they were generally quite narrow.

References: Atlas, p. 49; Irving, p. 204.

Portland

The name Portland mine is applied to three sets of workings in the area, all of which are part of the present Bald Mountain mine. The first Portland mine was located near the center of the north edge of sec. 2, T. 4 N., R. 2 E., west of Trojan. The ore occurred in two dolomitic zones and in the shales of the upper contact zone. At the east end of the workings, mining was done by open cuts and by drifting on three N. 25° E. shoots and one N. 40° E. shoot. All these workings were in the shale overlying the upper contact zone dolomites. At the west end the mine was opened by a southeast trending crosscut which intersected several small, narrow shoots along fractures at N. 20° E., N. 25° W., N. 30° W., N. 40° E., N. 55° E., N. 80° E., and N. 35° W. The strongest fractures were at N. 25°-30° E. The ore of the Portland mine was unusually high in silver.

As the district developed, workings on the upper contact zone in the vicinity of Trojan were connected by drifts. Eventually all of the upper contact workings from the Bunker Hill on the west to the Empire State on the east (Bunker Hill, Burlington, Portland, Leopard and Jessie Lee, Mark Twain, Clinton, Monday Group, Empire State, and others) were joined. This large group of interconnected workings is presently referred to as the "upper Portland" or "Portland" mine (Plate 11).

The third Portland mine is the lower Portland or Portland haulage level in the lower part of the intermediate zone. It was opened prior to 1900 to serve as a haulage level to which upper contact ore was dropped for transport from the mine. In spite of the fact that the haulageway was run in a southwesterly direction parallel to most of the shoots in the district, three ore bodies were intersected. Two of these proved to be the largest intermediate zone shoots found in the mine. All three shoots were mined out. In 1946, new ore was located on both sides of the haulageway by diamond drilling. This ore was developed as the 26 and 35 sub-levels (Plate 10) and ore was produced from them between 1948 and 1959. Diamond drilling carried on from the sub-levels has indicated additional ore bodies south of the 26 sub-level, and east of the 35 sub-level. However, no attempt was made to exploit these. Major fractures on the lower Portland level trend N. 30°-50° E. and N. 75°-90° W. The ore occurs along narrow shoots in slabby dolomites, dolomitic shales, and flat-pebble conglomerates.

References: Allsman, 1940, pp. 26-36; Atlas, p. 54; Baldwin, 1904, p. 170, Hummel, 1952, p. 55, Pl. 4-A, B, 5-A, B, 9; Miller, 1962, pp. 54-58, Pl. 3, 4; Slaughter, 1937, pp. 161-166.

Reliance

Shortly after 1900, the Reliance Gold Mining Company assembled 35 claims on Annie Creek, including the Ak-Sar-Ben, University, Bunker Hill, Iron Duke and Monitor groups. Most of the property was in the NE 1/4 sec. 3, and the NW 1/4 sec. 2, of T. 4 N., R. 2 E., and in adjacent parts of secs. 34 and 35, T. 5 N., R. 2 E. Activity was centered at the Bunker Hill mine (later included in the upper Portland mine) and the Annie Creek mine (owned by C. R. Hayes of Deadwood, S.D.) located in the N 1/2 NE 1/4 sec. 3, T. 4 N., R. 2 E.

The Annie Creek mine was worked for low-grade ore which was localized along irregular shoots in the upper contact zone. The fractures formed a northeast set. A total of 188,000 tons of ore was mined with an average grade of 0.15 ounces of gold per ton. All production was from the years prior to 1916. The porperty was acquired by the Annie Creek Mining Company in 1922. Four samples from the mill tailings averaged .75 ppm of gold.

In 1935 the lower contact zone under the mine workings, was explored by diamond drilling. It was reported at that time that development work was planned, but there is no record of any further work being done on the property. Maps of the property prepared at that time show substantial tonnages of ore in the mine.

References: Atlas, pp. 54-55; Baldwin, 1904, p. 161; Lincoln, 1937, pp. 92-93; Miller, 1962, pp. 61, 63, Pl. 3

Snowstorm (Bald Mountain Mining Company

The Snowstorm mine was located on the line between secs. 1 and 2, T. 4 N., R. 2 E., low on the slope on the south side of Nevada Gulch. The mine was opened by a 345 foot shaft to the lower contact zone. Extensive exploratory drifting was done at that level but no ore was found. In 1904 the Horseshoe Mining Company drove a drift from the Ben Hur mine to the Snowstorm shaft and used the shaft to lift ore from the Ben Hur. Some production is reported from the Snowstorm in later years. Miller (1962, Pl. 5) shows extensive workings on the lower contact zone south of the shaft and it is possible that the ore was produced from that area.

One of the intrusive masses which underlies Terry Peak was encountered in the mine. Miller (1962, p. 70) notes that the lower contact zone continued undisturbed under the intrusive, while the remainder of the Deadwood formation arched up over it.

The log of the shaft is given in Appendix V and VI.

References: Allsman, 1940, p. 28; Atlas, p. 55; Irving, 1902, p. 202; Miller, 1962, pp. 69-70, Pl. 5; State Mine Inspector, 1898, pp. 53-54.

South Dakota

The South Dakota mine was a small producer located near the head of Annie Creek, probably near the NE corner of sec. 3, T. 4 N., R. 2 E. Six small layers of low grade ore are reported to have been found in the mine.

References: Irving, 1904, p. 206.

Trojan (Bald Mountain Mining Company)

The Trojan mine was located on the north side of Green Mountain in the NW corner of sec. 1, T. 4 N., R. 2 E. The mine was opened by a tunnel driven S. 35° E. into Green Mountain. The workings consisted of one stope 700 feet long and up to 85 feet wide, on a 4-5 foot thick ore horizon. A dike of coarse rhyolite porphyry, striking N. 35° E. cut the ore at the south end of the mine. The ore was reported to be high in silver.

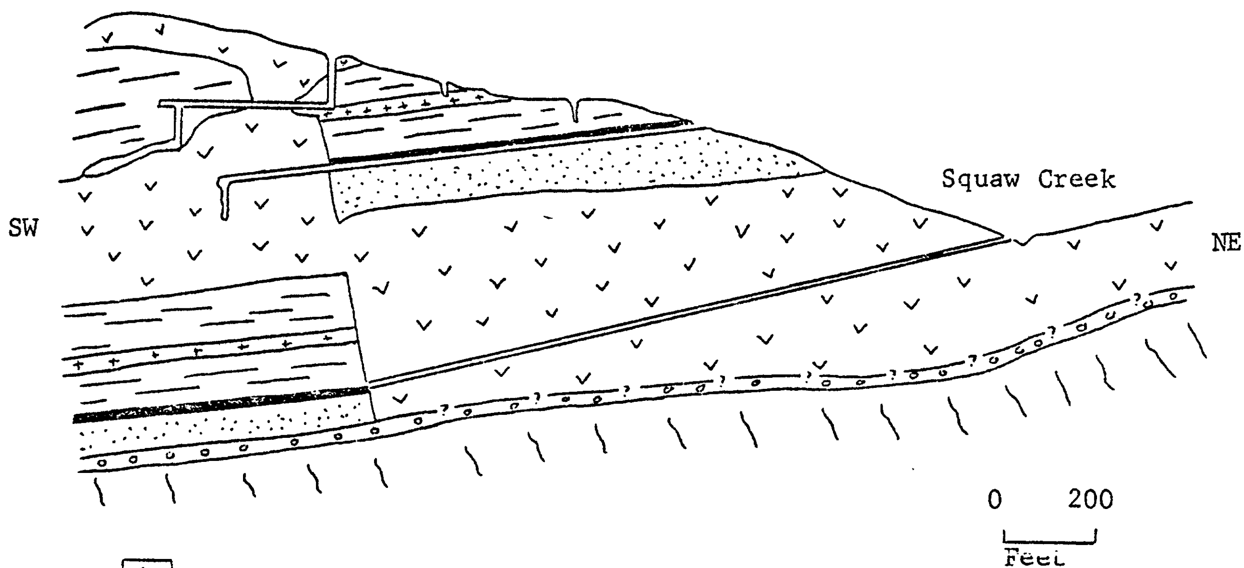
References: Atlas, p. 55; Irving, 1904, p. 203.

Two Johns (Bald Mountain Mining Company)

The Two Johns mine was located in the N 1/2 sec. 34, T. 5 N., R. 2 E., on the west side of Squaw Creek. A few feet of the lower part of the Deadwood formation are exposed there, resting on an extension of the rhyolite porphyry mass of War Eagle Hill. Initially, the mine workings were developed on two ore shoots: one at N. 50° E., and the second at N. 70° E. on the outcrop but changing to N. 25° E. down dip. At the west end of the mine an offset was encountered and the ore was found to abut against an eastward sloping wall of rhyolite porphyry.

In 1929-1930 an inclined tunnel was driven to intersect the lower contact zone which had been found to continue west of the offset (Fig. 8). This was successful and production from the mine continued until 1941.

The ore was both oxidized and unoxidized and carried large amounts of pyrite and some sylvanite. When the mine closed, "Substantial tonnages of both blue and brown ore, in various stages of development, were left unmined" (Miller, 1962, p. 73).



Rhyolite (Tertiary)

Phonolite (Tertiary)

Deadwood Formation, undifferentiated

Ore

Deadwood Formation, Basal Quartzite

Deadwood Formation, Basal Conglomerate

Precambrian

Figure 8. Cross-Section of the Two Johns Mine

References: Allsman, 1940, pp. 26-36; Connolly, 1927, pp. 60-61, 65, 67; Connolly and O'Harra, 1929, pp. 147, 151, 154, 155; Irving, 1904, p. 202; Miller, 1962, pp. 71-73, Pl. 5; State Mine Inspector, 1897, 1916, p. 12, 1917, p. 10, 1918, p. 4.

4.15 Mines of the Ruby Basin District

Alpha-Plutus (Golden Reward Group)

The Alpha-Plutus mine was located on the north side of Nevade Gulch at the center of the east edge of sec. 1, T. 4 N., R. 2 E. The property consisted of 14 mines on the lower contact zone about 30 feet above the Cambrian-Precambrian contact.

The ore was thoroughly oxidized and occurred in shoots varying in length from 50 to 600 feet. The shoots were widely spaced, up to 15 feet thick and rather narrow, passing into unmineralized fractures to the north. Dominant trends of the shoots were N. 12° E., N. 20° E., N. 20° W., N. 15° W., N. 60° W., N. 25° E., N. 45° W., and north-south.

A strong north-south joint set was prominent in the mine and a few north-south faults of minor displacement cut the deposit. The Tornado fault offset the shoots at the west side of the mine. The only igneous rocks observed underground were a few small grorudite dikes striking N. 7° W. (parallel to the foliation of the underlying schists) which were found in the northern end of the mine.

The Alpha-Plutus was the only mine in the Ruby Basin District which operated north of Nevada Gulch. Production is reported to have been extensive though the ore was generally of lower grade than that found further south.

References: Atlas, p. 61; Irving, 1904, p. 192.

Big Bonanza (Lundberg, Dorr and Wilson)

The Big Bonanza mine was located on the divide between Fantail and Stewart Gulches in the E 1/2 SW 1/4 sec. 6, T. 4 N., R. 3 E., on the east side of the phonolite dike. The mine was opened by several drifts driven southward along verticals which cropped out on the north side of the divide. Operations were confined to the lower contact zone. Information is sparse, because the workings were inaccessible when Irving visited the area.

At the adit, the lower contact zone is completely silicified. A sample from the outcrop yielded 18.7 ppm of gold and 20 ppm of silver. Additional samples in the immediate area were taken from a dump below the adit (2.6 ppm gold, less than 10 ppm silver), at the contact of the phonolite dike noted below (15.9 ppm gold, 12.5 ppm silver), and at an outcrop of quartzite below the adit (11.7 ppm gold, 88 ppm silver).

Irving reports that underground the dolomites of the lower contact zones ranged from 8 to 15 feet in thickness so that the ore was correspondingly thick. Verticals were reported to trend about north-south and northeast and were probably numerous, as evidenced by the fact that the ore body was quite wide.

Production from the mine is reported to have been extensive, but exact figures are unavailable. The underground workings were eventually connected with those of the Golden Reward to the east.

References: Atlas, p. 61-62; Irving, 1904, p. 186.

Boscobel and Double Standard (Golden Reward Mining Company)

The Boscobel and Double Standard mines were located in the SE 1/4 sec. 1, T. 4 N., R. 2 E., on the divide between Nevada and Fantail Gulches just west of the Tornado fault. The deposits were in the lower contact zone under the monzonite porphyry sill and were reached by means of a drift driven slightly west of north from the head of Fantail Gulch.

The general dip of the Deadwood formation in the mine is to the southwest with minor undulations superimposed on the dip. The shoots occurred in the crests of these undulations and were quite numerous. The main shoots were a 900-foot shoot trending N. 4° E. and a 150-foot shoot trending north-south with other important shoots trending N. 7° E., N. 10° E., N. 22° E., N. 25° E., and N. 30° E. Much of the ore in the mine was unoxidized and carried abundant gypsum, barite and fluorite. A north-south joint set was prominent in the mine workings, as well as numerous north-south striking rhyolite dikes.

References: Atlas, p. 62; Irving, 1904, p. 197-198; State Mine Inspector 1891, p. 58.

<u>Buxton</u> (Golden Reward Mining Company)

The Buxton mine is located in the SE 1/4 NW 1/4 sec. 6, T. 4 N., R. 3 E., on the divide between Nevada and Fantail Gulches in the outlier of Deadwood formation. The property was inaccessible when Irving visited the area, but he noted that the shoots trended north-south on the lower contact zone, and that the mine was opened by drifts driven into both sides of the divide. The ore was reported to be completely oxidized and of high grade. Production was about 2000 tons per year during the 1890's.

Additional mining was done on the property after Irving's visit. Open cuts were developed along the old drifts, and apparently most of the deposit was mined. Remaining tonnage is likely to be small. Nine samples were collected from the mine, and carried up to 7 ppm of gold and 15 ppm of silver.

References: Atlas, p. 63; Irving, 1904, p. 184; State Mine Inspector, 1891, p. 57.

<u>Clinton</u> (Golden Reward Mining Company)

The Clinton mine was opened by a drift extending southward into the divide between Nevada and Fantail gulches on the south side of Nevada Gulch. The property is located near the center of sec. 6, T. 4 N., R. 3 E.

The mine was a minor producer of medium grade ore which was derived from a gouge which, in turn, was the product of thorough weathering of the dolomite of the lower contact zone. Shoots were reported to trend about north-south and N. 22° E.

References: Atlas, p. 63; Irving, 1904, pp. 191-192.

Daisy (Golden Reward Mining Company)

The Daisy mine is located on the ridge south of Fantail Gulch in the SW 1/4 SW 1/4 sec. 1, T. 4 N., R. 2 E., just east of the trace of the Tornado fault. Irving reports that the mine was worked by open cuts and shallow drifts on the upper contact zone, and that the ore occurred as replacements in thin bands of dolomite interbedded with layers of glauconitic shale. At present, however, the only workings recognizable at the mine site are several irregular open cuts in glauconitic quartzite beds which may be part of the Finlander (see Fig. 5).

References: Atlas, p. 64; Irving, 1904, p. 200.

Dark Horse and General Grant (Bald Mountain Mining Company)

The Dark Horse and General Grant mine is located in the SW 1/4 NE 1/4 sec. 1, T. 4 N., R. 2 E. on the southeast side of Bald Mountain, just west of the Tornado fault.

The deposit was apparently worked by drifting along north-south verticals in the lower contact zone. Little information is available regarding the mine, because it is reported to have been almost worked out in the early 1890's, but a small amount of ore was produced subsequent to that time.

References: Allsman, 1940, p. 28; Atlas, p. 64.

Fannie (Golden Reward Mining Company)

The Fannie mine was opened by a 265 foot shaft sunk to the lower contact zone of the Deadwood formation in the SE 1/4 SW 1/4 sec. 6, T. 4 N., R. 3 E.

on the south side of the divide between Stewart and Fantail gulches.

Production came from four shoots: a small shoot trending N. 12° W. which was 10 feet thick and 30 feet wide; a second shoot 65 feet wide also trending N. 12° W. which divided into three smaller shoots to the north; and two small low grade shoots trending N. 10° W. The Sugarloaf sill cut across the ore bearing horizon so that the ore rested either on phonolite or quartzite in various portions of the mine.

There is considerable interruption to the continuity of the lower contact zone in the area of the Fannie mine with displacements of up to 150 feet noted. The ore bodies of the Fannie mine were probably continuous with those of the Sundance and Big Bonanaza mines. The workings were inaccessible when Irving visited the area.

References: Atlas, p. 64; Irving, 1904, pp. 186-187.

<u>Gladstone</u> (E. R. Wilson, Lead, South Dakota)

The Gladstone mine is opened by an adit driven into the north side of Stewart Gulch below the Sugarloaf sill on the line between secs. 6 and 7, T. 4 N., R. 3 E. The shoot is probably the same as that in the Stewart mine which is above the sill just to the north. The ore is probably in the lower quartzite.

<u>Golden Reward</u> (Golden Reward Mining Company)

The following description refers to the original workings of the Golden Reward mine which formed the nucleus around which the company grew.

The Golden Reward workings were developed on the lower contact zone in the SW 1/4 SE 1/4 sec. 6, T. 4 N., R. 3 E., on the divide between Stewart and Fantail Gulches. The mine was opened by trenches at the outcrop of the ore in Fantail Gulch from which point drifts were run to the south, down-dip along the ore shoots.

The shoots were localized by the intersection of a series of north-south fractures with a set of N. 30° E. fractures. One shoot reached a width of 340 feet which, according to Irving, is 160 feet wider than any other shoot in the district. To the south, this shoot separated into three smaller shoots, two of which trended N. 30° E. and one a few degrees east of south. The ores were both oxidized and unoxidized and were located just above the basal quartzite in all but one area of the mine where the lower contact dolomites were underlain by an unspecified type of porphyry.

The workings were largely inaccessible when Irving visited the area. Connolly and O'Harra (1929, p. 145) report that the estimated reserves of the mine in 1916 were at least 2,000,000 tons of ore, Miller (1963) suggests that the bulk of this ore may be in the basal quartzite and agrees that sampling indicates that the estimate may be correct. However, it is currently not clear as to whether the ore was located on the original Golden Reward workings or on other claims which the company had acquired at a later time. The latter possibility appears to be more likely.

References: Allsman, 1940; Baldwin, 1904; Connolly, 1926; Connolly and O'Harra, 1929; Irving, 1904; Miller, 1962; State Mine Inspector, 1918.

Great Mogul (Bald Mountain Mining Company)

The Great Mogul mine was located in Stewart Gulch on the eastern edge of the NE 1/4 sec. 12, T. 4 N., R. 2 E. It was opened by a 305-foot shaft which reached the Precambrian schists.

Production came from two large shoots. The first is the southern extension of the north-south Tornado shoot which attained a maximum width of 110 feet in the Great Mogul mine. Its thickness varied from 5 to 10 feet. At its north end the shoot was divided by a wedge of unmineralized country rock, while to the south it pinched out. Its total length in the mine was 1,350 feet.

The Tornado shoot is bounded on its west side by a phonolite dike which varies in thickness from 50 to 100 feet. The dike follows a fault which is downthrown on the west, with vertical displacement increasing from 40 feet to 100 feet to the south (this structure was not located on the surface). The second shoot lies on the downthrown block adjacent to the phonolite. Its maximum width is 75 feet, and it also pinches out to the south.

The ore was located in the dolomites of the lower contact zone. The basal quartzite, which underlies the dolomite, is very thin under the Tornado shoot and is absent under the west ore body so that in one locality fragments of schist are found in the dolomite and the ore rests directly on the schist. Production was reported from the top few feet of schist in this locality. The ore was partially or completely oxidized and in the eastern shoot layers of clay carrying gold values of several hundred dollars per ton were found interbedded with the normal ores. Irving reported that the mine was an important producer.

References: Atlas, p. 68; Irving, 1904, pp. 196-197.

Hardscrabble (Mogul Mining Company)

The Hardscrabble mine is located on the line between secs. 1 and 12, T. 4. N., R. 2 E., near the head of Fantail Gulch. It was originally developed by a series of trenches on the lower contact zone of the Deadwood formation. A tunnel was then run westward from one of the trenches for the purpose of intersecting ore shoots and stopes were later developed.

In the mine workings, the Deadwood formation is cut by an " . . . inextricable tangle of dikes, sills and irregularly bounded masses of rhyolite."

(Irving, 1904, p. 199). Fractures were also reported to cut indiscriminately through shales, rhyolite and dolomite. As a result, the shoots in the Hardscrabble mine were generally irregular although some were aligned on N. 20° E. fractures. In addition, the rhyolite was often mineralized. The ore was highly refractory, generally of low grade, and carried abundant fluorite.

References: Atlas, p. 66; Irving, 1904, p. 66; State Mine Inspector, 1894, p. 14.

Harmony (Golden Reward Mining Company)

The Harmony mine was opened by two drifts driven south from the south side of Fantail Gulch just west of the Tornado fault on the south edge of the SE 1/4 sec. 1, T. 4 N., R. 2 E.

The workings were inaccessible when Irving visited the area, but he reported that the shoots were in the lower contact zone and parallel to the fault.

The more easterly of the adits was driven into a bare face in which silicified dolomites of the lower contact zone are exposed. A fracture about one foot wide and filled with gouge is exposed in this face and five samples were taken from it. These contained 19.5, 40, 15, 13 and 7.6 ppm of gold, and two samples collected from the face for background contained 26 ppm and 30 ppm. Two additional samples collected from prospect pits on the slope south of the mine each yielded 2.2 ppm of gold.

References: Irving, 1904, p. 199; Atlas, p. 66.

Isadorah and Billy (Golden Reward Mining Company)

The Isadorah and Billy property consisted of two mines as indicated by the name. They are situated in the divide between Stewart Gulch and the north fork of Whitetail Creek in the NE 1/4 sec. 7, T. 4 N., R. 3 E., with the Isadorah about 700 feet northwest of the Billie, and about 150 feet higher. Both deposits occur in the lower contact zone.

In the Billy mine, the ore occurs in dolomites which rest on the basal quartzite and are overlain by the Sugarloaf sill. The sill breaks down across the Deadwood formation to the west so that in the Isadorah mine it is below the basal quartzite and the ore occurs between quartzite and shale.

Six shoots were found in the two mines with all but one trending between north-south and N. 10° W. The exception was a minor shoot trending N. 20° E. The ore was almost entirely siliceous and neither mine is reported to have been very productive.

References: Atlas, p. 67; Irving, 1904, p. 188.

Little Bonanza (Golden Reward Mining Company)

The Little Bonanza mine was located in the SW 1/4 sec. 6, T. 4 N., R. 2 E., on the north side of the divide between Stewart and Fantail Gulches just west of the phonolite dike.

The mine was opened by two southerly drifts following two narrow north-south verticals. These merged on strike to form one large shoot which reached a width of about 200 feet at a distance of 750 feet from the openings. Further south, this shoot was again divided into two shoots by a wedge of unmineralized country rock. The more westerly of these shoots was subsequently divided into three shoots along strike, the middle one of which was 540 feet in length and up to 25 feet thick. Most of the ore was siliceous.

The Little Bonanza mine was separated from the adjacent Big Bonanza mine by a thick north-south, phonolite dike, and other bodies of the same rock type were found in parts of the mine.

References: Atlas, p. 62; Irving, 1904, p. 187-188.

<u>Little Tornado</u> (Golden Reward Mining Company)

The Little Tornado mine was located on the divide between Nevada and Fantail Gulches in the SE 1/4 sec. 1, T. 4 N., R. 2 E., on the Tornado and Silver Fraction claims. The mine produced minor quantities of thoroughly oxidized ore and had closed down by the time Irving studied the area.

Seven ore shoots were worked in the mine, six of which were oriented at about N. 10° E. and one at N. 34° E. The workings were on the lower contact.

The mine was situated just west of the Tornado fault on the upthrown block and drag associated with movement along the fault is apparently responsible for the steep, easterly dip of the Deadwood formation in the mine workings. A number of small north-south faults with upthrown sides to the west were also discovered in the mine.

References: Atlas, p. 67; Irving, 1904, p. 197.

<u>Retriever</u> (Golden Reward Mining Company)

The Retriever mine was located on the Rebecca claim in the SE 1/4 NW 1/4 sec. 6, T. 4 N., R. 3 E., on the divide between Nevada and Fantail Gulches. The ore occurred in one long, narrow, 6-foot thick shoot along a vertical trending slightly west of north and was developed by tunnels driven into the divide at each end of the shoot. A sill overlies the ore and the vertical extends upward into it for an undetermined distance.

Samples from the adit on the north side of the divided contained 14, 10.5 and 1.1 ppm of gold.

References: Atlas, p. 68-69; Irving, 1904, p. 184-185.

<u>Ross Hannibal</u> (Golden Reward Mining Company)

The Ross Hannibal mine was actually a combination of three mines: the Hannibal, North Star, and Mikado (?) located in the center of sec. 7, T. 4 N.,

R. 3 E. The ore was reached by two drifts, one on Whitetail Creek, and the second on the north fork of the same creek. Some open pit mining was also done on one of the properties (North Star).

The ore shoots are in the dolomites of the lower contact zone which in this area are intruded by the Sugar loaf sill. The Ross-Hannibal shoot rests on the sill, and the workings map (Plate 9) shows that the Union #3 shoot which is under the sill, is an extension of the Ross-Hannibal.

The shoot trends north-south for about 2,000 feet with a thickness ranging from 4 to 8 feet. At its northern end, the shoot is about 100 feet wide but narrows to the south. After becoming quite narrow it thickens again and bends to a trend of N. 27° W. which it follows for about 800 feet before pinching out. Toward the south end of the mine the ore rests upon crystalline dolomite. The shoot is everywhere overlain by a shale which is extremely uniform and, except in small areas, unfractured.

The ore was dominately unoxidized and averaged about 80% silica. A pyrite segregation was reported at the base of the ore and Smith (1896) showed that uranium is present in the ore. One assay sample from the mine yielded 255.08 ounces of silver per ton, and 0.44 ounces of gold per ton (Smith, 1896). In general, however, the ore is said to have averaged about 1-3/4 ounces of gold per ton.

References: Atlas, p. 69; Irving, 1904, p. 189-190; State Mine Inspector, 1891, 1894.

Ruby Bell (Golden Reward Mining Company)

The Ruby Bell mine was located on the divide between the north and south forks of Whitetail Creek in the NE 1/4 sec. 7, T. 4 N., R. 3 E. Below the Sugarloaf sill, the mine was opened by two drifts driven on the outcrop of the ore shoots. One of these was driven southwest from Whitetail Creek, while the other was driven southeast from the north fork of the same creek.

Most of the production from the mine came from two large shoots, one of which was oriented just east of north, and the second, located east of the first, just west of north. The eastern shoot was found to be an extension of the Union #1 shoot, while the southern extension of the western shoot was located in a drift driven west from the Union shaft. Between the two large shoots were three parallel smaller shoots trending almost north-south. The two westerly of these bounded a phonolite dike.

The ore was thorougly oxidized, and the fractures which localized it were found not to extend up into the overlying shale. Production from the mine is known only for the years from 1894 to 1899.

References: Atlas, p. 69; Irving, 1904, p. 189.

South Golden Reward (Golden Reward Mining Company)

The South Golden Reward mine was located at the south end of the Golden Reward and Silver Case claims in the SW 1/4 SE 1/4 sec. 6, T. 4 N., R. 3 E., on the divide between Fantail and Stewart Gulches. The mine was opened by four tunnels driven into the south side of the divide.

The ore occurred in two shoots resting on the basal quartzite which in turn was underlain by the Sugarloaf sill. The shoots were about 600 feet long, 60 feet wide and trended slightly west of north. Two smaller shoots were found west of the main shoot.

A number of samples were collected from the workings and from outcrops of the lower contact zone and quartzite just to the south. The results indicate that the values of gold and silver are higher in the quartzite than in the dolomites. Five samples from the carbonate section in the workings contained a maximum of 1.4 ppm of gold and less than 10 ppm of silver. The quartzite in the mine gave values of 17.6 and 16.9 ppm of gold along fractures, and 1.3 ppm in massive quartzite. The samples away from the workings were all relatively fresh blue ore. The values of gold and silver in these samples varied from 0.3 ppm to 17 ppm of gold, and from less than 10 ppm to 125 ppm of silver.

References: Atlas, p. 65; Irving, 1904, p. 188.

Stewart (Golden Reward Mining Company)

The Stewart mine was located in the SW 1/4 SE 1/4 sec. 6, T. 5 N., R. 3 E., on the divide between Fantail and Stewart Gulches over the Sugarloaf sill. The ore shoot is 1,160 feet long, 10 to 60 feet wide, strikes slightly west of north, and is opened by two tunnels on opposite sides of the divide.

At its northern end the shoot follows two parallel north-south fractures. These are intersected by a set of fractures oriented at N. 30° E. which cause the main shoot to vary its direction to this trend for short distances. In contrast to other mines where an intersection of verticals caused a widening of the ore shoots, in the Stewart mine the shoots did not widen at the intersections.

The ore-bearing dolomites rest directly on the basal quartzite and are overlain by a fine-grained, impervious shale. The ore was reported to have been rich in both gold and silver and completely oxidized.

The ore shoots are probably an extension of the shoots of the Gladstone mine. The workings were shallow and connected by drifts to those of the Golden Reward.

References: Atlas, p. 66; Irving, 1904, p. 185; O'Harra, 1902, p. 12.

Sundance (Golden Reward Mining Company)

The Sundance mine was opened by a 265-foot shaft located in Stewart Gulch in the NW 1/4 sec. 7, T. 4 N., R. 3 E. The ore body was the southwestward extension of the west shoot of the Fannie mine.

The Sundance shoot was about 10 feet thick and followed a set of north-south fractures for a considerable distance although the exact length is unknown. The ore was thoroughly oxidized and averaged about 10 ounces of gold per ton. The mine was considered to be a major producer with most of the production coming from under the Silver Hill claim.

Within the mine, the Cambrian rocks dip to the east and west away from the shoot, indicating that the ore is localized on the crest of a minor undulation. The Sugarloaf sill was encountered in the shaft.

References: Atlas, p. 70; Irving, 1904, p. 188.

Tornado (Golden Reward Mining Company)

The Tornado mine underlies at least 12 claims centered in the SE 1/4 sec. 1, T. 4 N., R. 2 E. and extending into section 6 of the adjacent township. The mine was opened by a 315-foot shaft located in Fantail Gulch.

The ore occurred in 36 distinct shoots within the mine, all of which were in the lower contact zone and rested either on or near the basal quartzite, on the Precambrian schist where the quartzite was absent, or on a phonolite sill which was emplaced between the dolomites and the quartzite. The shoots ranged in thickness from 6 to 14 feet, and were overlain either by shale or igneous rock of unspecified type.

The main (Tornado) shoot extended from Nevada Gulch south through Fantail Gulch and into the Mogul mine. Its combined length in both mines was 4,153 feet and its width varied from 10 to 180 feet, making it the largest single ore body located in the Paleozoic rocks of the northern Black Hills. The shoot followed a trend slightly west of north from its outcrop in Nevada Gulch southweard for a distance 1,225 feet. It then bent to N. 15° W. and retained this orientation for the remainder of its length. About 750 feet south of its outcrop in Nevada Gulch, the shoot was cut by a N. 22° E. fault with the east side downthrown 72 feet. Numerous smaller shoots intersected the main shoot and the grade of ore increased at such intersections.

The second large shoot in the Tornado mine was the Bottleson shoot which extended north from Nevada Gulch for about 600 feet and south for 1500 feet to the Bottleson shaft. From the shaft it veered slightly to the west and extended another 300 feet to the south. It then terminated against a shoot trending N. 74° W. which was localized along a fault which had dropped the southwest side a distance of 8 feet. The cross shoot was about 350 feet long and terminated at its southwest end against two other shoots. The first of these was a narrow shoot extending about 700 feet in a N. 25° E. direction, while the second, larger and more irregularly shaped, trended about S. 30° E. for a distance of about 1,100 feet, where it connected with the north-south "E" shoot. The "E" shoot is a rather narrow ore body about 950 feet in length. The ore is situated on dolomite about 4 feet above the basal quartzite, but this distance increased to 12 feet at the south end of the shoot.

In the south end of the mine the basal quartzite was absent under the Tornado shoot, and the Precambrian schists underlying the dolomites were found to be mineralized. Values up to 1/2 ounce of gold per ton were reported from these rocks.

Numerous other ore shoots were discovered in the mine. The largest of these was the "A" shoot, located 500 feet west of the Bottleson shoot. The space between these two shoots was occupied by a syncline which was barren of ore. (Irving (1904, p. 194) measured dips of 15-20 degrees on the limbs of the fold.) The "A" shoot followed a set of N. 20° E. fractures for a distance of 700 feet. No detailed information regarding the remaining shoots is available. According to Irving (1904, p. 194), twelve trend N. 12°-15° W.; thirteen trend N. 14°-30° E.; and one trends N. 47° W.

Many igneous bodies were intersected in the mine workings. The largest of these was a 60 foot thick phonolite dike which formed the west boundary of the Tornado shoot for much of its length. Phonolite dikes were also common in the northern half of the mine. These are primarily oriented north-south, and cut the main shoot in many places. As mentioned above, the ore in some localities rested on a sill of unspecified type.

The Tornado fault does not cut any of the ore shoots. However, several smaller faults parallel to it do offset the shoots and, in some cases, the shoots occur on benches between faults. The displacement of these smaller faults varies from 40 feet to a few inches, and in most cases the downthrown side is to the east.

Both oxidized and unoxidized ore were mined, with an average value of about one ounce of gold per ton. In the northern segment of the mine, where dikes and faults are most common, the average value was about twice that given above. In other parts of the shoots the values mined ran as low as 1/2 ounce per ton. In general the grade was highest near the intersections of the shoots and little difference was noted between the values of oxidized and unoxidized ores.

References: Allsman, p. 38-39; Atlas, p. 70; Irving, p. 192-196.

Union (Golden Reward Mining Company)

The Union mine was opened by a 107-foot shaft situated in the canyon of Whitetail Creek in the center of the E 1/2 sec. 7, T. 4 N., R. 3 E. The log is given in Appendix V and VI. The ore shoots were in the lower contact zone, which here consists of 20 feet of interbedded shale and dolomite resting on the basal quartzite and just below the Sugarloaf Sill.

There were four ore shoots in the mine all of which were oriented about north-south. These were intersected by a crosscut driven west from the shaft. The shoots occurred at distances of 100, 650, 1,500 and 1,925 along the crosscut, and were named the Union #1, #2, #3, and #4 shoots, respectively. The crosscut was driven to a total length of 2,260 feet west of the shaft and about 1,100 feet east of the shaft. No shoots other than those mentioned above were found.

The #1 shoot was eventually worked to a total length of slightly over 3,000 feet. It ranged in width from 50 to 200 feet, was about 8 feet thick and rested on or near the basal quartzite and beneath a shale bed. In contrast, the other shoots were probably thinner because, in general, they rested on 4 to 6 feet of dolomite which was mineralized only along through-going fractures. The roofs of these shoots were either shale or phonolite, the latter occasionally very irregular and projecting down into the ore (Irving, 1904, p. 191, Fig. 16).

The ore of the #2 shoot is reported to have been unoxidized. No data is available regarding the ore in the other shoots.

References: Allsman, 1940, p. 38-39; Atlas, p. 70; Irving, 1904, p. 190-191.

Upper Welcome (Mogul Mining Company)

The workings of the Upper Welcome mine were located at about the center of the north line of sec. 12, T. 4 N., R. 2 E., high on the northwest slope of Fantail Gulch. Irving reports that the mine was in the upper contact zone, but the present investigation suggests that it is somewhat lower in the section.

The ore shoots followed a series of north-south fractures and were rather narrow, the mineralization not extending far from the fractures. The country rock consisted of interbedded thin layers of glauconitic shale and impure dolomites. According to Irving, (1904, p. 201) "Much eruptive rock occurs in rather confused relations".

References: Atlas, p. 71; Irving, 1904, p. 200-201.

Welcome (Bald Mountain Mining Company (?))

The Welcome mine was located in the SW 1/4 SE 1/4 sec. 1, T. 4 N., R. 2 E., on the northwest side of Fantail Gulch. It was opened by a shaft sunk on a north-south fault along which the west side was dropped about 30 feet. The displacement dies out to the south. The Deadwood formation dips 10 or 12 degrees to the south at the shaft.

The shoot was located a few feet west of the shaft. It was about 100 feet wide, 10 feet thick, 625 feet long and developed along a complex series of fractures striking from north-south to about N. 30° E. (see Irving, 1904, Plate XIII, p. 214). The main shoot, bounded on the west by an igneous body of undetermined type, pinched out to the south. Other shoots oriented north-south, N. 10° W., N. 15° E., and N. 30° E. were found in the southwest part of the mine.

The ore was overlain by highly fractured and partly mineralized shale and rested on 2 or 3 feet of red dolomite above the basal quartzite. Production was extensive.

References: Irving, 1904, p. 199.

4.16 Suggestions for Further Prospecting

Most of the activity in the Bald Mountain District has been concentrated in the upper and lower contact zones of the Deadwood formation and these horizons have been prospected wherever they were located on the surface. However, the presence of deposits in the middle member of the Deadwood formation and in the Finlander has been demonstrated in the Bald Mountain mine, though it is doubtful that these units have ever been systematically prospected. The same is true of the basal quartzite which was found to be mineralized in the Stewart and Gladstone mines during this study, at the Bald Mountain mine (Miller, 1963) and which carries the major mineralization at Galena (R. R. Grunwald, oral comm.).

The maps of mine workings in the Bald Mountain District (Plates 9, 10 and 11) indicate the extent of underground prospecting in the various ore horizons. Comparison of these maps with the geologic map of the district (Plate 5) show those areas where ore zones are potentially present but unexamined. Miller (1963, Plates 3 and 5) suggests that the lower contact zone north of Trojan to Squaw Creek and down dip to the southwest of the limits of the present workings under Green and Foley Mountains is essentially unprospected.

The upper contact zone has been mined on Crown Hill, in the center of sec. 34, T. 5 N., R. 2 E., and just south of the offset in sec. 27. It is probably present in the SW 1/4 sec. 27, and adjacent areas, under the igneous mass which may be up to 500 feet thick over part of the area. In addition, this horizon is present above 6600 feet on the northwest slope of Terry Peak, above the offset in the E 1/2 sec. 2, T. 4 N., R. 2 E., and it is doubtful that it has received more than a cursory examination in this area.

4.2 Carbonate Mining District

4.21 Introduction

The Carbonate District lies on the limestone plateau, east of Spearfish Canyon, in T. 5 N., R. 2 E., Lawrence County. It is bounded on the north by Rubicon Gulch, and on the south by the canyon of Squaw Creek. Iron Hill, the center of mineralization, is located near the middle of the north half of sec. 15.

4.22 History of the Carbonate Mining District

High-grade lead-silver ores were discovered within the Pahasapa limestone in 1881, and incomplete records indicate a production of more than $1 million in silver, gold, and lead within the next 10 years. About 1882, the Iron Hill Company built a small stamp-amalgamation mill, then a 50-ton smelter, on Rubicon Gulch. However, much of the ore was hauled to outside smelters. The year of greatest activity was 1886. In 1887 claim map indicates at least 15 small companies active in an area about one mile square. The camp was virtually deserted when the price of silver dropped in 1891. There were sporadic activities at the mines, and extensive reworking of the dumps between 1901 and 1911. A small cyanide plant was set up about 1901 to treat tailings from the stamp mill. Consultants' reports indicate extensive sampling programs at the Iron Hill and Seabury-Calkins properties in 1910-11, 1916-17, and 1939-40. The U. S. Bureau of Mines examined the properties as potential sources of low grade manganese ores in 1942.

4.23 Geology of the Carbonate Mining District

A complete sedimentary section, from the Deadwood through the Pahasapa, is present. With local exceptions, the strata dip northwestward at 6 to 12 degrees. The sequence has been extensively invaded by dikes and sills of Tertiary porphyry. The sills have preferentially invaded shaly members of the Deadwood formation, the Ice Box shale, and Englewood formation. Locally, heavy sills have also invaded the massive Pahasapa limestone (Plate 13). Observations on Squaw Creek show that the sills which have invaded the Deadwood tend to be of fairly uniform thickness over wide areas, and to taper down to a feather's edge at their margins. The result is that the top of the Deadwood is a fairly smooth surface. However, the sills which cut the higher beds tend to end abruptly against vertical fracture surfaces, giving rise to fault-like displacements of the overlying strata.

The dikes, which are generally less than 25 feet in width, seem to have a preference for the following bearings: N. 20° W., N. 30°-35° W., and N. 55°-65° W. Irregular crosscutting relations between sediments and intrusives are common.

Plate 13 presents the result of detailed plane table mapping of the north half of sec. 15. The complexity of the relationships between sediments and intrusives is apparent. Unfortunately, no logs have been found of any of the shafts in the area. It is difficult to draw meaningful cross-sections based on surface mapping only.

The principal mineralization at Carbonate is associated with the vertical Iron Hills fissure which crosses the area in a N. 80° W. direction.* Most of the shafts are sunk on successive claims laid out across the fissure. A similar mineralized fissure 1,100 feet to the north, extends N. 76° W. across the Far West, Rattler, Wilkinson, Enterprise, and Hartshorn claims on the north

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* Irving's and Allsman's reported bearings are given from magnetic north in the Carbonate area. They have been converted to bearings from true north in this report, and further corrections made where necessary.

edge of sec. 15. There appears to be little if any displacement along these verticals.

The Iron Hill vertical has been traced for an east-west distance of 2,100 feet; if the Liberty and Mugwump shafts are on its eastward extension, the length is over 4,000 feet. It was explored to a maximum depth of 460 feet, and is reported to have been from 2 to 25 feet in width.

Two apparently distinct types of ore body are found in the district. The Iron Hill fissure is reported to have been partially filled with a soft ferruginous gouge, pinkish-red in color, said to have contained galena, lead carbonate, and cerrargyrite. The adjacent country rock is extensively replaced to a width of several feet with ferruginous jasper carrying lower values of gold, silver, lead, and manganese. Mineralogical studies of samples recovered recently from the Iron Hill dump revealed the following minerals: anglesite, atacamite, calcite, corkite, goethite (limonite), matlockite, plattnerite, pyrolusite, quartz, and wulfenite (Lingard, 1969, p. 34).

A second type of ore body is reported to have consisted of irregular shoots apparently following solution cavities within the limestone, and intimately associated with the porphyry dikes. The ore contained gold, silver, lead, and manganese. These ores were often very high in silver, and were less siliceous than the jasperoid ores of the fissure zone. Other minor types of ore have been described, but they are probably variations of the above two.

The principal host rock has been the Pahasapa limestone. Only the lower half of the formation, representing the Lodgepole Member, is present on Iron Hill. The formation is thin-bedded for the most part, and the areas which have been mineralized are frequently dark gray to black—presumably stained by manganese oxides. The deeper ore in both the Iron Hill and Spanish R mines must have come from just above the Englewood contact.

The earlier writers fail to make any mention of the potential of the Whitewood dolomite, although it has been extensively prospected in sections 10 and 15. Nearly all grab samples taken from such prospect holes have shown gold values—one as high as 26 ppm. The Mutual tunnel, whose dump is reported to assay $7.00 per ton in gold, is driven in the Whitewood formation. Ore was reported in travertine-filled vugs in Whitewood dolomite during construction of the county road down to the drainage tunnel. Grab samples taken at this point during the present survey ranged from 0 to 2.6 ppm gold.

The Deadwood formation has been mineralized along Squaw Creek at the Old Ironsides (lower quartzite), and at the Cleopatra (upper contact) (Fig. 6). Early efforts to explore the Deadwood beneath the higher ore bodies at Carbonate were thwarted by water problems. Between 1917 and 1921, the Stoddard drainage tunnel was driven 1,300 feet on a N. 5° E. bearing, from the bottom of Silver Springs Gulch to the 300-foot level of the Iron Hill mine. This drift started at the contact between the Ice Box shale and the Roughlock siltstone, a short distance beneath a large porphyry sill. No record is available, but calculating from the dip of the sediments, and the probable rise of the tunnel, most of the drift is probably cut in Roughlock, and it may be in Mississippian rock at the Iron Hill shaft. It is likely that only four widely spaced shafts in the Iron Hill area reached the potential ore horizon beneath the Deadwood *Scolithus* quartzite. These are the Liberty and Mugwump to the east, the Iron Hill shaft itself, and the Spanish R shaft to the west (Plate 13). None of these reached the ore horizon at the top of the basal quartzite. The Cleopatra shaft reached the lower quartzite, but insufficient drifting was done to determine if that zone was mineralized directly beneath the ore body on the upper contact.

4.24 Mines of the Carbonate Mining District

Adelphia

The Adelphia shaft, located on the Adelphia Lode (M.S. 489), was sunk on the Iron Hill vertical. The collar elevation is about 5,680 feet; the depth is not known. The ore consisted of red gouge similar to that in the Iron Hill mine (Atlas, p. 27). Some ore may be related to Tertiary intrusives, as a vertical contact between limestone and porphyry is exposed in the caved collar of the shaft.

Several other shallow pits, all of which are in limestone, have been sunk along the strike of the fissure within the confines of the Adelphia claim.

No production figures are available.

Iron Hill

The Iron Hill mine was the principal silver and gold producer of the district. The main shaft, sunk on the Utica Lode (M.S. 447-A), is on the vertical fissure to which it has given its name. According to Irving (1904, pp. 177-178), the ore bodies are of two types, argentiferous lead minerals associated with porphyry intrusions into the Pahasapa limestone, and soft gouge carrying gold and silver values which occurred as fissure filling along the Iron Hill vertical. One pocket of 4 to 5 tons of vanadinite has been reported (Irving, 1904, pp. 177-178). Allsman (1940, p. 56) cites a grab sample from the Iron Hill dump which assayed 14.98% Mn.

The main shaft, collar elevation 5,683 feet, reached a total depth of 460 or 470 feet. Drifts were driven east and west along the vertical at the 60-, 100-, 160-, 200-, 240-, and 300-foot levels, and stopes were raised wherever the ore justified. Lateral drifting, some to the north, but more to the south, occurred at these same levels. Much of this was exploratory drifting, but old maps suggest that extensive ore bodies were found in association with porphyry dikes south of the vertical on the 200- and 240-foot levels. It appears from these old maps that the big sill exposed on the hillside south of the Iron Hill does not extend to the shaft. At the same time, the vertical dikes indicated in old underground maps, cannot be recognized on the surface. As its total reported depth, the shaft should have encountered the Scolithus quartzite. Although over 800 feet of horizontal drilling was done from the lower levels of the Iron Hill mine, there is no record that a vertical hole was attempted.

The nature of the mineralization in the Home Run and Buntz shafts is not known. Both are sunk in black, thin-bedded lower Pahasapa carbonate. The Home Run is credited in unpublished reports, with significant production from a depth of 60 feet and above. Several pieces of siliceous rock from the dump ran 9.2 ppm gold. The Buntz shaft was probably somewhat shallower. Narrow porphyry dikes striking N. 25°-30° W. are exposed in both shafts. Rock at the Buntz shaft, containing dark siliceous jasper and white calcite, assayed 16 ppm gold. Ore was found at the surface in the rimrock workings east and west of the Buntz shaft.

Production from the Iron Hill mine is reported for 1885-88, and 1891, as $677,218 (Allsman, 1940, p. 54). This presumably represented the market value of all silver, lead, and gold produced during that time. Operations continued, under a series of leasors, until at least 1898. Between 1901 and 1911, the dumps were reworked, with an additional recovery of 82.91 oz. gold, 18,511 oz. silver, and 183,191 pounds of lead. The dumps were sampled in 1940 by the Richmond Hill Mining Company, by the U. S. Bureau of Mines in 1942, and again under the Solid Waste Disposal Act in 1968-69 (Lingard, 1969, pp. 32-38. A composite sample from 18 trenches on the three Iron Hill dumps was fire assayed and showed 5.74 oz. silver and 0.02 oz. gold per ton.

Seabury-Calkins

The Seabury-Calkins was the second most important mine in the Iron Hill area. It is located on the Calkins Lode claim (M.S. 1022). The principal shaft is located on the Iron Hill vertical, 250 feet east of the Iron Hill shaft. The collar elevation is about 5,690 feet. The fissure was explored to a depth of 240 feet by the main shaft (Allsman, 1940, p. 53) and also by drifting at the 65- and 100-foot levels. To the west, the 65- and 100-foot levels were extended about 170 feet where they encountered a porphyry dike which separated the Seabury-Calkins and Iron Hill ore bodies. On the 65-foot level, drifting extended 245 feet from the shaft, where it raised to the surface at the "Snow Hole". Old maps also show a stub drift, about 100 feet long, to the east at the 100-foot level.

The ore seems to have been confined largely to the fissure. Irving (1904, p. 178) stated that it consisted of soft, red gouge carrying high values in lead (reported as lead, lead carbonates, cerargyrite) and gold, lying between limestone walls which were replaced by jasper to a width of 2 to 3 feet.

An unpublished report indicates 1,000 tons of ore shipped to the Deadwood smelter from above the 190-foot level in the early 1890's. No other production figures are available.

Segregated Iron Hill

The Segregated Iron Hill shaft was sunk to an undetermined depth on the Iron Hill vertical. It is located on the Ultimo claim (M.S. 442-A) the original Segregated Iron Hill Company also owned the adjacent Tideout and Minni claims to the east.

Nothing is known of the ore; presumably it was similar to that of the nearby Seabury-Calkins and Iron Hill properties. In 1948, the writer observed a nearly horizontal contact between limestone and underlying porphyry just below the collar of the shaft (Atlas, p. 29). The shaft has subsequently been filled in. The dump consists almost entirely of dark gray porphyry.

No production figures are available.

Spanish R

The Spanish R mine is located on the western edge of the Carbonate District. The main shaft is on the Richmond claim (M.S. 680), though workings extend under the adjacent Spanish claim (M.S. 679) to the east. A second shaft on the property, 100 feet S. 80° E. of the main shaft, may have been an airshaft or manway.

The Iron Hill vertical crosses the extreme northeast corner of the Spanish claim. The Spanish R workings do not lie on this vertical, as claimed by earlier writers, but may be on a second, subparallel vertical 500 feet south of the Iron Hill fissure. A plat of the property, made at the time of patent, also shows a 300-foot drift near the shaft, bearing S. 80° E., with shorter stub drifts branching off to the south.

The main shaft started in porphyry at elevation 5,480, and it is reported by Baldwin (1904, p. 151) to have entered the Cambrian (probably the Ice Box shale of present usage) at 300 feet, and to have reached a total depth of 425 feet (Allsman, 1940, p. 54). If the report is correct, the shaft should have reached the upper contact zone in the Deadwood formation. This is substantiated by presence of Scolithus fragments on the dump. Serious water problems, reported in the lower portion of the shaft, may have prevented further sinking or exploratory drifting.

The principal ore bodies were apparently in the 300-foot drift, and at the 100-foot and 170-foot levels in the shaft. Baldwin (1904, p. 151) states that most of the ore came from the 300-foot level, but this seems unlikely.

Mineralization is reported to have occurred near the contact between the Pahasapa limestone and irregular intrusions of porphyry. The ore has been described as a thoroughly oxidized red gouge along vertical fractures (Atlas, p. 29-30). Another report mentions that a leasor was stockpiling gray ore in 1896. The ore was apparently higher in gold and lower in silver than from mines along the Iron Hill fissure. Baldwin (p. 151) reported galena, pyromorphite, argentite, and vanadinite. The Spanish R is reported to have produced over $50,000 in gold from upper levels prior to 1904 (Baldwin, p. 151). There is no record of subsequent production.

Titanic

The Titanic Gold Mining and Milling Company was formed in 1899. It acquired properties along the eastward extension of the Iron Hill vertical, with the avowed intention of prospecting for the lower contact ores of the Cambrian.

The old Titanic shaft, on the Little Ellen claim (M.S. 1376) was believed to lie at the extreme eastern end of the Iron Hill vertical. The shaft collared in the Deadwood formation at about elevation 5,630. An old report indicates that "this shaft passed through a few feet of shales at the surface, then through upwards of 150 feet of porphyry, and into shales again, and at a depth of 200 feet was supposed to be within about 30 feet of the quartzite." There is no record that the shaft was subsequently deepened to that horizon.

The company also acquired the properties upon which the Mugwump (Republic) and Liberty (Independent) shafts are located. Allsman (1940, p. 54) reported depths of 140 and 165 feet respectively for these shafts. They both were started in the Roughlock siltstone. The Mugwump undoubtedly reach the ore horizon beneath the *Scolithus* sandstone as the dump includes Roughlock, Ice Box, and Deadwood material. The Liberty dump includes Ice Box and porphyry, and material which may be either Roughlock or Deadwood.

The New Titanic shaft, on the Carbonate claim (M.S. 417) west of the Iron Hill shaft, was also known as the "Combination" shaft. The collar elevation is about 5,636 feet. It was sunk on the Iron Hill vertical, and workings at the 300-foot level were connected to the Iron Hill mine. It is not known to have been deepened below that level, so it is doubtful if it tested even the upper Deadwood ore horizon. Although the shaft is now caved, the Iron Hill vertical is clearly seen cutting altered porphyry at the collar. Seven samples, cut across the east face including the vertical, showed not a trace of gold. A group of ochrous looking rocks from the dump assayed 17.1 ppm gold.

No production is credited to the Titanic Company.

4.3 Deadwood District

4.31 Introduction

The term "Deadwood Mining District", as used in this report, is intended to include the city of Deadwood and immediately adjacent areas. The district is best known for production from placer deposits, although some mining was also done in the Precambrian schists and in igneous rocks of Tertiary age. The only mine in rocks of Paleozoic age was the Belle Eldridge, which is described below.

4.32 Mines of the Deadwood District

Belle Eldridge Gold Mine, Inc.

The holdings of Belle Eldridge Gold Mines, Inc. consist of 31 claims totaling 177 acres, centered in the NW 1/4 sec. 25, T. 5 N., R. 3 E. However, virtually all production from the property has come from the Belle Eldridge mine located in Spruce Gulch on the line between the NE 1/4 sec. 26 and the NW 1/4 sec. 25, T. 5 N., R. 3 E.

Gold mining operations were conducted on the property in the early years of mining in the northern Black Hills, but little is known about the results of this work. During World War I, lead-zinc ores were produced commercially from the mine for the first time, and production of these ores continued sporadically until about 1950.

The ore body occurs in the dolomites of the lower contact zone and ranges in thickness from 6 inches to 18 feet, averaging about 5 feet. The dolomites rest on a 240 foot thick monzonite sill which was apparently emplaced just above the basal quartzite. The ore is capped by shale. The shoots trend northeast following fractures of the same orientation.

The primary ore minerals are pyrite, arsenopyrite, sphalerite, chalcopyrite, galena and pyrrhotite deposited in the order in which they are given with overlapping of all phases except pyrrhotite (Berg, 1949). Secondary malachite and azurite are common in the ores. Gold and silver values are usually quite low.

The ores of the Belle Eldridge mine are unusual for the northern Black Hills Tertiary ores because of the abundance of sphalerite and coarse-grained arsenopyrite. Sphalerite is generally rare in the Tertiary ores, while arsenic minerals are known only from small amounts of arsenic found in analyses of the ores.

References: Allsman, 1940, p. 49; Atlas, pp. 30-31; Berg, 1949; Connolly, 1927, pp. 109-110; Lincoln, 1937, pp. 94-95; Schwartz, 1937, pp. 810-825.

4.4 Galena Mining District

4.41 Introduction

The limits of the Galena Mining District are usually defined to include two separate groups of mines. The first group consists of the lead-silver mines in the Deadwood formation located east of Bear Butte Creek in sec. 9, in the eastern half of sec. 4 and in sec. 3 of T. 4 N., R. 4 E. The second group of mines are developed on gold deposits which occur in brecciated zones in a large mass of quartz monzonite and monzonite porphyry. These are located near the common corner of secs. 5, 6, 7, and 8, T. 4 N., R. 4 E., near the head of Strawberry Gulch, at Anchor Hill one-half mile north of the corner, and in the SW 1/4 SW 1/4 of sec. 6 of the same township, near the head of the east fork of Two Bit Creek.

4.42 Geology of the Galena Mining District

The major physiographic feature of the area is the deeply incised canyon of Bear Butte Creek which divides the district into two parts. On the east side of the Canyon, the Cambrian-Precambrian contact is close to the level of the creek and the Paleozoic section, through the Mississippian, is exposed in the slope. West of the creek, the outcrop is dominantly Precambrian, with only a small remnant of Deadwood formation present, capping the divide between Strawberry Creek and Ruby Gulch. The contact between the Precambrian schists and the Tertiary intrusives lies along a rough arc stretching from the head of Strawberry Creek to the mouth of Butcher Gulch. The strike of the sedimentary rocks of the Paleozoic section is just west of north over much of the district. Dips are east from 8°-20° although considerable variation is present. Three sills have been intruded into the Deadwood formation east of the creek. These have been termed rhyolite porphyry by Connolly (1927, p. 99) and mapped as quartz monzonite and monzonite porphyry (Darton and Paige, 1925). Numerous other igneous rock types have also been identified in the area (Stearns, 1955; Mukherjee, 1967, 1968, 1969).

4.43 Lead-Silver Mines of the Galena District

Alexander Claim

The Alexander claim is located just north of the center of sec. 9, T. 4 N., R. 4 E. near the top of Custer Hill. Irving mentions this property as being the 8th most important silver producer in the district, prior to 1902. No exact data is available and it seems probable that no work has been done on the property since 1891. The workings consisted only of a number of small pits, trenches, and shallow drifts. The ore was developed in the upper contact zone, and was reported to have been thoroughly oxidized.

References: Atlas, p. 30; Darton and Paige, 1925, p. 29; Irving, 1902, p. 170.

Alice

The Alice mine is near the southern edge of the Galena Mining District in the center of the S 1/2 sec. 9, T. 4 N., R. 4 E. on the east side of an unnamed tributary of Bear Butte Creek. The mine is opened by a tunnel driven northeast into the hillside for a distance of 375 feet. About 180 feet from the portal a second drift was driven southeast.

The ore lies just above the basal quartzite in the lower contact zone in shoots localized by a set of parallel fractures of unknown orientation.

The Alice was reported to be one of the better producers among the smaller mines in the area.

Reference: Atlas, p. 30.

Bion Mine

The Bion property consists of three claims and a fraction near the southwest edge of the Galena Mining District. Two of the claims are on the eastern end of an outlier of the Deadwood formation in the NW 1/4 SW 1/4 sec. 9,

T. 4 N., R. 4 E., while the remainder were placer claims in the valley of Bear Butte Creek below the outlier in the E 1/2 SW 1/4 of the same section.

Information on the property is sketchy and there is no record of production although some mining was apparently in progress in 1901. It appears likely from the nature of the workings, that the owners had also hoped to develop a pyrite mine in graphitic schists which outcrop at the creek level.

References: Atlas, p. 57; O'Harra, 1902, p. 16.

Branch Mint

The Branch Mint mine is located in the NW 1/4 sec. 3, T. 4 N., R. 4 E. The mine workings include two adits about 150 feet apart with several hundred feet of drifts extending northeast into the hillside.

The ore shoots were in the upper contact zone following mineralized fractures which trend to the northeast. A second set of fractures intersects these at a high angle, and the size of the ore bodies is enlarged at the intersections. The ores were thoroughly oxidized. Miners who worked in the mine claim that the silver occurred primarily as horn silver.

The Branch Mint mine was one of the richer small producers in the district. It was a part of the extensive (over 200 claims) holdings of the Branch Mint Mining Company.

References: Atlas, p. 31; Baldwin, 1904, p. 172; Connolly, 1927, pp. 102-107; Connolly and O'Harra, 1929, pp. 193-197; Lincoln, 1937, p. 96.

Bullion

The Bullion claim is located south of Bear Butte Creek in the NE 1/4 sec. 9, T. 4 N., R. 4 E. It was a smaller producer developed at the upper contact zone. The ore shoots were controlled by a set of verticals striking N. 75° W.

References: Atlas, p. 31-32; State Mine Inspector, 1891, 1892.

Coletta

The Coletta mine is located on the divide between Bear Butte Creek and an unnamed tributary entering from the south in the NW 1/4 sec. 16, T. 4 N., R. 4 E. The ore was in the lower contact zone following three sets of verticals striking N. 45^{o} E., N. 63^{o} E., and N. 30^{o} W. and was thoroughly oxidized.

Irving lists the Coletta as the 4th most important silver producer in the district prior to 1902.

References: Atlas, pp. 32-33; Connolly, 1927, p. 99; Connolly and O'Harra, 1929, p. 190; Darton and Paige, 1925, p. 29; Irving, 1902, pp. 170-171.

Cora

The Cora mine is located in the center of the N 1/2 sec. 9, T. 4 N., R. 4 E. The workings consist of several drifts driven into the hillside off a small gully. The Deadwood formation dips southeast at about 24^{o} in the mine workings, in contrast to the normal northeast dip.

The ore was only slightly oxidized and high in pyrite. It was developed in the lower contact zone, about 30 feet above the base of the Deadwood formation. Mineralized fractures in the mine trend between N. 30^{o} E. and east-west with most about N. 50^{o} E.

References: Atlas, p. 33; Connolly, 1927, p. 99; Connolly and O'Harra, 1929, p. 190; Darton and Paige, 1925, p. 29; Irving, 1902, pp. 170-171; State Mine Inspector, 1891, 1892.

Custer

The Custer mine is located in the SE 1/4 sec. 4, T. 4 N., R. 4 W., high on the slope south of Bear Butte Creek. The workings are at the upper contact zone, about 440 feet above the creek bed, extending about 100 feet into the hillside.

The ore consists of a few inches of soft, oxidized material resting on a quartzite which is highly impregnated with iron and manganese oxides. No production data are available but, from the extent of the workings, it seems likely that some ore was produced.

The Custer mine is currently part of the Double Rainbow group.

References: Atlas, p. 33.

Double Rainbow (Formerly Richmond-Sitting Bull)

The Double Rainbow group presently consists of 28 claims totaling about 290 acres located in secs. 3 and 4, T. 4 N., R. 4 E. The property is built around the Richmond-Sitting Bull mine which is described here.

The mine workings extend about 1,300 feet in a north-south direction, and 650 feet east-west, beneath the Richmond-Sitting Bull, Tiger Tail, Silver Terra, Grand View and Gulch claims. All the workings are at the upper contact zone.

The location of the ore shoots is controlled by two sets of high angle fractures of unknown orientation with the size of the ore bodies increased at the intersections of the fractures. The highest grades of ore came from vug fillings of argentiferous galena. Pyrite and galena are scattered throughout the mine in various states of oxidation.

Irving lists the Richmond-Sitting Bull as the largest producer of silver in the district.

References: Atlas, p. 34; Connolly, 1927, pp. 102-108, Pl. 18A; Darton and Paige, 1925, p. 29; Irving, pp. 170-171; Lincoln, 1937, pp. 110, 114; Smith, 1897, p. 427.

El Refugio

The El Refugio claim is located on the ridge just north of the intersection of Butcher Gulch and Bear Butte Creek in the S 1/2 NE 1/4 sec. 4,

T. 4 N., R. 4 E. The workings consist of a series of pits, trenches and shallow drifts at the upper contact zone.

The ore is thoroughly oxidized. It rests directly upon a quartzite which is heavily indurated by iron and manganese oxides and is overlain by slabby dolomite. The controlling fracture is apparently oriented at about N. 80° E.

The El Refugio was a small producer during the early years of operation in the district.

References: Atlas, p. 34; Darton and Paige, 1925, p. 29; Irving, 1902, pp. 170-171.

Florence

The Florence mine is located in the NW 1/4 sec. 3, T. 4 N., R. 4 E. across Bear Butte Creek from the Richmond-Sitting Bull claim, and is now part of the Double Rainbow group. The mine is opened by a 700 foot tunnel driven at N. 50° E. into the hillside about 190 feet above the creek. Smaller drifts and a 100 foot winze are developed off the main tunnel.

The ore is in the upper contact zone and is thoroughly oxidized to a soft, yellow-brown material in which no minerals are identifiable. Both native and horn silver were, however, reported to occur abundantly in the ore. The controlling fractures had a northeast orientation.

Irving lists the Florence mine as second in the district in importance as a silver producer.

References: Atlas, p. 35; Connolly, 1927, pp. 102-108; Darton and Paige, 1925, p. 29; Irving, 1902, pp. 170-171.

Groshong

The Groshong mine is located in the center of sec. 9, T. 4 N., R. 4 E. near the south end of the Galena Mining District. The mine is opened by two portals leading to one tunnel which follows a northeast trending vertical for about 310 feet.

The ore occurs in the lower contact zone just above the basal quartzite. It is oxidized to a soft, yellow-brown material in which no minerals can be identified.

The dip of the Deadwood formation in the mine varies from 5°-11° in directions ranging from N. 15° W. to N. 80° E., in contrast to the regional dip of about 10° northeast.

The Groshong was a small producer of silver during the early years of operation of the district.

References: Atlas, pp. 36-37; Connolly, 1927, p. 99.

Hayes (Rutherford B. Hayes)

The Hayes mine is located high on the hillside east of Bear Butte Creek in the NE 1/4 SW 1/4 sec. 9, T. 4 N., R. 4 E. The mine workings were developed in the lower contact zone over an area 450 feet east-west by 360 feet north-south.

The ore occurs in a sandy dolomite layer cut by a set of northeast trending verticals, and by a few minor faults of unspecified strike.

The mine was a small producer during the early years of activity in the district.

References: Atlas, pp. 37-38; Connolly, 1927, p. 99; State Mine Inspector, 1893.

Hester A

The Hester A mine is located in the NW 1/4 sec. 9, T. 4 N., R. 4 E. on a hillside about 240 feet above the level of Bear Butte Creek.

The ore occurs about 15 feet above the base of the Deadwood formation, where several verticals of unspecified strike cut the lower contact zone. The mine is opened by drifts on these verticals.

Irving lists the Hester A as the third most important silver producer in the district during the early years of activity.

References: Atlas, p. 38; Darton and Paige, 1925, p. 29; Irving, 1902, p. 170; State Mine Inspector, 1893.

Horseshoe-Comet

The Horseshoe-Comet mine is located on the north slope of Custer Hill near the center of the north edge of the NE 1/4 sec. 9, T. 4 N., R. 4 E. The workings are developed at the lower contact zone and extend over a vertical range of about 100 feet. This is attributed to " . . . displacement of the ore horizon by a series of intrusive sills . . . " (Atlas, p. 39). The ore is fairly fresh, and the results of polished section work done on it has been described above.

The Horseshoe-Comet mine was operated from the early 1880's until 1918. It was reported that the ore was mined both for silver and market pyrite.

References: Atlas, pp. 38-39; Connolly, 1927, pp. 99, 102, Pl. 17; Connolly and O'Harra, 1929, p. 192, Pl. 24-A; Darton and Paige, 1925, p. 29; Irving, 1902, p. 171.

Merritt No. 1 and No. 2

The Merritt claims extend north-south through the center of the SE 1/4 sec. 4, T. 4 N., R. 4 E. on the southeast side of the valley of Bear Butte Creek. Irving lists the Merritt No. 2 mine as the fifth most important producer in the district.

The ore occurs in the upper contact zone localized along fractures which vary in strike from north-south to N. 80° E. The ore minerals were in various stages of oxidation though still identifiable. These included galena, pyrite and lollingite. Sulfides were reported to be more common on these properties than on those further south.

References: Atlas, p. 40; Connolly, 1927, pp. 102-106, Pl. 18-B, 19-A; Connolly and O'Harra, 1929, p. 192; Irving, 1902, pp. 170-171; State Mine Inspector, 1917.

Red Cloud

The Red Cloud mine is located near the west edge of the NW 1/4 sec. 3, T. 4 N., R. 4 E. in a steep gulch north of the old Mogul mill. The mine is opened by a tunnel driven into the hillside for a distance of 320 feet. For the first 180 feet, it follows a vertical contact between the upper contact zone of the Deadwood formation and a rhyolite porphyry mass. The contact strikes slightly south of east, with the porphyry on the north. For the last 140 feet, the drift follows a set of mineralized fractures striking about N. 80° E.

Oxidation is thorough and no recognizable minerals were present in the ore. There are old reports of the presence of horn and native silver in some of the richer ore pockets.

The Red Cloud mine was one of the more important small producers in the early years of the district.

References: Atlas, p. 43; Connolly, 1927, pp. 102-108.

Savage

The Savage mine is located in the SE 1/4 sec. 4, T. 4 N., R. 4 E. high on the slope south of Bear Butte Creek. The property was never more than a prospect.

The ore occurs about 70 feet below the top of the Deadwood formation, following three sets of verticals which strike N. 25° E., east-west, and N. 75°-80° W. The ore horizon rests on a quartzite which is thoroughly impregnated with iron and manganese oxides.

Dips of the Deadwood formation are variable in the mine workings, ranging from 8°-16° northeast.

Reference: Atlas, p. 47.

Silver Queen (Queen, New Silver Queen)

The Silver Queen mine is located in the SW 1/4 SE 1/4 sec. 9, T. 4 N., R. 4 E. north of the unnamed tributary to Bear Butte Creek. The shallow drifts which constitute the mine workings cover an area about 600 by 700 feet, all at the lower contact zone. The verticals trend northeast.

The ore shoots are lenticular in cross-section with thicknesses ranging from less than an inch to two feet, and widths up to 18 feet. The country rock is a dolomitic sandstone. All the ore in the mine is thoroughly oxidized, and assays show high values of silver, lead and vanadium.

References: Atlas, p. 44; Connolly, 1927, p. 99; Connolly and O'Harra, 1929, pp. 188-189; Darton and Paige, 1925, p. 29; State Mine Inspector, 1893, 1917.

War Eagle

The War Eagle mine is located high on the slope east of Bear Butte Creek in the SE 1/4 sec. 4, and the NE 1/4 sec. 9, T. 4 N., R. 4 E. The mine workings consist of 450 feet of drifts at the upper contact zone of the Deadwood formation.

The ore is thoroughly oxidized to a yellow-brown material, and rests on a quartzite which is impregnated with manganese and iron oxides. Verticals in the mine trend N. 25° E., east-west and N. 70° W.

The property was a very small producer during the early years of activity in the district.

Reference: Atlas, p. 45.

4.44 Gold Mines of the Galena District

Anchor Mountain

The Anchor Mountain property includes about 780 acres in secs. 5 and 6, T. 4 N., R. 4 E. The mine workings consist of a 150 foot shaft and 1200 feet of drifting, most of which was developed during 1919-20.

The gold occurs in auriferous pyrite as a replacement in the Deadwood formation and in the same quartz monzonite body in which the other mines in the area occur.

There is no record of any production from the property.

References: Allsman, 1940, p. 63; Atlas, pp. 45-46; Lincoln, p. 92; State Mine Inspector, 1919-20.

Gilt Edge

The Gilt Edge mine is located near the head of Strawberry Gulch at the SW corner of sec. 6, T. 4 N., R. 4 E. Underground workings are extensive, and at least part of the ore was mined by means of a glory hole.

The ore is auriferous pyrite weathered to limonite near the surface. It occurs as a cement in a brecciated mass of porphyry.

References: Allsman, 1940, pp. 56-62; Atlas, p. 36; Connolly, 1927, p. 112: Darton and Paige, 1925, p. 29; Lincoln, 1940, pp. 101-102; State Mine Inspector, 1898, Mukherjee, 1967, 1968, a, b)

Golden Crest

The Golden Crest mine is located in the SW 1/4 sec. 6, T. 4 N., R. 4 E. on the divide between Two Bit Creek and Strawberry Gulch. The mine is opened by a 330 foot shaft which penetrated about 200 feet of porphyry, a few feet of quartzite from the lower Deadwood formation and then entered the Precambrian schists.

The ore is developed in a southeast-trending shear zone which varies in width from 8 to 50 feet, with the northeast side up. Extensive drifting and stoping has been done in the shear zone at the 80-, 125-, 180-foot levels. Exploratory drifting has also been done in the Deadwood formation and in the schist, but the result of this work is not known.

References: Allsman, 1940, pp. 63-64; Atlas, pp. 35-36; Lincoln, 1937, pp. 98-99.

Hoodoo-Union Hill

The Hoodoo-Union Hill group includes 120 acres of patented claims in the SW 1/4 sec. 5 and the SE 1/4 sec. 6, T. 4 N., R. 4 E. Three shafts, 200, 300, and 470 feet deep, and extensive drifting constitute the mine workings. The ore occurs in the same manner as described for the Gilt Edge mine.

References: Allsman, 1940, pp. 56, 62-63; Baldwin, 1940, p. 17; Darton and Paige, 1925, p. 29; Lincoln, 1937, p. 207.

Oro Fino

The Oro Fino mine is located in Strawberry Gulch in the SW 1/4 NW 1/4 sec. 8, T. 4 N., R. 4 E. The workings consist of a shaft, two glory holes, and appropriate crosscuts.

The ore occurs in a mass of brecciated schist cemented by pyrite, galena, sphalerite and other sulphides.

References: Allsman, 1940, p. 57; Atlas, pp. 41-42; Carpenter, 1889, p. 587.

Rattlesnake Jack

The Rattlesnake Jack mine is located in Strawberry Gulch in the SW 1/4 SW 1/4 sec. 5, T. 4 N., R. 4 E. and extends a short distance into sec. 8 of the same township. The mine workings consist of an adit with a winze to levels at 52 and 155 feet below the adit. Some of the ore was also removed through a glory hole.

The ore was in brecciated porphyry as described above for the Gilt Edge mine.

References: Allsman, 1940, pp. 56-63; Atlas, pp. 42-43; Connolly, 1927, pp. 111-114; Grout and Schwartz, 1927, pp. 369-373; Lincoln, 1937, pp. 101-103, 114.

4.5 Garden-Maitland Mining District

4.51 Introduction

Irving (1902, p. 150) defined the Garden Mining District as consisting of a group of mines " . . . situated in Blacktail and Sheeptail Gulches, and at the head of a small tributary of False Bottom Creek about two-thirds of a mile east of south from Garden". This area includes the SE 1/4 sec. 18, NE 1/4 sec. 19 and the N 1/2 of sec. 20 of T. 5 N., R. 3 E. Later developments in the area require that the definition of the district be expanded to include most of secs. 17 and 18 of township above, as well as the NE 1/4 of sec. 13, T. 5 N., R. 2 E.

4.52 Geology of the Garden-Maitland Mining District

Within the district, the Deadwood formation dips northeast. A thick cap of rhyolite covers much of the area, its position in the section varying around the district. In some places it rests directly on the Precambrian schists while in others it is much higher in the section. North of Tetro Rock, the Deadwood emerges from beneath the rhyolite and passes under the younger rocks. Relationships within the Deadwood formation are obscure due to the presence of numerous irregular intrusives in the unit as well as the presence of the cap mentioned above. A number of small, north-south faults with the west side upthrown also cut the area.

The shoots dominantly trend to the north-east although there is wide divergence in their strike. They tend to be fairly long but narrow compared with those of the Bald Mountain District. Numerous layers of barren shale are interbedded with the ore and these tend to reduce the grade. All of the mines produced gold and silver from either the basal conglomerate or the lower contact zone of the Deadwood formation.

4.53 Mines of the Garden-Maitland Mining District

American Express

The eleven claims of the American Express group are located in the center of sec. 20, T. 5 N., R. 3 E. in Blacktail Gulch, Sheeptail Gulch, and the divide between them. The mine was opened by a tunnel driven north on the basal quartzite, from Sheeptail Gulch.

There were numerous shoots in the mine, four of which were fairly large. All were replacements in hard, blue, crystalline dolomite which in most cases also served as the base of the shoots with 5 to 7 feet of dolomite between the ore and quartzite. The shoots were capped either by shale or rhyolite.

The fracture systems which controlled the larger shoots were at N. 40°-45° E., N. 50°-55° E., N. 60°-65° E., and N. 85° E. Twelve small shoots were also located on these same trends. The largest ore bodies were developed at the intersections of the N. 40° E. and N. 85° E. fractures.

References: Atlas, p. 76; Baldwin, 1904, p. 133; Irving, 1902, pp. 210-211; State Mine Inspector, 1893, 1898, 1915, 1916.

Blacktail (?)

Irving mentions a property for which he could not obtain a definite name so that his description of it is headed as above (Irving, 1902, p. 210). The mine was probably located in the center of the W 1/2 sec. 20, T. 5 N., R. 3 E., and was opened by four tunnels at the lower contact zone. The ore occurred in seven small shoots following fractures at N. 30° E., N. 43° E., N. 20° E., and N. 50° E. The intersections of the latter two sets gave rise to the largest ore bodies. The workings were cut by a series of small northeast-southwest faults. Production was reported to be extensive.

References: Irving, 1902, p. 210.

Carroll

The Carroll group included 12 claims in secs. 19 and 20, T. 5 N., R. 3 E.

in Blacktail Gulch. The ore occurred in the lower contact zone in shoots following northeast trending fractures.

References: Atlas, p. 77; Baldwin, 1904, p. 171; Irving, 1902, p. 118; State Mine Inspector, 1892, 1897.

Garden City Mining Company-Minnesota Mining Company

Prior to 1902, The Garden City Mining Company conducted operations on the lower contact zone of the Deadwood formation in the W 1/2 sec. 18, T. 5 N., R. 3 E. A small chlorination plant was constructed to process the ores but it failed to give satisfactory recovery grades and was closed down. In 1903 the Garden City properties, along with two adjacent claims, were purchased by the Minnesota Mining Company which mined the property until 1910 and continued exploration until 1912 before permanently halting its operations.

No detailed geologic descriptions of the area are available. In general, the ore was a replacement of dolomite immediately overlying the basal quartzite. Verticals probably were oriented northeast-southwest.

References: Allsman, 1940, p. 24; Baldwin, 1904, p. 169; State Mine Inspector, 1907-12; Atlas, p. 78.

Golden Gate

Information about the Golden Gate mine comes only from a brief paragraph in Irving (1902, p. 210). Its location was probably in the NW 1/4 sec. 20, T. 5 N., R. 3 E. The workings were inaccessible when Irving studied the area but production was apparently resumed sometime between 1900 and 1902.

References: Irving, 1902, p. 210.

Keystone and other mines

These properties were mentioned by Irving, (1904, p. 209) in a short paragraph and no other information regarding them is available. Their approximate location was the SE 1/4 sec. 18, T. 5 N., R. 3 E. It appears likely from this location that they were later incorporated into the Penobscot property.

Production came from several small workings at the lower contact zone. The strike of the fractures controlling the ore shoots were N. 38° E., N. 45° E., N. 55° E. and N. 60° E. The ore bodies were generally small with the largest occurring at the intersection of fractures.

Reference: Irving, 1904, p. 209.

Kicking Horse

The Kicking Horse group consists of six claims in the N 1/2 sec. 20, T. 5 N., R. 3 E., near the head of Blacktail Gulch. The ore was reported to be located either in the basal conglomerate (Lincoln, 1937, p. 109) or in the lower contact zone (Atlas, p. 79). The mine was opened by a 106-foot shaft from which a crosscut was run to the northwest. Nine small northeast-trending ore shoots were intersected. A northeast-southwest fault with the northwest side up cut the basal quartzite at the end of the crosscut.

Production was estimated at about $100,000 prior to 1916.

References: Atlas, p. 79; Irving, 1904, p. 210; Lincoln, 1937, p. 109; State Mine Inspector, 1897, 1898, 1899.

Penobscot

The Penobscot property consists of 1100 acres of claims in sec. 17 and 18, T. 5 N., R. 3 E. The group was assembled in 1902 from the holdings of two mines: the Penobscot (SE 1/4 sec. 18) and the Realization, located in the center of the same section. The combined property was acquired by the Alexander Maitland Company in 1904 and retained until 1906. It was then operated until 1911 as the North Homestake Mining Company. A 100 ton stamp mill was operated on the property over the six year period from 1907 to 1911, and the mine was evidently profitably operated during this time by restricting production to oxidized ores. When it became necessary to mine unoxidized ore the recovery grade dropped and the property changed hands. From 1912 to 1915 an unnamed organization conducted extensive exploration work on the property. A shaft was sunk to a depth of 600 feet into the Precambrian schists and an unknown amount of drifting was done off it for the purpose of locating the northern extension of the Homestake main ledge. The effort failed and no further work was done on the property until its acquisition by the Canyon Corporation in 1934. Roasting and cyaniding equipment were then installed on the property and mining operations were resumed. Production was finally halted in 1942 by WPB order L-208 and has not been resumed since that time.

Irving (1904, p. 209) described the workings of the original Penobscot mine. It was opened by a tunnel on the basal quartzite of the Deadwood formation which followed a shoot of oxidized ore 12 feet thick and up to 12 feet wide, trending N. 40° E. Two minor shoots oriented N. 54° E. were located east of the main shoot. The ore occurred in thin layers of dolomite interbeddded with barren shales. Vugs lined with jarosite were common in the ore and barite was a common constituent.

Sigman (1937) discussed the operations of the Canyon Corporation as well as some aspects of the geologic character of the deposit. The basal conglomerate of the Deadwood formation is present in parts of the mine and often carries gold values of about $1.50 per ton. The above author stated that this was the product of Tertiary mineralization, and not "fossil" placer deposition. The basal quartzite varies in thickness from zero to 15 feet, with the highest gold values occurring in those places where the quartzite is thin or absent.

The dolomites of the lower contact zone vary from pure to sandy, and there is some indication that the grade of ore increases with the purer dolomites.

According to Sigman (1937), verticals are not as well developed in the Maitland District as in other districts in the region. Further, he states that the primary orientation of the verticals is northwest-southeast, parallel to the foliation of the underlying schists. This is in conflict with Irving's observations of dominantly northeast striking verticals. The shoots ranged up to 100 feet in width and varied in thickness from 2 to 10 feet with gradual thickening of each individual shoot from the margins to the center, giving them lens-shaped cross-sections.

No gradations were noted between oxidized and unoxidized ore and no mixing of the two types occurred. The presence of arsenic was indicated in the ore by laboratory tests, although no arsenic minerals were ever found in the mine. Fluorite was present as vug fillings.

References: Allsman, 1940, p. 41-47; Baldwin, 1904, p. 173; Irving, 1902, p. 209; Lincoln, 1937, p. 97; Sigman, 1937, pp. 188-191.

Wells Fargo

The Wells Fargo property was located on the south side of Blacktail Gulch in the NW 1/4 sec. 20, T. 5 N., R. 3 E. The property included three full claims and one fraction. It was owned and operated by the Golden Reward Mining Company during its most productive years.

The shoots occurred in the lower contact zone of the Deadwood formation which has a strong easterly dip in the area. Two sets of workings were developed. The western (upper) workings were opened by a southeast crosscut which intersected ten narrow shoots striking N. 65° E. and N. 57° E. with minor shoots at N. 20° E. and N. 32° E. The lower (eastern) workings were developed on one large N. 55° E. shoot with three smaller shoots at N. 47° E., N. 50° E. and N. 69° E. The controlling fractures were virtually closed, and did not extend up into the overlying shales.

References: Atlas, p. 79; Irving, 1902, p. 210; State Mine Inspector, 1892, 1893.

4.6 Lead Mining District

4.61 Introduction

The Lead Mining District is defined here to include the SE 1/2 sec. 21, secs. 28, 29, 32 and 33 of T. 5 N., R. 3 E., and secs. 4 and 9, T. 4 N., R. 3 E. As defined, the district includes an area about 6 miles long in a north-south direction by 1 1/2 miles wide. The north-south axis passes approximately through the center of the city of Lead.

Rocks of Precambrian age outcrop over most of the district. However, remnants of the basal conglomerate and quartzite of the Deadwood formation, as well as a few feet of dolomite of the lower contact zone are present capping the higher ridges in the area.

In the northern half of the district the mines were all developed in the basal conglomerate. Operations were conducted at the following localities:

1. On the north side of Blacktail Gulch in the NW 1/4 SW 1/4 sec. 21, T. 5 N., R. 3 E. (Minerva, Deadbroke).
2. On the divide between Deadwood and Blacktail Gulches near the common corner of secs. 20, 21, 28, and 29, T. 5 N., R. 3 E. (Baltimore and Deadwood, Esmeralda, Hidden Treasure).
3. On the divide between Deadwood and Bobtail Gulches on the line between the S 1/2 NW 1/4 and the N 1/2 SW 1/4 sec. 28, T. 5 N., R. 3 E. (Pinney, Omega, Deadwood-Terra).

4. On the crest of the hill just east of the open cut in the SE 1/4 SW 1/4 sec. 28, T. 5 N., R. 3 E. (Hawkeye-Pluma, Gentle Annie, Monitor).
5. On the hill west of the open cut in the E 1/2 NE 1/4 sec. 32, T. 5 N., R. 3 E. (Durango, Harrison).

Several mines were also opened in the southern half of the district on the divide between Whitewood and Yellow Creeks to exploit ore bodies in the basal quartzite and lower contact zones.

4.62 Mines of the Lead District

4.62.1 Lead-Blacktail Area

Baltimore & Deadwood, Esmeralda, Hidden Treasure

The Baltimore and Deadwood, Esmeralda and Hidden Treasure mines were inaccessible when Irving investigated the area in 1899. Hence, information regarding these mines is sparse.

The basal conglomerate is not visible on the outcrop but is reported by Irving (p. 106) to be of "great thickness". The Hidden Treasure was the richest of the three mines, reportedly yielding "extremely large amounts of gold".

References: Allsman, 1940, p. 22; Atlas, p. 82; Irving, 1904, pp. 106, 181; Lincoln, 1937, p. 100; State Mine Inspector, 1891, 1898.

Deadbroke, Minerva

Both the Minerva and Deadbroke mines were opened by tunnels driven northward into the slope north of Blacktail Gulch. The basal conglomerate is about 2 feet thick on the outcrop but thickens to 22 feet at the north end of the mines, about 600 feet from the portals. Most of the ore was cemented by iron oxides although some small bodies of conglomerates cemented by pyrite were also located. The ores were reportedly of low grade.

Allsman (1940) considered this area to have the best potential for the production from the basal conglomerates.

References: Allsman, 1940, pp. 22-23; Atlas, pp. 77, 84-85; Irving, 1904, pp. 106-110; Lincoln, 1937, p. 98; State Mine Inspector, 1893, 1897, 1899.

<u>Deadwood-Terra, Omega, Pinney</u> (Homestake Mining Company)

The Deadwood-Terra, Omega and Pinney mines were developed in a small patch of basal conglomerate about 12 feet thick which caps the divide between Deadwood and Bobtail Gulches. The cement of the conglomerate was entirely limonitic in these mines, and the ores were generally of good grade.

The Deadwood-Terra mine was situated directly above the Homestake formation (Atlas, p. 80). Although the mine was opened to work the cement ores, when the value of the underlying Precambrian ores was discovered, the workings were extended downward to exploit the latter ores. The main shaft eventually reached a depth of 900 feet.

In the Pinney mine the conglomerate reportedly contained fragments of Precambrian schists which contained high gold values.

References: Allsman, 1940, p. 22; Atlas, pp. 80, 85; Irving, 1904, pp. 106, 182, 207, Pl. II; Paige, 1924, p. 19; State Mine Inspector, 1897, 1899.

<u>Durango, Harrison</u> (Homestake Mining Company)

The Durango and Harrison mines were opened to exploit the gold-bearing basal conglomerate of the Deadwood formation. It was later realized that the overlying beds of the lower contact zone were mineralized carrying both gold and tungsten and operations were extended into that horizon.

The basal conglomerate is about 15 feet thick in both mines, occurring as fill in a northwest trending depression on the surface of the schists. In general, the ore was thoroughly oxidized, but in the Durango mine a few patches of conglomerate cemented by pyrite were found. Much of the gold in both mines occurred in the free state, and according to Irving (p. 208), Devereux reported that the ore was richest at the contact with the schists, and that the gold "was often dissolved and reprecipitated in crevices in the latter rock." Irving also noted that native gold occurred at the top of the conglomerate, directly beneath the silicious ore at several localities in the mine.

The mineralized dolomites of the lower contact zone range in thickness from 8 inches to three feet. The ore is granular and white, occurring in northwest trending shoots. According to Irving (p. 208), it is often mistaken for mineralized quartzite. It consists of large quantities of barite in interlocking crystals and irregular masses imbedded in a matrix of secondary silica replacing dolomite crystals and detrital quartz. The ore is reported to have ranged up to 3 ounces per ton in gold.

The tungsten occurs as wolframite with minor amounts of scheelite either rimming or capping the gold ores, and occasionally in irregular masses in the gold ore. The wolframite ore is generally very low in gold.

References: Atlas, pp. 80-81; Cummings, 1936, p. 15; Irving, 1904, pp. 207-208; Lincoln, 1936, p. 104; State Mine Inspector, 1899.

Gentle Annie, Hawkeye-Pluma, Monitor (Homestake Mining Company)

The Gentle Annie, Hawkeye-Pluma and Monitor mines were opened in the basal conglomerate on the ridge just east of the Homestake open cut. The ridge is capped by a sill of rhyolite porphyry and, in the Gentle Annie mine, a second sill of the same rock was found intruded between the conglomerate and the underlying schist. The thickness of the conglomerate varies up to 40 feet although it is generally much less than that. Where the conglomerate is completely mined out, the roof of the stopes is a friable, cross-bedded sandstone cut by numerous intersecting iron-stained fractures which cross into the conglomerate.

The most important single ore body in this group was found in the Hawkeye-Pluma mine, where the mine workings intersected a thick mass of conglomerate. Irving (1904, p. 183) described it as " . . . a basin of conglomerate, the gold-bearing portion of which forms a channel trending in a general way north and south . . . " The length of the channel was 1300 feet with an average width of about 60 feet. The southern 400 feet of the channel trended about N. 60° E., while for the remainder of its length, the trend was just west of north.

In general the ore of the western end of the cap was thoroughly oxidized, while to the east and south the conglomerate was cemented by unoxidized pyrite. Irving (1904, p. 184) reported that pillars in the stopes of the Hawkeye-Pluma mine carried about 1/2 ounce of gold per ton, although values in the walls were considerably lower.

References: Atlas, pp. 82-84; Baldwin, 1904, pp. 164-165; Irving, 1904, pp. 106, 182-183, Pl. 18; State Mine Inspector, 1899, 1902.

4.62.2 Yellow Creek Area

Etta (Homestake Mining Company)

The Etta mine is located at the center of sec. 4, T. 4 N., R. 3 E., high on the ridge south of Whitewood Creek. The ore occurs in the basal quartzite of the Deadwood formation, and consists of wolframite and minor amounts of gold in pyrite. Rhyolite porphyry occurs as dikes and sills cutting the quartzite.

References: Atlas, p. 74; Connolly and O'Harra, 1929, p. 204; Cummings, 1936, p. 26; Lincoln, 1937, p. 100; Runner and Hartman, 1918, p. 75-76.

Little Blue Fraction Group

The Little Blue Fraction Group consists of almost 40 acres of claims located in the NE 1/4 sec. 9, T. 4 N., R. 3 E. The group was assembled in 1901 by the Alder Creek Mining Company who operated a 60-ton cyanide mill on the property from 1901 to 1904. In 1911 the Bismarck Consolidated Mining Company acquired the property. The mill was rebuilt in 1913 and production of gold and silver was conducted through 1914. During 1918 the property was operated under lease by a former operator of the Wasp #2 mine and gold, silver, and tungsten were produced from the group.

The ore occurred as shoots in the lower contact zone and in the basal quartzite. In general, the country rock was thoroughly weathered so that individual fractures were not observed. The shoots ranged from 5 to 40 feet in width and were 5-6 feet thick.

One shoot on the Donelson fraction and Kickapoo claim was probably well over 300 feet long trending N. 12° W. over most of its length and bending to S. 20° E. at its southern end. A second shoot intersected the main shoot about 300 feet south of its north end and extended about 300 feet along a fracture oriented N. 60° E. No continuation of the shoot to the southwest of the main shoot was found. Other important shoots trended N. 33°-40° E. and north-south.

The lower contact ores were reported to contain about 2 1/2 ounces of gold per ton, while the basal quartzite yielded about one ounce per ton. A small amount of tungsten was also produced from the property.

References: Allsman, 1940, p. 26; Cummings, 1936; Irving, 1904, pp. 211-212; Lincoln, 1937, p. 95; Runner, 1917, pp. 75, 93; SMI, 1897-1918.

Wasp #2 (Homestake Mining Company)

The Wasp #2 group is located on the divide between Yellow and Whitewood Creeks in the E 1/2 sec. 9, T. 4 N., R. 3 E. It consists of about 130 acres of mineral claims.

Production began from the group as early as 1894 with most of the claims under individual ownership. However, in 1900 the Wasp #2 Gold Mining Company constructed a 500-ton cyanide mill on the property and acquired the adjacent claims. Ore was mined by open pit methods and, because of the deeply weathered condition of the ore, coarse crushing and cyaniding gave excellent recovery. The company operated through 1917 mining and milling ore which averaged about $2.00/ton in gold and silver at a cost of between $1.28 and $1.50 per ton. During 1918 the property was operated by the leasee of the Bismarck mill, and a small amount of gold, silver, and tungsten were produced.

Production came primarily from the basal quartzite of the Deadwood formation. Rhyolite porphyry occurs as dikes, sills and irregular masses throughout the mine.

References: Allsman, 1940, p. 40; Atlas, p. 75; Connolly and O'Harra, 1929, pp. 145-146; Cummings, 1936, pp. 3, 11, 15, 19, 29; Irving, 1904, pp. 165, 211-212; Lincoln, 1937, p. 116; Runner and Hartman, 1918, pp. 74-75.

4.7 Ragged Top Mining District

4.71 Introduction

The Ragged Top District is located in the southwest quarter of T. 5 N., R. 2 E., Lawrence County, South Dakota (Fig. 6). It lies on a limestone plateau bounded on the west by Spearfish Canyon, on the south by Annie Creek, on the north by Squaw Creek, and on the east by a series of Tertiary intrusions which rudely divide the Paleozoic sediments on the west from Precambrian rocks to the east. The plateau stands at an elevation of 5600 to 5800 feet, but it is deeply dissected by short, steep tributaries of Spearfish Creek. Two intrusions stand above the general plateau level,— Elk Mountain which reaches 6422 feet, and Ragged Top, more impressive, but **only slightly above 6200 feet in elevation.**

Access to the area is from the southeastern corner, near the old mining town of Trojan. The network of mining and logging roads which covers the area diverges from Crown Hill, about two miles west of Trojan.

Professors F. C. Smith and T. V. McGillicuddy, and students of the South Dakota State School of Mines, prepared a map of the "Northern Connected Siliceous-Ore District" during the field season of 1896. (See Smith, 1897, p. 22). Dr. C. C. O'Harra apparently visited the area at the same time. Smith, serving as geologist, examined many of the newly opened mines of the Ragged Top District. In a paper entitled "The Potsdam Gold-Ores of the Black Hills of South Dakota" (1897) Smith included his observations on the geology of several of these deposits. J. D. Irving spent the summer of 1898 in the Ragged Top area. His dissertation, "A Contribution to the Geology of the Northern Black Hills" (1899) dealt primarily with the intrusions of the Terry

Peak-Elk Mountain-Ragged Top area. By the summer of 1899 when Irving, Jaggar, and Emmons did the field work for their classic "Economic Resources of the Northern Black Hills" (1904) many of the workings were inaccessible, and Irving's principal contribution was a detailed megascopic and microscopic description of the ores, with some chemical analyses. O'Harra, in the first edition of "The Mineral Wealth of the Black Hills" (1902) gave geological and historical information not recorded elsewhere. "Black Hills Illustrated" (1904), edited by G. P. Baldwin, provides anonymous, semi-popular descriptions of several Ragged Top properties. Scattered reports on mining, milling and fiscal operations may be gleaned from weekly issues of the "Black Hills Mining Review", and from annual "Reports of the State Mine Inspector". Although Darton and Paige remapped the area for the "Black Hills Folio" (1925), they were content to summarize Irving's descriptions of the district. J. P. Connolly, who made exhaustive studies of the Cambrian and Precambrian ores in preparation for his dissertation, "The Tertiary Mineralization of the Northern Black Hills" (1927), did not study the deposits in the Pahasapa formation, and in turn quoted Darton and Paige's summary of Irving's earlier work.

Except where specifically stated otherwise, all references to values of ore or production are based on the old ($20 per ounce) price of gold which prevailed throughout the productive life of the Ragged Top mines.

4.72 History of the Ragged Top Mining District

Gold was discovered in the Ragged Top area in 1896. The period from 1896 to 1900 was one of selective mining during which high grade ores were shipped to smelters outside the area. From late 1900 to 1906 large tonnages of low grade ore were treated by the cyanide process at mills adjacent to the larger mines. A few short mill runs are recorded between 1912 and 1916, but the additional production was small. Except for systematic sampling and testing of a few of the major properties in 1938, there has been no mining or exploration activity at Ragged Top since the start of World War I. Miller (1962, p. 75) states that ore from selected dumps in the Ragged Top District was milled by the Bald Mountain Mining Company in 1957-1958.

The nearest railroad service to the Ragged Top District was at Crown Hill Station (Fig. 6), on the Burlington branch line between Englewood and Spearfish. This settlement was approximately two miles south-east of Dacy, hence not close enough to the mining operations to serve as a living or service center. For a short time a rush to establish new townsites near the mines threatened to overshadow the promotional activities at the mines themselves. (See maps of Robinson, 1897; Vincent, 1898; and Peck, 1900, 1904).

Mining on Dacy flat began in the summer of 1896. A settlement, soon called Dacy, grew near the Dacy shaft, on the east end of the Flora E No. 1 lode and the west end of the Iva claim. At least one small hotel, and several cabins were built.

Wall, Rouse, and Madill laid out the townsite of Balmoral on the east flank of Ragged Top in October 1896. The town, which occupied the Morning Star, and the Anchor Nos. 1, 2 and 3 claims, grew rapidly. The population exceeded 150 men by early November. A hotel, assay office, saloon, feed store and stable, and several stores were in operation, and another hotel and numerous other commercial buildings were started by the time the bubble burst the following year. Many residences were built and the settlement continued to be occupied long after commercial interests moved elsewhere[1].

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[1]The Balmoral townsite is labelled Cyanide on the 1:62,500 geologic map of the Lead Quadrangle in Folio 219 (1925) and Preston on the Savoy 7 1/2 minute quadrangle topographic sheet (1951).

In November of the same year, Kellar and Preston staked out a townsite a quarter of a mile farther north on the Nerve Nos. 1 and 2 claims, where a short, north-draining tributary enters Long Valley. This town was originally called Nerve City, but by February 1897 was renamed Preston. The town served as a focal point for mining operations in the Ulster area on the north side of Long Valley.

In January 1897, 90 acres adjoining Balmoral on the southwest was set aside as a townsite called Ragged Top. It was located at the head of Calamity Gulch on the Alaska Group of lode claims, in the northwest corner of sec. 33 and the northeast corner of sec. 32, T. 5 N., R. 2 E. Although this location was convenient for prospectors working on the south and southwestern sides of Ragged Top, exploration there did not develop beyond the prospecting stage, and the town apparently never consisted of more than a few cabins along the sides of the draw. Smith (1897, p. 22, and Irving, 1899, Pl. 13) show the Raun cabin within this townsite.

Numerous buildings at Dacy were dismantled or moved when the American Mining Company decided to drift under the Dacy area from Spearfish Canyon. American City was established in the fall of 1899 on the east side of Spearfish Creek, just above (south of) the mouth of Long Valley, in the center of the east side of sec. 19. This, like Dacy, was a company town established without the promotion and fanfare which accompanied the founding of Balmoral, Preston, and Ragged Top.

With the building of the Spearfish Gold Mining and Reduction Company mill on Johnson Gulch in late 1900, a fair sized town (Cyanide Postoffice) developed on the Hermitage Group of claims near the corner common to secs. 29, 30, 31, and 32. The following year a small settlement grew up around the new

Deadwood Standard mill in the NW 1/4 SW 1/4 sec. 32. Apparently it had no formal name.

Two settlements grew up around the operations of thr Victoria Gold Mining Company. A camp, complete with running water, located in the SW 1/4 SE 1/4 sec. 17, served the mining operations on the limestone plateau, and another camp developed at the railroad spur and mill in Spearfish Canyon.

4.73 Geology of the Ragged Top Mining District

4.73.1 Stratigraphy

Less than 1,100 feet of gently dipping Paleozoic sedimentary rocks are present in the Ragged Top area. They range from Late Cambrian to Early Pennsylvanian in age. The pre-Paleozoic erosion surface on which they rest has a local relief estimated at 50 to 80 feet.

Deadwood Formation.—The Deadwood formation consists of sandstone, quartzite, conglomerate, shale, argillaceous limestones and dolomites, and a distinctive edgewise intraformational conglomerate. In the Ragged Top area, only the upper part of the formation, consisting of slabby sandstones and dolomites, is exposed. The uppermost bed, which is an excellent stratigraphic marker, consists of a white to pink-stained quartzitic sandstone with abundant worm borings. It varies from a few inches to a few feet in thickness. This is the *Scolithus* sandstone.

Diamond drill holes Nos. 1 and 2 (see Appendix), put down by the U. S. Geological Survey at Dacy in 1968, cut 445.8 and 461.7 feet of Deadwood, including 93.5 and 114.9 feet respectively of basal quartzite and conglomerate. This is an unusually large thickness for the lower member.

Winnipeg Group.—The middle Ordovician is represented by 60 feet of green shale, locally called the Ice Box member, overlain by 25 to 30 feet of white to greenish-gray argillaceous siltstone, the Roughlock member. Neither is well exposed in the Ragged Top area, but good outcrops are evident at numerous points along the sides of Spearfish Canyon.

Whitewood Formation.—The Whitewood dolomite consists of mottled buff to red granular dolomite containing characteristic chain corals, straight orthocone cephalopods, and a *Maclurites*-like gastropod. A thickness of 56 feet was measured near the mouth of Long Valley. In drill holes at Dacy, 36 1/2 and 49 feet were logged.

Englewood Formation.—Along Spearfish Canyon, the Englewood formation consists of buff to pink dolomitic limestone. A thickness of 41 feet of Englewood was measured near the mouth of McKinley Gulch (C E 1/2 sec. 5, T. 4 N., R. 2 E.) where the complete section is well exposed at a point between two forks of the gulch. Forty-six and 52 feet are recorded in the Dacy drill holes. The lower shale unit of the Englewood formation, present at Deadwood, has not been seen in Spearfish Canyon, but some shale appearing on dumps within the townsite of Balmoral, on the east side of Ragged Top, bears a close resemblance to the basal Englewood shale at Deadwood.

Pahasapa Formation.—The Pahasapa consists of several hundred feet of limestone, dolomitic limestone, and dolomite. Outcrops along Spearfish Canyon suggest an alternation of massive, cliff-forming members and thin-bedded units which weather to steep, talus-covered slopes. We have not measured a detailed section.

Although earlier workers suggest a thickness of 580 to 630 feet in Spearfish Canyon, our observations suggest 490 feet at the Deadwood Standard property, under the divide between McKinley and Johnson Gulches. There is not over 450 feet of Pahasapa present at Dacy. At Victoria, on the divide through which the Homestake Mining Company aquaduct is driven, a thickness of 570 feet is calculated. These thicknesses are consistent with the regional isopach map (Gries and Mickelson, 1964, Fig. 2, p. 110).

Minnelusa Formation.—Remnants of basal Minnelusa formation have been noted in the Deadwood Standard and Victoria areas. On the divide between Johnson Gulch and Spearfish Creek, in the SE 1/4 sec. 31, T. 5 N., R. 2 E., at least three small remnants of sandy red shale and sandstone have been studied (Plate 14). These appear to be original deposits of basal Minnelusa (of early Pennsylvanian age) in low spots on the pre-Minnelusa Pahasapa erosion surface, and suggest that essentially the full thickness of the Pahasapa formation remains on the divide. A somewhat thicker red shale section, probably filling a sinkhole in the old Pahasapa karst topography, is preserved beneath a small sill at Victoria, on the line between secs. 17 and 20, T. 5 N., R. 2 E. (See Plate 3).

Tertiary sediments.—Clays and gravels similar to those which Darton and Paige have mapped elsewhere in the northern Black Hills as White River Group (Chadron and Brule undifferentiated) were discovered on the Black Diamond Group in the Spearfish Gold Mining and Reduction Company area. A shallow shaft, just east of the large phonolite mass in the center of W 1/2 NW 1/4 sec. 32, T. 5 N., R. 2 E. shows the following section:

Clay, buff, well bedded	7
Gravel and boulders, limestone and porphyry . . .	5
Limestone, buff, weathered, to bottom of shaft .	1

It is likely that other remnants of this formation are concealed by vegetation.

4.73.2 Tertiary Intrusions

The Tertiary intrusives in the Ragged Top area are typical of those throughout the northern Black Hills, both as to composition and geometry.

In the Ragged Top area, the intruding magmas showed preference for certain zones of weakness within the sediments, notably at or near the base of the Deadwood formation, in the middle of the shale and edgewise conglomerate section of the Deadwood formation, just beneath the upper ore zone, just below the Scolithus sandstone, in the Ice Box shale member of the Winnipeg group, at or near the base of the Englewood formation, and at or near the top of the Pahasapa limestone. Numerous sills, of which only fragments remain, forced their way into the detrital section at the base of the Minnelusa formation. Larger sills often broke across from one zone to another so that two or three sets of stratigraphic relations may be worked out for a single intrusion.

The thinner intrusions often wedge out to a feather edge around the margins but thicker ones usually raised the overlying rocks, with movement probably along joint planes. The rocks above such intrusive bodies appear to be faulted, and the contact around the margins of the sill is vertical with igneous rocks abutting horizontal sediments. Many of the contacts on the accompanying maps are of this type.

Elk Mountain is capped by 150 to 170 feet of grorudite overlying essentially horizontal Pahasapa limestone. Irving (1899, p. 232) studied it carefully when several of the peripheral workings were accessible. Since the original shape of the igneous mass cannot be determined from the existing remnant, it is impossible to say whether it represents a thick sill or the basal section of a larger, laccolithic mass.

Four small outliers of phonolite west of Elk Mountain in sec. 32 appear to be remnants of a once-continuous sill intruded at or near the top of the Pahasapa limestone. Irving considered it to be related to the Ragged Top upheaval. The most westerly of the four outcrops, at the Black Diamond mine, is described more fully elsewhere in this report.

The Ragged Top intrusive mass is a complex, and possibly a compound intrusion. Heavy talus and dense vegetation make it difficult to map in detail. Irving (1899, p. 212-218) studied it when many of the workings were open and the vegetation was less dense. He concluded that the intrusion was emplaced in the upper part of the Deadwood formation. From a study of the Badger shaft (Appendix) on the north side of the intrusion, he decided that the north margin, at least, was bounded by a fault. Jaggar (1901, p. 241) considered the faulting to be of minor importance in the emplacement of the intrusion. On the basis of this shaft, which collared in Deadwood shales beneath talus, Irving's areal maps (1899, 1904) as well as those of Darton and Paige (1925) show a thin band of Deadwood and Englewood formations along the north boundary of Ragged Top. No natural outcrops have been found.

At the west end of Ragged Top, Pahasapa limestone can be found within inches of the porphyry, suggesting that the faulting across the north side wraps around the west end, and perhaps extends even farther to the southeast.

A band of topographically low ground on the east, southeast and south sides of Ragged Top is separated from the upstanding part of the intrusion by a belt of heavily timbered talus slope. On the south side of Calamity Gulch, continuous outcrops of Scolithus sandstone, Winnipeg shale, Whitewood dolomite, and Englewood limestone have been traced. Below the Scolithus sandstone to the bottom of Calamity Gulch, we have mapped weathered porphyry.

Irving (1899, p. 217) implies that this slope is largely underlain by Deadwood shales with several porphyry sills. However, the Raum drill hole (Appendix) near the head of Calamity Gulch, penetrated nothing but porphyry to a total depth of 375 feet. We could not trace the Scolithus-Englewood sequence of outcrops westward across Calamity Gulch. We suggest that they are cut off and dropped to the west by a fault.

At the east end of Ragged Top the Pahasapa outcrop swings away from the intrusive. The Englewood-Scolithus sequence is also cut off. The basin between the heavy talus slope of Ragged Top and the limestone rim seems to be carved in shale. Some looks like Deadwood formation, and some like the lower shale of the Englewood formation as developed on Whitewood Creek at Deadwood. At least one of the drifts or shafts within the Balmoral townsite penetrated the Englewood formation. Material from this dump has been used as road metal with the result that some of the "outcrops" of Englewood in that area are man made. Irving suggested (1899, p. 217) and we agree, that small knobs of porphyry east of Ragged Top are minor intrusions into the shales,—formed perhaps before the main mass broke through the Pahasapa limestone.

Irving used the concept of differentially uplifted blocks of limestone to explain the unique, double-crested shape of Ragged Top (see Fig. 9). He considered that other faults, both radial and peripheral, were formed in this manner. He suggested also (1899, p. 202) that the verticals at Dacy, with their attendant brecciation, may be faults. Except for O'Harra's marginal note on slickensides (Fig. 10) this is the only suggestion of the fault origin that we have encountered. Our own observations have not suggested any displacement across these verticals as would certainly be expected if there had been sufficient movement to cause extensive brecciation.

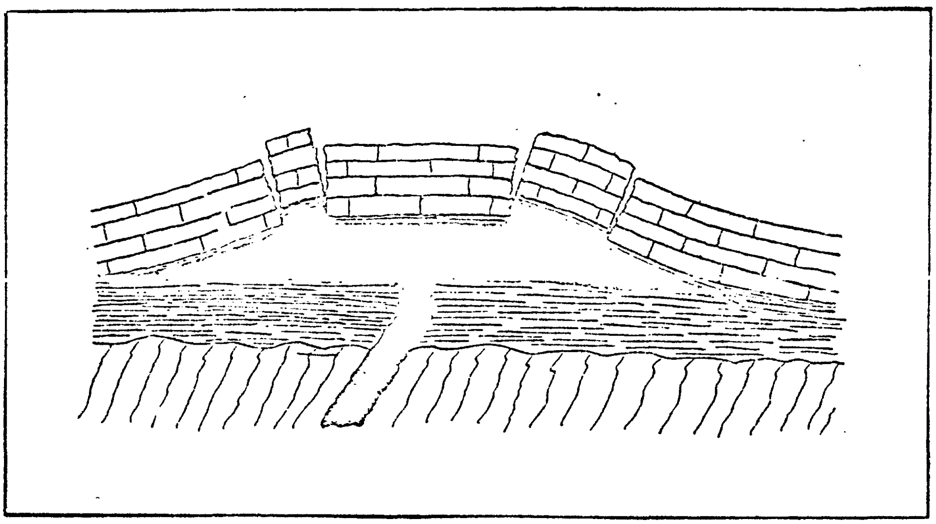


Figure 9. Cross-Section Through Ragged Top Mountain
(from Irving, 1899)

depth. In the Doyle vertical lateral enrichments occur and also in the Metallic Streak Mine on the ridge south of Calamity Creek.

The ore is essentially a silicified mass of brecciated limestone fragments, which are stained with iron oxide and which contain calcite in the lower grade ores. The general run of ore, however, is hardly to be distinguished from the limestone except that it is very slightly darker and is very hard, being an almost complete replacement of the limestone. Porphyry is not present in these verticals.

The line where the ore is cemented to the wall rock (see diagram) is often clearly marked, but the structural details, such

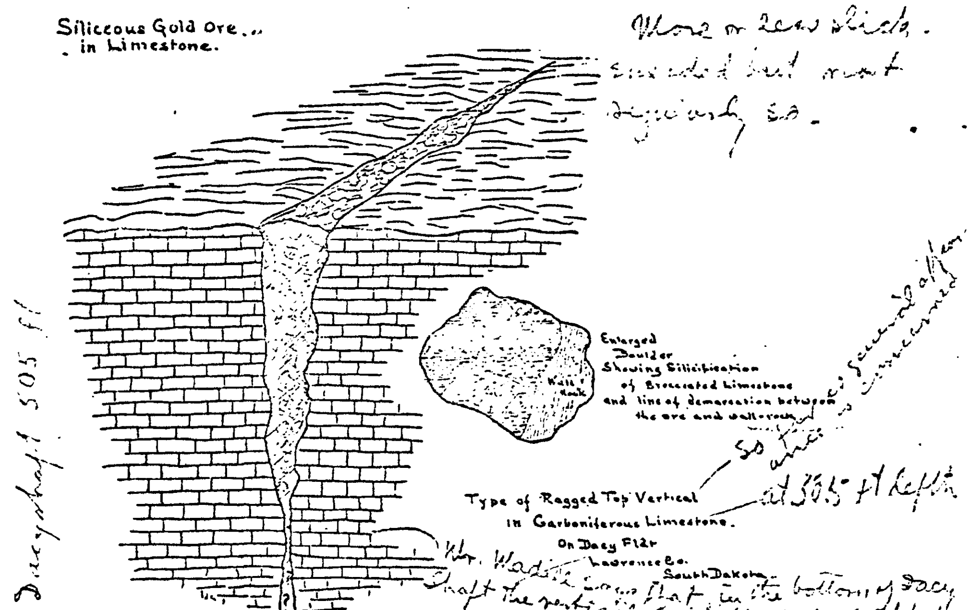


FIG. 20. Diagram in perspective to illustrate the character of the Ragged Top Verticals.

as banding etc., pass from the one into the other, and it is only possible to tell them apart, from the slightly darker color and greater hardness of the ore. The ore in the Metallic Streak Mine, is often brilliantly stained with fluorite. No

Figure 10. Idealized Section of Dacy Vertical (from Irving, 1899. Marginal notes by C. C. O'Harra)

Smith (1897, p. 420) considered the phonolites to have been among the last of the intrusive series, and credited the vertical fractures at Dacy to emplacement of the Ragged Top mass in a manner not specified.

A complex intrusion of quartz monzonite porphyry bounds the northeast side of the Ragged Top District. The intrusion has invaded the Deadwood formation in at least two horizons, as well as intruding at the base of the Whitewood dolomite, and near the top of the Pahasapa formation. For much of its length, the western margin is a vertical fault contact with Pahasapa carbonates. A block of Deadwood formation has been raised on the northwest flank of Twin Peaks, and a long, narrow, westward dipping outcrop of Deadwood is sandwiched between porphyries on the west side of Redpath Creek. Remnants of the same stratigraphic unit of the Deadwood cap two high points on the ridge between Redpath and Labrador Gulches. Half a mile south of Squaw Creek a northwest-southeast fault offsets the beds. North of the fault, the sedimentary rocks are uplifted and tilted westward.

In the Ulster area, part of the intrusion is a normal sill, whereas the remainder has cross-cutting relationships with the Pahasapa formation.

The crescentic outcrop of Deadwood formation on the west side of Redpath Creek has been extensively explored by drifts. Several of these were examined. Numerous dikes are in evidence, cutting across from the sill below the Deadwood inlier to the sill above it. Oxidized gouge along the Deadwood-dike contacts appears to have been the objective of the prospector. Two samples of this material each showed only a trace of gold.

4.73.3 <u>Types of Ore and Distribution</u>

Ore bodies in the Ragged Top District fall into three categories:

(1) Low grade blanket deposits in dolomite or dolomitic limestone. These are generally associated with fairly persistent, silicified carbonate layers and often lie just below thin beds of dolomitic limestone which have been leached to a residual dolomite sand or even to a greenish, clay-like material. The ore bodies at Victoria, Deadwood Standard, Metallic Streak, and probably the lower workings on the Warren lode at Ulster belong in this category. Figures 12 and 15 illustrate this mode of occurrence.

(2) Deposits in dolomite and dolomitic limestone, above, below, or adjacent to masses of greatly altered porphyry. No strong mineralization has been noted in association with fresh igneous rock. It is not clear whether mineralization accompanied the intrusions of the porphyry, or whether the porphyry was affected by the same mineralizing solutions which brought in the gold. Both Smith (1897) and Irving (1899, 1904) considered the possible relationship of the intrusions to the ore bodies, but further work needs to be done on this relationship, and on the relative age of the intrusion of the several types of igneous rocks. Deposits at Ulster and on the Black Diamond property fall into category 2. Figure 13 may be typical.

(3) Deposits definitely associated with sharply defined vertical fractures as at the Dacy flat. Silicification and gold mineralization of the wall rock occurred only for a matter of a few inches to a few feet laterally, but extended for many hundreds of feet along the individual fractures, and to depths of 50 to 60 feet below the present surface.

The commercial ore bodies were distributed around Ragged Top in a manner which may be entirely fortuitous (See Fig. 6 and Plate 2). Most of them occur on narrow divides, or adjacent to sharp drainages suggesting that they may be erosional remnants of somewhat larger deposits whose original shape and orientation may only be inferred. A general northwest trend to the ore bodies may be due more to the northwest trend of the present topographic features than to original distribution. Only at Dacy are clearly defined orientations present, and even here it is to be noted that the mineralized area itself has its long dimension in a northwesterly direction, nearly at right angles to the strike of the individual vertical fractures. Until detailed joint studies are made in the mineralized areas, and until more is known of the Precambrian structure, little can be concluded about the significance of structural control on the distribution of the ore bodies around Ragged Top.

The Ragged Top area is on the northwestern side of the Bald Mountain-Ruby Basin District, where mineralization was well developed in the Deadwood formation, but where the Pahasapa carbonates are missing by post-Laramide erosion. If the Pahasapa formation were originally mineralized above part or all of the productive areas within the Cambrian rocks, as seems entirely reasonable, there is equally good reason to anticipate mineralization in the Deadwood formation beneath the remaining mineralized parts of the Pahasapa formation in the Ragged Top District. It is to be noted that there is mineralization in the Deadwood formation in Annie Creek to the south of Ragged Top (Reliance Gold Mining Company) and in Squaw Creek to the north and northeast of the Ragged Top plateau. As to why there is no strong evidence of mineralization in the Deadwood formation in Spearfish Canyon, we can only suggest that the canyon is too far west of the center of mineralization.

4.74 Mines of the Ragged Top Mining District

4.74.1 Dacy

Historical sketch.—The initial discovery in the Dacy area was made by

A. J. Smith in 1886. The ore reportedly contained silver but was of much lower grade than that then being developed at Carbonate Camp two and one-half miles to the northeast. After sinking a shaft to an unrecorded depth on what was then called the Silver Ridge claim (Fig. 11), Smith and his a associates abandoned the property.

The area lay dormant until the spring of 1896, when a chance analysis of iron-stained siliceous boulders by F. M. Wall resulted in a minor gold rush to the flat between Long Valley and Jackass Gulch (the north fork of Calamity Gulch). Wall, Rouse, Murray, and Madill located the Balmoral group in the southeastern part of the area (Fig. 11), while Starner Brothers, operating as the Ragged Top Mining Co., staked the Eva II and Silver Tongue lodes, and Johnson and Whiting located the Iva and Gossan claims. The Flora E group to the west was staked by W. H. Dacy and associates. The Small Fraction lode was owned by L. Eilenberg. Ellington and Geddes staked the Badger group between the Dacy ground and Ragged Top.

Early development indicated that the ore lay in narrow verticals whose surface position was marked by lines of gossan in the form of iron-stained siliceous boulders (Fig. 10). The ore seldom occurred in mineable widths below a depth of 50 or 60 feet. To explore in greater depth, the so-called Dacy shaft was sunk on the Flora E No. 1 claim near the southwestern end of one of the stronger ore shoots. It was started in August 1896, and sinking was discontinued in mid-June 1897 at a depth of 430 feet. In May 1898, Dacy and Kilpatrick Brothers, owners of the Dacy group, took options on adjacent claims, and formed the American Mining Company. Work was resumed on the Dacy shaft in February 1899. Water problems were reported at about 500 feet, and sinking was discontinued at 505 feet. A diamond drill was immediately set up

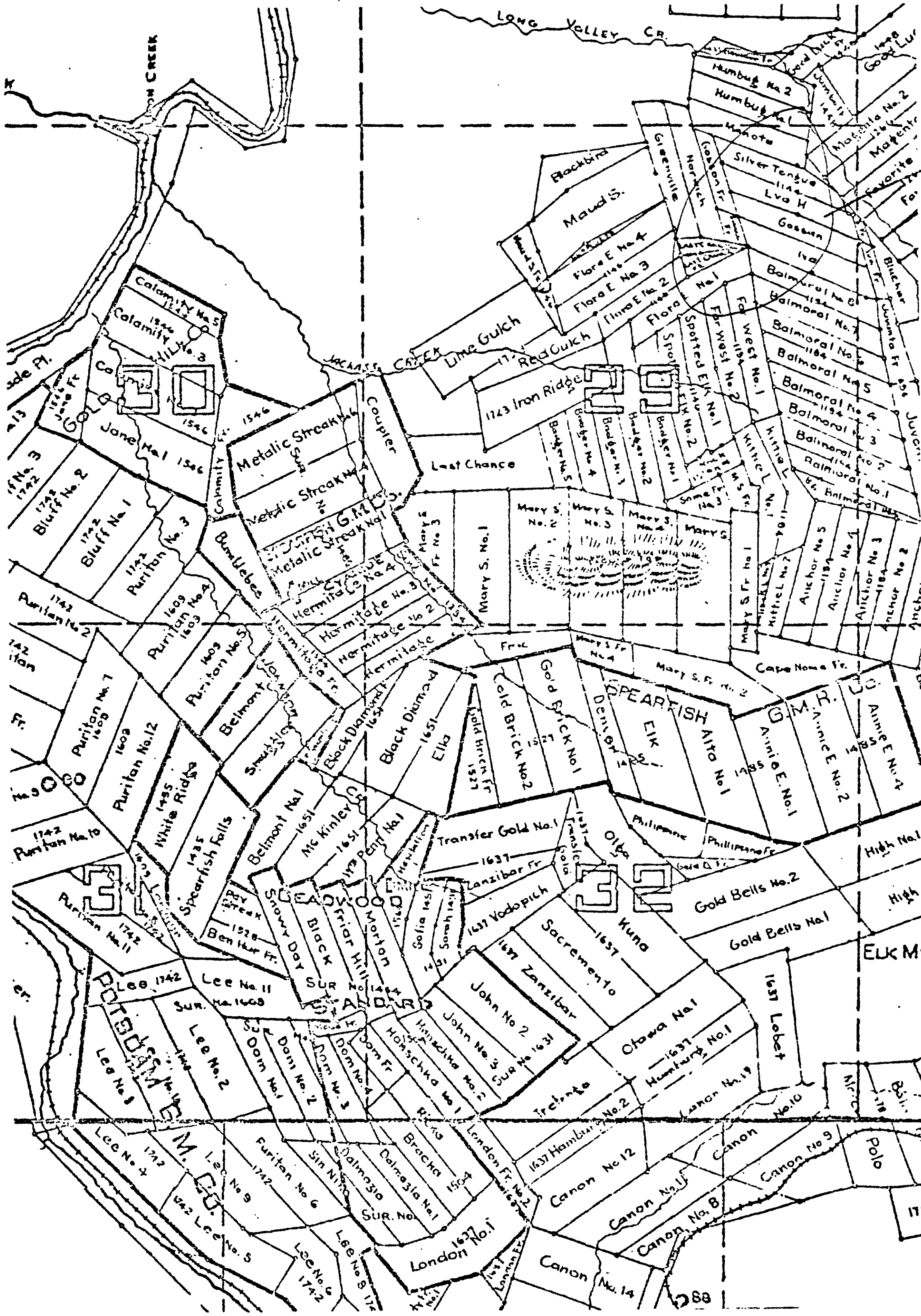


Figure 11. Claim Map, Ragged Top Area

in the bottom of the shaft. By October, a total depth of 1013 (or 1035) feet had been reached, and the lower quartzite of the Deadwood formation penetrated (See log, appendix III, IV). A 37-foot phonolite sill was encountered within the lower part of the Deadwood formation, and a trachyte sill was entered just below the quartzite. The hole was bottomed in the sill.

On the strength of ore showings reported at the lower contact the company moved operations to Spearfish Canyon, just above the mouth of Long Valley. In November 1899, sinking began on a shaft, the collar of which lies roughly 40 feet below the top of the Deadwood formation. No log of this shaft is available, but it is reported to have encountered quartzite at 350 feet. Drifting was then started, on top of the quartzite, toward the Dacy shaft 5,750 feet to the southeast. Contemporary reports indicate that diamond drill holes were put down into the underlying schists at undetermined intervals. About 2,000 feet of drift had been driven, and a reported $200,000 spent, when the project was abandoned in late 1901.

Back on the Dacy flat, owners and leasors continued mining the shallow ores until about the end of 1899. The area then lay idle until 1938, when Ragged Top Mines, Inc. assembled a group of about 20 claims, cleaned out several old workings, and did extensive sampling. Allsman (1940, p. 51, 52) states that construction had been started on a 75 ton per day batch cyanide mill at the time of his examination in the summer of 1938. The mill was not completed, and nothing appears to have been done on the site since the time of Allsman's visit. As mentioned in the general historical summary, Miller (1962, p. 75) states that most of the ore remaining in dumps in the Dacy area was milled by the Bald Mountain Mining Company in 1957 and 1958.

At the present time, taxes on the Balmoral property are being paid by Elizabeth Blatchford.

Geology.—The Dacy flat is a dip slope underlain by medium- to thin-bedded Pahasapa dolomite. It is bounded on both the Jackass Gulch and Long Valley sides by 10- to 30-foot precipitous dolomite cliffs, which then give way to more gentle talus or colluvium covered slopes.

Plate 14 shows the center of the Dacy area as it appears today. The position of the verticals is evident, either from ridges of broken rock thrown out to the sides, or simply from deep trenches where mining or caving has extended back to the surface. It is obvious from the map that the verticals are slightly sinuous to arcuate. The average strike of each of the principal verticals is shown along the right hand margin. They may be seen to fall into two sets, one with bearings ranging from N. 52 to 63^{o} E., the others N. 35^{o} to 40^{o} E. Apparently the verticals are rightly named, because all accounts agree that the Dacy shaft followed the Dacy vertical from the grass roots to the total depth of 505 feet.

Much of the rock thrown out beside the verticals is silicified and some is finely brecciated. The breccia is invariably recemented, either with calcium carbonate, silica, iron oxide, or a combination thereof.

In the few workings which we entered the walls were normal, but somewhat weathered, dolomite. In one opening, from which no ore had been removed, the rock was buff "dolomite sand" grading laterally to harder, less weathered dolomite. The "sand", so common in Black Hills caves, and along vertical fractures throughout the dolomitic parts of the Pahasapa formation, consists simply of minute rhombs of dolomite, uncemented by calcite. One sample of this material, taken from the second vertical south of the Daçy vertical, contained no detectable gold.

Two drifts have been driven for a short distance beneath the Dacy flat from the southwest side of the Balmoral No. 7 lode (Plate 14, T.P. 5). The east drift is accessible. The drift is divided into two branches, in both of which the lower 1 to 3 feet of the drift is cut in hard, massive dolomite which weathers dark gray. Above is softer, buff weathering dolomite. About waist high in both drifts there is an oxidized streak of soft to hard, red to buff, gouge-like material. From the way this has been dug out in pockets, it was apparently ore. A few similar pockets of gouge-like material in, or close to, the back, have also been "gophered out". A sample of gouge from the east branch showed 0.8 ppm gold; a similar appearing sample from the west drift carried no measurable gold.

Professor F. C. Smith (1897, p. 15) of the South Dakota State School of Mines, seems to have been the first mining geologist to have recorded his observations on the Dacy area, and he may have been the only geologist to enter the Dacy shaft. He states:

> " . . . In the vicinity of the Dacy mine, gold was first discovered in boulders and pebbles, usually of a reddish color and resembling in most respects the ordinary ores of the Potsdam; further exploration developed wedge-like lenses of similar ores, frequently rich in gold and tightly encased in limestone, together with loose boulders of the material. These deposits were at first supposed to pinch out within a few feet of the surface, but recent deeper working has proved that they can be traced deep into (if not quite through) the limestone, though in places they thin down to a mere streak . . .
>
> "In the Dacy shaft, which is now at a depth of about 385 feet and is evidently nearly through the limestone, the crevice or fissure through which mineralization has occurred may be seen. In places it is still open, with no filling; again, it is filled with a breccia of silicified limestone fragments, cemented by crystalline calcite; wherever the walls are visible may be seen eminent siliceous incrustations rounding off the angular points of the fractured limestone. Irregularly scattered through the limestone are many bluish translucent flinty nodules of varying sizes; these, in some cases, are said to be rich in gold, though I have not yet found a sample which yielded over $12 in gold per ton upon assay. At another working upon the Dacy ground it has been found

advisable to screen the ore coarsely as it comes to the surface. In this way a fine material, consisting largely of carbonate of lime, and carrying small value in gold, is separated from the coarser and highly siliceous material which is shipped to the reduction works.

"In light of the present development of the Dacy mine it is impossible to determine the shape of the ore-body at any considerable depth below the surface or to offer further description of it. It is, however, safe to say that the mineralized portion of the deposit is generically connected with the fissure already described."

With regard to the origin of the Ragged Top ores in general, O'Harra (1902, p. 44-45) said:

"The origin of the Carboniferous ores is practically the same as that of the Cambrian ores. Siliceous solutions carrying gold have removed original calcite, leaving silica instead, the exchange taking place subsequent to the intrusion of the igneous rocks in post-Cretaceous time. The ore bodies are vertical on the Dacy flat and elsewhere, approximately horizontal in the properties owned by the Spearfish and Deadwood Standard mining companies, and irregular in the Ulster. The intrusions have affected the country rock differently in the different localities, and the various positions and shapes of the ore masses are simply due to the form and direction of the particular fissure through which the solutions reached the limestone."

Irving (1904, p. 176-177) said:

"The general character of the ores is such that they may be readily seen to be replacements of limestone by silica and fluorite with small quantities of gold, silver, and tellurium. Whenever sufficiently exposed to permit of observation, they are associated with fractures which, in the case of Ragged Top deposits, have been traced downward for more than 300 feet. It is is assumed that the deposits were formed by ascending solutions the differing lithologic conditions will account for their difference from the siliceous ore bodies, which is chiefly one of form. The country rock here is a massive, homogeneous limestone in which there seems to be nothing that would favor a concentration of ore at any particular horizon, whereas, in the Cambrian deposits, there have been impervious shale beds or sheets of porphyry which have caused the mineralization to spread out away from the verticals at definite horizons."

Irving (1904, p. 173-174) offers the only microscopic description of the ores:

"Examined under the microscope the ore is found to consist chiefly of secondary quartz in irregularly bounded individuals, which do not show crystalline boundaries except where open spaces have allowed their formation. A little opaline silica is also present. The yellow color seems to be due to the presence of a uniformly distributed pinkish-brown pigment, which is spread between the grains of quartz in such thin films that its character cannot be definitely determined. Some of the richest portions of the ore show minute opaque particles, that may be metallic. In one specimen of ore, carrying $3.05 per ton, a small speck of metallic mineral resembling sylvanite was detected, but in general tellurides, if present, have been completely oxidized."

Milling and production.—According to Baldwin (1904, p. 129) the first ores were shipped from the Balmoral group in July 1896. By July 1897, at least 9 owners and leasors were making steady shipments from the Dacy flat. Recorded production apparently is limited to the years 1896-97, but contemporary reports indicate periodic shipments into mid-1899. Because the ores were shipped concurrently to custom smelters at Deadwood, Aurora, Ill., and Kansas City, Mo., and because two or more leasors might be shipping from the same claim under different names or from the same vertical on adjacent claims, no good production statistics for individual lodes or verticals have been preserved. Baldwin (1904, p. 129) states that $250,000 in gold was taken from the Balmoral, Dacy, Starner, Ulster, Little Bud, and McPherson and Gray groups, of which $60,000 was from the Balmoral group. O'Harra (1902, p. 43) gives identical figures for essentially the same group of mines. However, the Ulster, across Long Valley to the northeast, and not part of the Dacy flat group of mines, is reported by the U. S. Brueau of Mines (1954, p. 88) to have produced up to $50,000 through 1899. The Little Bud was a productive part of the Ulster group (Plate 17). The McPherson and Gray property has not been identified. It may be the old Doyle ground, which was the west end of the most northerly vertical (Doyle vertical) on Dacy flat. If we credit the

Ulster, and other claims north of Long Valley with a total production of $100,000, we have a rough figure of $150,000 as the value of ore removed from the verticals on Dacy flat.

Potential.—There is little evidence that sufficient lateral enrichment occurred at Dacy to produce blanket deposits of the type found at the Deadwood Standard, Spearfish, or Victoria properties. Irving (1899, p. 312) mentions lateral enrichment in the Doyle vertical, but does not elaborate upon the statement. It is unlikely that any vertical remains undiscovered on Dacy flat. All known verticals seem to have followed down on the ore as far as practicable. The only suggestion that there might be ore deeper within the Pahasapa formation is the report of lateral drifting at the 110 and 270 foot levels in the Dacy shaft (Appendix VI). However, had ore been discovered at those levels, certainly shafts on other nearby properties would have been deepened to corresponding depths.

No information relative to mineralization of the Deadwood formation was released at the time the diamond drill hole was put down in the bottom of the Dacy shaft. Contemporary newspaper accounts make no mention of possible ore development at the upper contact or ore zone of the Deadwood formation. It seems almost certain that if ore had been discovered, an attempt would have been made to deepen the Dacy shaft the necessary 125 to 150 feet to reach it.

When the drill reached the lower contact zone, rumors of an ore strike were rampant. The sudden decision of the American Mining Company to drift in under the area from Spearfish Canyon, at an estimated cost of $1 million did nothing to allay the rumors. By the time this drift had extended 2,000 feet, the verticals in the Pahasapa on Dacy flat had been exhausted, and interest in the area dropped when the American Mining Company quit drifting still 3,750 feet from the supposed ore body encountered by the drill hole at Dacy.

An unpublished report (Henry Beeler, 1925) mentions another attempt to explore the basal quartzite beaneath Dacy by means of a 1,000-foot inclined tunnel driven southwestward from the bottom of Long Valley in the extreme southeastern corner of sec. 20. We have found no other reference to this effort. However, there is a fairly good sized dump, and a caved drift at this point. At the portal, the drift has a S. 80° W. bearing; there is no indication that it was inclined. The elevation is 210 feet below the collar of the Dacy shaft. The volume of the dump may indicate a few hundred, but not 1,000 feet of drifting. Material on the dump is mostly gray Pahasapa limestone, but there is also abundant weathered, buff porphyry. If the drift were projected with the above bearing, it would pass 1,250 feet north of the Dacy shaft.

Following the present detailed mapping of Dacy flat, the U. S. Geological Survey sank two diamond drill holes to the Precambrian in 1968. Hole No. 1 was located on the northeast side of the area, at the junction of the Doyle and Dacy verticals (Plate 14). The second hole, 1500 feet to the southwest, lay at the projected intersection of the Dacy vertical, and the next strong vertical south of the Dacy.

Of 22 samples taken from the top 60 feet of both cores, only 3 contained traces of gold, and 7 showed low silver values. This was somewhat disappointing in view of the proximity of the drill holes to the verticals from which high grade gold ores were mined in years past. In both cores traces of silver occurred throughout the Pahasapa limestone section wherever "sanding" of the dolomite occurs, or in slightly vuggy zones with pinpoint porosity.

Low gold values were noted in the lower and upper contacts of the Deadwood formation. Low silver values were also present in the basal part of the lower contact zone and in the adjacent upper part of the basal quartzite.

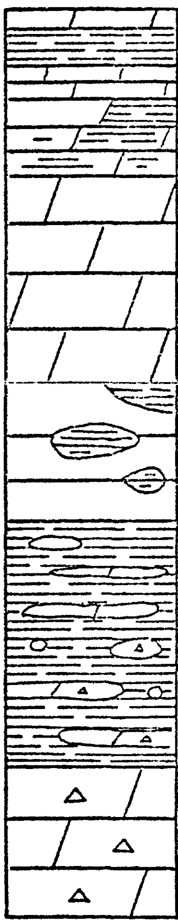
Should additional test drilling be considered, the hole(s) should probably be more centrally located with respect to the old workings.

4.74.2 Deadwood Standard Gold Mining and Milling Company

Historical sketch.—The Deadwood Standard Gold Mining and Milling Company was organized in 1900 to develop and operate the Ed Hanscha and Old Slavonian properties south of Ragged Top. These totaled about 212 acres of mineral claims in secs. 31 and 32, T. 5 N., R. 2 E., and in sec. 5 of the adjacent township. Included were Mineral Surveys 1464, 1491, and 1560 which are shown in part on Plate 15; Mineral Surveys 1504, 1631, and 1637 to the south; and Mineral Surveys 1435 and 1528 to the northwest of the mapped area (See Fig. 11).

The company built a mill which it operated from 1902 to 1904. It was also operated under lease for short periods in 1912, 1914, and 1916. There has been no activity at the property since World War I. At present, taxes on the property are being paid by Fenton Brothers Foundation.

Geology.—The early geologists who have given accounts of the other Ragged Top mines have left no description of the Deadwood Standard properties. Our study of the workings indicates that the ore deposits were very similar to those of the Metallic Streak group three-fourths of a mile to the north, and to those at Victoria, 3 miles to the north. Ore seems to have lain above an undulating bed of silicified carbonate which is more or less iron-stained, and to have been capped by layers of greenish "clay". Figure 12 is a section measured inside an exploratory drift extending south from Sta. 3, Plate 14.



Thickness	Lithologic Description	Sample number and value
20 in.	Carbonate, weathered, alternating with layers of greenish clay formed from decomposition of carbonate. Grades from hard rock to clay	52-32-G-56 (0.53 ppm Au)
20 in.	limestone, dolomitic, massive-bedded.	
24 in.	limestone, dolomitic, buff, blocky to rubbly, with pockets of red "gouge"	52-32-G-57 (2.2 ppm Au)
30 in.	gouge, mostly red, with siliceous nodules and ledges of silicified carbonate	52-32-G-58 (1.8 ppm Au)
12 in.	carbonate, massive bedded, completely replaced by silica. Druses give sparkly appearance underground.	52-32-G-59 (0.1 ppm Au)

Figure 12. Measured Section in Adit, Deadwood Standard Mine

A maximum thickness of 8 to 10 feet of ore was mined. Although the trend of the mined-out area is about N. 52° W. (Plate 15) there is a vague suggestion that some of the individual ore shoots had a nearly north-south alignment and others a bearing close to N. 27° W. No pronounced verticals have been seen.

Milling and production.—Encouraged by the success of the Spearfish Gold Mining and Reduction Company's original cyanide mill, the Deadwood Standard Mining Company completed a similar dry crushing, 120 ton per day cyanide mill near the head of Johnson Gulch in 1902. The operation continued into late 1903. A mill cleanup in 1904 resulted in a small bullion production for that year. Exploration in 1904 failed to develop adequate ore, and the mill remained idle for several years. It was repaired, and operated under lease to John Gray, Edward Manion, and Paul Rewman for a short period in 1912. In 1914 and 1916, it was leased for short runs by the Elk Mountain Mining and Milling Company. These three short runs treated ore from the "Slavonian Property" according to reports of the State Mine Inspector. Allsman (1940, p. 53) gives the following production figures:

Table 2.—Production data, Deadwood Standard Mining and Milling Company

Year	Ore, tons	Gold, oz.	Value @ $20	Value @ $35	Recovery per ton @ $20	Recovery per ton @ $35
1902	36,000	6,966.01	139,320.20	243,810.35	3.87	6.77
1903	30,000	4,250.00	85,000.00	148,750.00	2.63	4.96
1904	60	32.72	654.40	1,145.20	10.90	19.01
1912	8,000	397.66	7,953.20	13,918.10	0.99	1.74
1914	4,000	336.90	6,738.00	11,791.50	1.68	2.93
	78,060	11,983.29	239,665.80	419,415.15		

The State Mine Inspector's report for 1916 also credits this mill with a recovery of $10,862.47 from 6,000 tons of ore from the "Slavonian Property". The Slavonian ground is believed to be the south end of the original holdings of the Deadwood Standard Company, which was not developed during the 1902-1904 operation. Properly, production for 1912, 1914, and 1916 should not be credited to the excavations shown on Plate 15.

By January 1, 1904, the Deadwood Standard Company had paid $6,000 in dividends after 14 months operation (Baldwin, 1904, p. 172).

Potential.—The mill operated at near capacity for two years, on ore taken from a succession of open pits along the north edge of a narrow divide between Johnson Gulch and an unnamed tributary of Spearfish Creek to the south. Including a small cleanup in 1904, the mill treated 66,060 tons of ore, and recovered 11,248.73 ounces of gold, for an average recovery of $3.40 per ton. Assuming a recovery of 87 percent, which the almost identical Spearfish Company's mill attained on comparable ores, the heads had an average value of $3.92 per ton. The mill shut down for lack of ore in late 1903. According to contemporary reports in the "Black Hills Mining Review", an active exploration campaign in the first half of 1904, including exploratory drifting, test pitting, and churn drilling, found insufficient ore to justify a mill run that year. Considering that the ore horizon lies only 20 to 30 feet below the grass roots over much of the narrow limestone flat to the south of the old workings, it seems that ore should have been found if ore existed. Only if the exploratory work was not as extensive as the published reports would indicate, would additional exploration be justified within the Pahasapa formation.

The location of the ore bodies along the outcrop bordering Johnson Gulch suggests the possibility that the northern edge of the original ore body may be missing by erosion. If so, logical starting points for drill holes to explore the Deadwood formation might be north, and slightly down slope from the existing diggings, perhaps about the elevation of the old mill site.

4.74.3 Eleventh Hour

The Eleventh Hour group is located on the limestone plateau, west of Spearfish Canyon, in the center of the north half of section 19, T. 5 N., R. 2 E. Reportedly, about 2,000 feet of trenching and tunneling was done along conspicuous verticals in the Pahasapa limestone prior to 1904. Mineralization appears to have been mostly sulfide deposition, with much less silicification than in the Dacy area a mile and a half to the southeast. Joint surfaces are characterized by abundant cubes of limonite, pseudomorphous after pyrite, up to half an inch on an edge.

Apparently the mineralization carried small values in gold, for a 240 ton cyanide mill was built on the property in 1907. It operated only a short time, the gold recovery did not come up to expectations, and the project was abandoned. A note in the Black Hills Mining Review, July 8, 1904, states that the company was stockpiling shipping ore averaging $5.30 per ton.

4.74.4 Pottsdam

The Pottsdam Gold Mining Company was organized in 1902 (Baldwin, 1904, p. 170). Their holdings included a large group of claims along the east rim of Spearfish Canyon, west of Ragged Top. Extensive trenching and shallow drifting was done along verticals in the Pahasapa limestone which strongly resemble the silicified verticals at Dacy. Apparently no sizable ore bodies were developed, and no shipments have been recorded from the property. A hand picked sample of ironstained limestone and jasper collected during the present study, showed 2.2 ppm gold.

4.74.5 Spearfish Gold Mining and Reduction Company

Historical sketch.—This company was formed in May 1900 by a group of individuals from Colorado Springs, Colo., who leased the Metallic Streak and Black Diamond Groups of claims southwest of Ragged Top (Fig. 10). The Metallic Streak group, located in the SE 1/4 sec. 26, T. 5 N., R. 2 E., was located in or shortly after 1896 by J. Hattenbach, Plunkett, Dunn, and Abbott. Extensive development work had been done, and mining on a small scale was in progress, at the time of the take over. The Black Diamond group, centering in the NW 1/4 sec. 32, was the property of Albe Holmes. Details of the productive history of the Spearfish Company are reserved for the section on milling and production.

Taxes on the property are currently being paid by Fenton Brothers Foundation.

Geology of the Metallic Streak Group.—These ore bodies lie high in the Pahasapa limestone, on the narrow divide between Calamity and Johnson Gulches. As seen today, the diggings appear as a series of small open pits extending for about 1,000 feet in a N. 20° W. direction. They lie on the east side of the ridge, adjacent to a steep drop-off into Calamity Gulch. A small amount of underground work was undertaken. Irving (1904, p. 175-176) visited the property while it was in operation, and he has given the following description:

> "It comprises a series of shallow diggings from which are quarried flat bodies of red-stained limestone that are reported to carry as high as $10 to $25 per ton in gold. Associated with this ore are certain irregular patches of siliceous material resembling the Ragged Top ores in many respects, but carrying less gold, and often heavily impregnated with purple fluorite. The latter material also occurs in dense, sandy masses and in general does not carry much gold. In a few cases, there are masses of brecciated material parallel with the bedding, cemented by brown-stained silica. The deposits are small and irregular, and now so decomposed that their relationships cannot be readily appreciated."

Fulton (1902, p. 40) stated that the gold in this deposit occurred largely along cleavage planes, associated with manganese dendrites.

We did not map the Metallic Streak workings. At one point in a short tunnel near the south end of the mined area, the following sequence was observed on what had been a mining face:

Soil
Silicified rock (originally carbonate)
Dolomite, fractured, grading up to greenish-buff clay
Dolomite, buff, solid

It was not clear, from visual inspection, whether the better ore had been immediately below the clay, or in the floor of the drift. In the open pits, mining appeared to extend almost from the grass roots to the top of an undulating, partly silicified limestone or dolomite surface. According to contemporary reports, all rock below the soil zone, and above the undulating floor, went through the mill.

Geology of the Black Diamond Group.—The ore bodies on the Black Diamond group are different from any others encountered in the Ragged Top area in that they are intimately associated with a sill. On the Ella and Gold Brick fraction lodes of this group, there is an outcrop of phonolite porphyry 500 feet long, 300 feet wide, and at least 30 feet in thickness (Plate 16). The igneous mass appears to be faulted through the middle, so that the south half stands up as a conspicuous topographic feature. The top of the north side is lower, and not so well exposed. Because horizontal limestone seems to butt up against the igneous mass, it is presumed that the intrusion bodily lifted a block of limestone, and formed a sill bounded by peripheral faults. The base of the sill is not exposed. There is some indication on the west side that mining may have extended under the sill; if so the maximum thickness is only a few tens of feet.

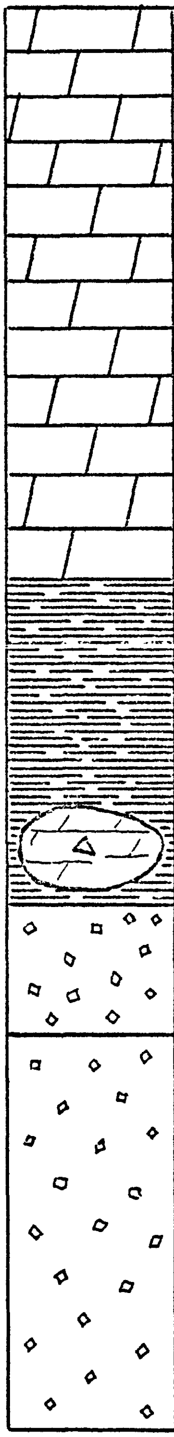
The highest Pahasapa bed in the area, which forms the surface of the flat east, north, and west of the mine, except where eroded by gullies, is an easily identified, fine-grained, blue-gray limestone carrying abundant remains of the coral Syringopora halli. Beneath this bed, at least on the north, west, and south sides of the above-mentioned resistant sill, is another sill of undetermined original extent. This was a wedge-shaped body, 10 to 30 feet in thickness. There is inconclusive evidence that it also was bounded, at least on the north and northwest sides, by small faults or offsets. Unlike the upper sill, this one is almost completely decomposed to a soft, green clay-like material, with only occasional masses of harder rock. Contemporary reports refer to it as trachyte or trachytoid phonolite. Both above and below this weathered sill are thin-bedded, dolomitic limestones and dolomites, which apparently carried the mineralization. A measured and sampled section above this sill is shown in Figure 13.

O'Harra (1902, p. 43) gives the following description of the deposit:

> "The ore is in close association with intrusions of trachytoid phonolite, the origin of the ore being due to the presence of the igneous rock. A shallow shaft on the Spearfish property cuts through six feet of phonolite with ore above and below, while in a tunnel on the same property the roof is phonolite, the ore lying immediately beneath."

> "The ore looks much like ordinary gray limestone weathered to a rather soft and porous condition and containing iron oxide and silica. The gold content is not high, but the ore is easily mined and cheaply treated, hence may be worked with considerable profit. On the Spearfish ground where the ore body is most extensively exploited, the ore under favorable conditions of weathering is simply quarried in large open pits. Tunnels for underground winter work have been made, but they nowhere extend far beneath the surface."

The ore was mined by open cuts around the periphery of the deposit, and by underground stoping when the thickness of the overburden made open



Thickness	Lithologic Description	Sample number and value
72 in.	limestone, dolomitic, tan, with conchoidal fracture; becomes softer toward base	52-32-G-32 (0.17 ppm Au)
41 in.	clay, white to red and yellow	52-32-G-33 (10.5 ppm Au)
	siliceous nodules up to one foot in diameter	52-32-G-34 (11.0 ppm Au)
17 in.	porphyry, soft, weathered, red	52-32-G-35 (2.0 ppm Au)
	porphyry, soft, weathered, green, not measured	52-32-G-36 (0.1 ppm Au)

Figure 13. Measured Section in Open Pit, Black Diamond Claim

pit mining impractical. The ground must have been heavy, for many of the larger stopes are caved to the surface, exposing the very heavy stulls and caps which were used to support the ground above the haulageways. None of the workings at this level is presently accessible.

In some small workings at the lower level on the south end of the Black Diamond claim (Plate 16, below Sta. 20), sharply delineated areas of brecciated limestone and dolomite resemble collapse features due to solutions by groundwater, rather than brecciation due to movements associated with igneous intrusion. It is suggested that this solution occurred during the post-Pahasapa, pre-Minnelusa period of weathering which initiated the cavernous zone in the upper part of the Mississippian carbonates throughout the Rocky Mountain area.

Milling and production.—Two small mills pioneered the cyanide treatment of siliceous limestone ores of the Ragged Top District. In the summer of 1898, an unused plaster mill at Spearfish, S. Dak. was converted to a 20 ton per day batch cyanide mill, and ore from the Metallic Streak property was successfully treated for recovery of gold. Operation continued at least until mid-1899, and probably up to the time the mill burned in July 1900. The State Mine Inspector's report for 1899 credits this mill with the recovery of $63,000 in gold during the year.

Messrs Allen, Small, and Slater, operating as the Ragged Top Cyanide Company, built a small dry crushing cyanide plant (20 tons per day) in Calamity Gulch in 1899. It was situated in the bottom of the gulch, on the south side of Ragged Top, in the C N 1/2 sec. 32, T. 5 N., R. 2 E. Apparently small quantities of ore from the Ulster, Dacy, Metallic Streak and Black Diamond properties were treated successfully. Recovery for 1899 is given as

$19,000 by the State Mine Inspector. A grab sample of ore from the site of the old mill showed a grade of 5.5 ppm (approx. $5.50 @ $35 per oz.).

The Spearfish Gold Mining and Reduction Company completed a 250-ton per day dry crushing cyanide plant on a hillside overlooking Johnson Gulch in December 1900. It was only a few hundred yards from the ore bodies on the Metallic Streak claims, and less than half a mile from the Black Diamond group. This mill burned on October 26, 1901, and was immediately replaced by a similar mill of 250 to 300 tons per day capacity. The new mill started operation in late March 1902, and continued to operate into 1906. Up to January 1, 1904, the company is reported to have paid over $90,000 in dividends. The last monthly dividend was paid in September, 1904. The following tables outline the productive history of the property.

Table 3.—Production data, Spearfish Gold Mining and Reduction Company[1]

Year	Ore, tons	Gold, oz.	Value at $20 per oz.	Value at $35 per oz.	Recovery per ton at $20	Recovery per ton at $35
1901	42,000	9,172.63	183,452.60	321,042.05	4.37	7.64
1902	36,426	7,047.00	140,940.00	246,654.00	3.87	6.77
1903	62,167	11,909.50	238,190.00	416,632.50	3.83	6.71
1904	82,871	9,854.54	197,090.80	344,908.90	2.70	4.73
1905	64,620	5,563.80	111,276.00	194,733.00	1.72	3.01
1906	21,540	1,916.33	38,326.60	67,071.50	1.78	3.11
Total	299,624	45,463.80	909,276.00	1,591,032.95		

[1]After Allsman (1940). Allsman gives figures for 1899 which should have been assigned to the Spearfish Cyanide plant in Spearfish, S. Dak. They have been omitted here even though a majority of the ore probably came from the Metallic Streak and Black Diamond mines. A contemporary report states that $11,000 had been recovered from the Metallic Streak ores by small cyanide mills prior to April 9, 1900.

Table 4.—Statement covering operations from January 1903 to October 1904, inclusive. Spearfish Gold Mining and Reduction Company[2]

Item	Total 22 months	Average/month	Average/ton
Tonnage	120,747.5	5,488.5	
Production	$415,165.16	$18,070.62	$3.438
Operating expense	282,576.91	12,844.45	2.423
Profit	132,587.25	5,026.69	1.0515
Tailings assays	---	---	.591
Heads assays	---	---	4.373
Average recovery	---	---	86.72%

[2]Statement issued by David N. Heinzer, Secretary and Treasurer, Spearfish Gold Mining and Reduction Company, and published in the January 27, 1905 issue of the Black Hills Mining Review, p. 17.

Table 5.—Statement of operations of mine and mill for 1904. Spearfish Gold Mining and Reduction Company[1]

	Net tons	Heads	Tails	Average recovery	Total cost	Cost/ton
Jan.	4111.3	$4.625	0.966	15,709.31	13,238.09	$ 3.212
Feb.	4844.1	4.681	.71	21,634,34	12,395.50	2.556
Mar.	4723.8	4.627	.832	17,187.44	12,555.22	2.591
April	5539.69	3.647	.828	17,310.24	12,650.22	2.28
May	5867	3.471	.457	18,500.46	11,557.99	1.97
June	5861	3.33	.452	16,184.80	11,604.78	1.98
July	5723	3.074	.437	16,102.02	11,503.23	2.01
Aug.	8349.6	3.055	.51	15,507.36	12,107.50	1.45
Sept.	7275.6	2.611	.674	15,991.57	11,568.84	1.59
Oct.	7171	2.784	.628	14,865.74	11,473.60	1.60
Nov.	7125.8	3.007	.55	15,499.59	12,455.05	1.74
Dec.	6279.48	3.065	.576	12,998.02	12,521.28	1.994
	72871.37	$41.994	$7.620	197,490.89	145,631.30	$24.973

Average recovery per ton	$2.71
Average cost per ton	1.998
Average profit per ton	.712

[1]Issued by David N. Heinzer, Secretary and Treasurer, Spearfish Gold Mining and Reduction Company, and published in the February 3, 1905 issue of Black Hills Mining Review, p. 17.

Potential.—Allsman's figures for the years 1901-1906 (Table 3) show that this company milled 299,624 tons of ore, from which it recovered 45,463.8 ounces of gold, for a recovery of 0.152 ounces, valued at $3.04, per ton. In a report to stockholders in January 1905, the company claimed an average recovery over a 22-month period of 86.72 percent (Table 4). Applying this figure to the 6-year interval above, the average grade of mill heads from the Metallic Streak and Black Diamond groups was $3.51 per ton. There is obviously some slight discrepancy between these figures and those published by the company. There is also an appreciable difference between the tailings values of $0.47 per ton calculated above or the $0.59 to $0.64 admitted by the company, and the figures of $1.14 to $1.43 ($2.00 to $2.50))reported by Allsman (1940, p. 52) from the dumps. One grab sample from the Spearfish dump, perhaps typical of the final mill runs, shows 1.3 ppm gold or about $1.30 at the present price. Considering that at least 200,000 tons of these tailings could be easily recovered from the dump, or from the upper reaches of Johnson Draw, a more systematic sampling of the tailings dumps should be made.

Tables 3 and 5 show also that the company was having trouble after 1903 in keeping up both the volume and value of the milling ore. The ore from the Metallic Streak claims had been exhausted by this time and all mill feed was coming from the Black Diamond group. A force of 65 men was reported to be working on the property in 1903. It appears from periodic reports in the "Black Hills Mining Review" that during late 1904 and 1905, much effort was devoted to exploratory drifting at a supposed lower ore level, 35 feet below the main ore body underlying the weathered porphyry. Without mine maps, it is impossible to evaluate the effectiveness of this exploratory work. Drill holes 30 to 50 feet in depth would be necessary to evaluate the ore potential around the eastern end of the porphyry mass. So far as is known, the potential of the underlying Deadwood formation has not been tested. The shaft in the No. 1 opencut apparently was never much deeper than its present measured depth of 41 feet, although a report (Black Hills Mining Review, May 26, 1905) states that a new shaft was down 250 feet at the Spearfish. This report is probably in error.

The ore bodies on the Metallic Streak claims were confined to the very eastern edge of the divide, suggesting that the eastern part of the deposits may have been removed during the erosion of Calamity Gulch. With this possibility in mind, any exploratory holes to evaluate the potential ore horizons in the Deadwood formation beneath the ore bodies in the Mississippian carbonates, might well be started just east of the old excavations, and slightly down over the edge into Calamity Gulch.

4.74.6 Ulster Area

Historical sketch.—The Ulster area straddles a ridge between two branches of Long Valley Creek, in the W 1/2 NW 1/4 sec. 28, T. 5 N., R. 2 E. The principal operators seem to have been Allen, Small, and Slater, who held a group of 6 lode claims (MS 1206) and the fractional John and Little Bud claims (See Plate 5). Production of ore started as early as 1897 with shipments to Deadwood and out-of-state smelters. In 1899 these three men built a small cyanide mill in Calamity Gulch to treat ore from their own mines, and to do experimental work on ores from other nearby properties. A further account has been given under the milling section of the description of the Spearfish

Gold Mining and Reduction Company. Operations at the Ulster group continued at least through the end of 1900. In November 1905, the Ulster and several adjacent claims became the property of the Victoria Extension Company.

Geology.—The most productive part of the Ulster group lies one-half mile due east of the Dacy area, but the most productive mines do not line up with any of the principal mineralized vertical fractures on Dacy flat.

Ore was developed in the upper part of the Pahasapa Limestone, close to its contact with the Twin Peak sill, and with one or more vertical dikes. Plate 17 is a map of the Ulster area as it appears today. Even after careful mapping of the surface, the subsurface relations are not clear.

J. D. Irving was the only geologist to describe the area during the time when some of the properties were still producing ore, and while a great deal of exploratory and development work was still in progress. However, he confined himself to the following description of the Ulster mine (1897, p. 313-314):

> "In the Ulster mine the ore occurs in contact zones between the limestone and a very irregularly intruded mass of porphyry. This is cut by a dike of dense green phonolite, and the ore seems to have resulted from the silicification of brecciated limestone, which has been fractured by the intrusion of Twin Peaks and other porphyry bodies in the Cambrian below. Brilliant purple fluorite occurs in great quantities. The ore is irregularly distributed. It may thin to a mere streak, and again open up to a very large and thick mass. The values obtained are very high, running frequently up to $150 per ton, and in one instance, $1,000 per ton."

In a subsequent publication (1904, p. 176), he says essentially the same thing, adding:

> "The porphyry is often so decomposed as to be little more than soft clay. The portion containg fluorite is usually lower in gold than other parts of the rock, and the highest values are contained in the dark-colored silicified limestone. Much of the ore from this mine carried very high values, some of it yielding as much as $2,000 per ton in gold. The greater part of the ore was taken

> from the surface workings, but the conditions are now such that but little can be made of the general relations of the ore."

Irving's description seems to fit the workings in the middle of the Ulster claim (Plate 17). We infer that ore was developed along one or more vertical contacts between porphyry and limestone (or dolomite), and possibly below a sill, as at the Black Diamond property of the Spearfish Gold Mining and Reduction Company 1 1/2 miles to the southwest.

An intrusion with much greater vertical range appears on the west end of the Delhi claim where extensive exploration and development were undertaken. No production is specifically attributed to the Delhi lode but, since it is part of the same mineral survey as the Ulster, all production may have been assigned to the Ulster group.

Irving does not mention the workings on the Warren and Little Bud claims which produced considerable ore according to contemporary reports. These ores lay at a lower level and seem to have been blanket deposits not intimately related to any known intrusive. In accessible workings near ths southwest corner of the Warren lode, the drift is driven with the lower half in well-bedded limestone, and the upper half in brecciated limestone with no particular evidence of silicification or other mineralization. This drift seems to be directed toward an area of caved stopes into which we could not gain access. These workings are believed to have been developed by the Victoria Extension Company just prior to World War I.

Mining and production.—The bulk of the very rich ore mined in the Ulster area was shipped to the smelters at Deadwood, Aurora, Ill., and Kansas City, Mo. Later, the less siliceous ores were treated at the Ragged Top cyanide plant on Calamity Gulch. Possibly optimistic contemporary reports indicate that the total gold production from the Ulster group probably totaled $100,000 by early 1899.

After the peak of production had passed, exploratory drifting, apparently from a lower level, was undertaken. Contemporary reports mention the Smith or Ulster tunnel being driven in 1899 and having reached a length of 500 feet by late August 1900. We did not identify the adit or dump from this tunnel.

Potential.—At this late date, it is virtually impossible to judge the effectiveness of the exploratory work mentioned above. The workings are inaccessible, and only one old mine map has been located. Test pitting to permit more precise geologic mapping of contacts, followed by oblique diamond drilling, might be effective. Considering the high reported unit values of the early day ore, an attractive ore body might be discovered.

Drill holes to evaluate the ore potential of the Deadwood formation might be sunk either close to the Ulster shaft, or in the center of the mined-out area on the Warren lode.

4.74.7 Victoria Gold Mining and Milling Company

Historical sketch.—The siliceous gold ores at Victoria were apparently discovered about 1896, for Smith (1897, p. 15-16) alluded to this property, though not by name. By 1904, a group of 15 claims (Fig. 14) had been acquired by the Victoria Gold Mining and Milling Company of Deadwood, S. Dak. A. B. Smith of Omaha, Neb. was the promotor. The claims were located in the SE 1/4 sec. 17 and the NE 1/4 sec. 20, T. 5 N., R. 2 E., Lawrence Co. Extensive development work was done, and several ore shoots delineated. A cyanide mill overlooking Spearfish Canyon was planned, but it was ultimately

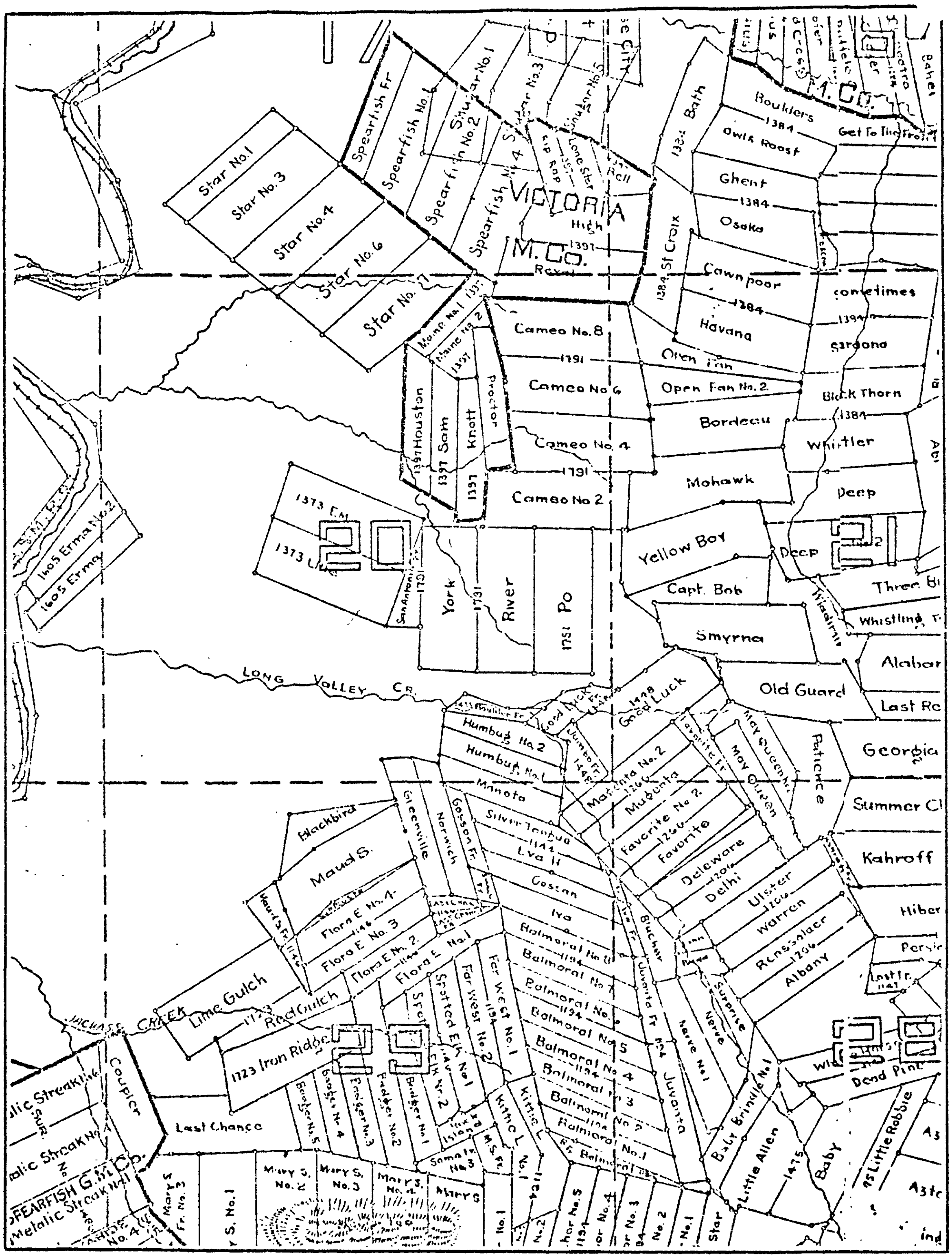


Figure 14. Claim Map of Victoria Area

built in the canyon. It was operated a short time in 1912-1913 whereupon operations were suspended indefinitely.

Current taxes on the property are being paid by White House Congress, Inc., believed to be a corporation held by John Aye of Spearfish, S. Dak. and Miles City, Mont.

Geology.—The local structure of the Pahasapa formation is controlled by extensive intrusions into the underlying Deadwood formation, as may be seen in Spearfish Canyon to the west and north of the property. Changes in dip and strike of the limestone are apparent. Until the structure has been worked out in more detail, it is not possible to state with certainty that the ore deposits lie in the uppermost beds of the Pahasapa, but this is believed to be the case. A full section of Pahasapa formation is present 1,000 feet to the west, where remnants of a sill overlie a sinkhole filled with basal Minnelusa red shale.

The most conspicuous stratigraphic marker within the Pahasapa formation in the Victoria area is a massive, 4- to 6-foot, more or less brecciated carbonate usually completely silicified to a gray, brown, or pink "jasperoid". The upper part is invariably very hard; sometimes the lower foot or two is a less siliceous, well-bedded dolomite.

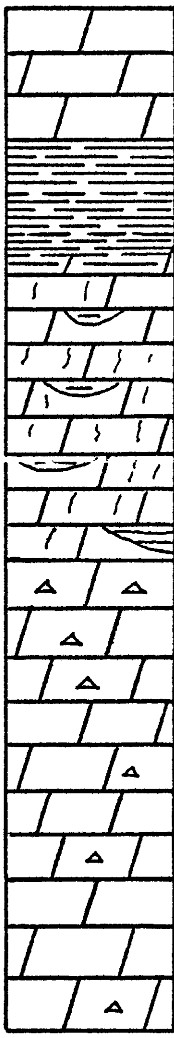
Underlying the jasperoid, a five- to eight-foot layer of thin-bedded, slabby, dolomitic limestone or dolomite has been partially leached, altered, or dissolved, with most of the alteration at the top. At or near the top, the dolomite has broken down to a greenish-gray to buff, gouge-like residue resembling clay. It varies in composition from a very fine-grained argillaceous, calcareous dolomite sand, to a non-calcareous, clay-like material.

Locally the lower part of the clay layer may be stained with iron and manganese oxides. Preliminary sampling indicates that the stained material carries low values of gold; the unstained material contains no detectable gold (Fig. 15). Below the clay, the dolomite shows all gradations, laterally and vertically, into dolomitic sand or into the same type of greenish-buff clay. Scattered throughout this interval are pockets or streaks of brown- to red-stained gouge containing nodules and siliceous material. Some of these nodules apparently carried the highest gold values. The dolomite itself apparently carried minable values. Below this altered unit, another replaced bed consisting of drusy gray chert at least one foot in thickness is generally present.

Above the jasperoid layer lies thin bedded dolomite or dolomitic lime-stone. Apparently residual clay partings also developed locally. Scattered open pits at this level suggest that some ore was also developed in the lower part of this dolomite section, probably at or just above the jasperoid bed.

At the Victoria property, the Pahasapa formation dips westward at about 400 feet to the mile. Superimposed on this dip are very gentle north-south folds, providing slight reversals of dip toward the east. One such fold, only a few tens of feet across, may be seen in the workings below Sta. 11, Plate 18, where it has an axial trend of N. 10° W. It is possible that these flexures may have have had some influence in localizing the ore deposition.

According to Baldwin (1904, p. 137), extensive development work had been done on the property prior to 1904. Five ore shoots had been delineated. From north to south they were the Spearfish, Rip Rap, Royal, Swift, and Hurd (Wiker). The first three names are those of claims, though in retrospect most or all of the ore seems to have been mined from the Spearfish No. 2 and



Thickness	Lithologic Description	Sample number and value
10 in.	dolomite, finely crystalline, buff	52-17-G-28 (0.15 ppm Au) 52-17-G-29 (0.7 ppm Au)
7 in.	dolomite, finely crystalline, buff	52-17-G-30 (3.5 ppm Au)
5 in.	clay, green, iron-manganese stain	
5 in.	clay and weathered dolomite	52-17-G-31 (0.62 ppm Au)
36 in.	dolomite, very finely crystalline, buff, more or less siliceous, with pockets of iron-stained "gouge"	dol:52-17-G-32 (0.57 ppm Au) gouge:52-17-G-33 (3.5 ppm Au)
36 - 60 in.	dolomite, silicified, with pockets of oxidized "gouge"	dol:52-17-G-34 (0.0 ppm Au) gouge:52-17-G-35 (0.1 ppm Au)

Figure 15. Measured Section in Stope, Victoria Mine

No. 4 lodes. Photographs were also shown of three ore shutes (sic), with no clues as to the correlation between the named and numbered shoots, but with the following dimensions given:

Ore Shute No. 1	6 feet thick,	35 feet wide,	500 feet long.
Ore Shute No. 2	6 feet thick,	25 feet wide,	225 feet long.
Ore Shute No. 3	8 feet thick,	35 feet wide,	125 feet long.

No locations or bearings were given.

From examination of Plate 18, three separate groups of minable ore bodies may be inferred. There was apparently ore both above and below the heavy siliceous bed in the large open cut which has a general S. 80° E. trend. Underground workings extending east and southeast from this cut are generally accessible, though they have caved to the surface at the larger stopes. Figure 15 shows a sampled section in one of these stopes.

A second group of small ore pockets, with essentially the same trend, lay 150 to 200 feet to the south. These are only accessible in part, and probably extended southeastward from the present road. A third mineralized area, developed mostly by open cuts along the hillside, lies west of the others, across a small draw (near Sta. 4, Plate 18). Here also, there is evidence that some ore was mined above the jasperoid bed, but most of it came from below that layer. Some underground mining was done. Pockets of iron-stained gouge within a slabby dolomite layer, sampled in a short drift 85 feet south of Sta. 4 (Plate 18) showed 15 ppm gold by atomic absorption. Although the trend of these workings is about S. 40° E., there is some suggestion of north-south orientation to the individual ore bodies.

The control which localized the ore bodies cannot be determined. It generally has been accepted that ore-bearing solutions, rising along vertical fractures, spread laterally in suitable host rocks below supposedly impermeable shale partings. No pronounced verticals have been seen. It has been suggested on a previous page that very gentle folds, oriented more or less parallel to the regional strike, may have assisted in confining the ore-bearing solutions to certain areas.

Mining and milling.—According to a contemporary report in May 1904, several hundred tons of ore from the southernmost shoot on the Victoria property had been shipped to the Deadwood smelters and to the cyanide mill at Spearfish by previous operators. Later mining was in part by open cut, but largely by shallow underground stopes. Ore was trammed to the brink of the canyon, crushed, and placed in storage bins.

A 100 ton per day cyanide mill was located in Spearfish Canyon, on a spur (Victoria Siding) of the Burlington Railroad between Englewood and Spearfish. It is not known when the mill was completed. The first published reference to a mill run is in September 1912, but there is also a mention that the mill had been idle two years. Ore was transported by aerial tram from bins at the mining level high on the cliff to the mill 1,600 feet to the west, and 600 feet lower in the canyon.

Production.—The only production figure available is for the period from Sept. 15, 1912 to Oct. 30, 1912, the cutoff date for the State Mine Inspector's report for 1912. Presumably the mill ran beyond that date in 1912, and for a short period in 1913, but no production record is available. During the 6-week period for which records are available, the mill recovered $14,671.92 in gold from 3347 tons of ore. It is reported that 32 men were employed at mine and mill.

Potential.—On the basis of the above figures, gold recovery amounted to $4.38 per ton. If mill recovery was similar to that at the Spearfish Company's mill on Johnson Gulch (87 percent), the mill heads would have had an approximate value of $5.10. However, a preliminary grab sample of mill tailings from the Victoria mill showed 2.0 ppm gold on the atomic absorption equipment, or roughly $1.20 at the old price of gold. This suggests that mill recovery here may have been about 78 percent. A grab sample of ore stockpiled near the old mill assayed 0.36 ounces of gold, and 0.44 ounces of silver per ton.

Presumably any new ore found would have a value in the $5.00 to $7.00 range. There is a large area northeast of the old workings where the ore horizon lies less than 25 feet below the surface. It is not known whether the area has been adequately prospected either by drilling or by drifting. At the west end of the property, across the small draw to the south, the ore-bearing zone soon extends under heavy overburden.

The geology in Spearfish Canyon adjacent to the Victoria property is complex. Extensive intrusion has taken place within the exposed Deadwood formation, and some evidence of mineralization has been noted. A contemporary report of drifting from the canyon toward the mineralized area of Pahasapa, but at a level which would place the drift within the Deadwood formation, has not been confirmed in the field. Test drilling to the Deadwood formation beneath the old mine workings cannot be recommended at this time.

4.74.8 Other Prospects

Elk Mountain area.—Exploratory drifts into the Pahasapa limestone were noted on all sides of Elk Mountain. The present road around the southwest side of that peak cuts what were probably extensive workings. They are caved at the portal, and no samples were taken. They are not located near the top of the formation, and it is not now apparent why drifting was undertaken at this horizon. A drift on the south side, the portal of which is cut by the upper logging road, extends for 135 feet nearly due north into the mountainside. It follows a horizontal ledge or zone of chert stringers about one foot thick, but no vertical fracture was noted. On the southeast flank of Elk Mountain, very near the center of the S 1/2 sec. 32, a 95-foot shaft in dolomite with fine galena is reported to have yielded assays up to 40 oz. silver per ton (Black Hills Mining Review, v. 1, no. 14, p. 6). The prospect was reported to lie on the Idaho claim, which is shown on Peck's 1900 map, but not on the 1904 edition. This is the only report of visible quantities of lead-silver ore in the Ragged Top area. On the east side of Elk Mountain, a caved drift is the source of water which forms a springy area just above the road between Crown Hill and Balmoral. Irving (1899, p. 233) noted a 20° dip to the northeast at this tunnel. On the northwest side of Elk Mountain, in a draw at about elevation 5950 feet, extensive drifting has been done at the base of the Pahasapa formation. This work may be somewhat more recent than other prospecting in the vicinity.

Ragged Top-Long Valley area.—Around the northeastern side of Ragged Top, within the old townsite of Balmoral (Preston on Plate 3) there is evidence of extensive shallow drifting and one or more shafts of undetermined depth. Dumps indicate that most of the work was in gray, green, and lavender shales of the Deadwood formation, and possibly both the Winnipeg and Englewood formations. A random dump sample showed no trace of gold. These diggings are believed to be the work of John Madill, who was reported to be working near Preston in annual reports of the State Mine Inspector for 1914, 1916, and 1917.

In the bottom of Long Valley, in the extreme northeastern corner of sec. 28, (probably on the Magenta No. 2 lode) there is a timbered shaft of undetermined depth. Close by, a shallow shaft in the creek bottom gives access to a short drift swinging southeast. Above flood level, a dog-legged drift is driven 210 feet in an east-northeast direction. A specimen of spongy limonite and limonite-cemented breccia, selected from the dump, showed no trace of gold. These workings are directly on a northeastward projection of the most northerly vertical at Dacy flat. The name of the original operator is not known.

In the NE 1/4 SW 1/4 sec. 20, probably on the Po claim, a sizable shaft of unknown depth is sunk in the Pahasapa limestone, within a few hundred feet of a porphyry contact. Numerous pieces of dark brown, brecciated, siliceous, ferruginous rock have been stockpiled. A random sample contained 1.5 ppm in gold.

4.8 Squaw Creek Area

4.81 Introduction

As defined here the Squaw Creek area refers only to the mines located in the canyon of Squaw Creek along the narrow band of outcrop of the Deadwood formation and the intrusive rocks which cut it. Three properties are included in the area, all within two miles of the junction of Squaw Creek with Spearfish Canyon. Total reported production from the district is $200,000 in gold and silver, all of which came from the Cleopatra mine.

4.82 Mines of the Squaw Creek Area

Cleopatra

The Cleopatra group lies on the north side of Squaw Creek, about one mile above the junction with Spearfish Canyon. Topographic relief on the property is about 900 feet, and rocks exposed on the north side of Squaw Creek include the complete sedimentary sequence from the middle of the Deadwood formation to the middle of the Pahasapa carbonate. At least three porphyry sills have intruded the Deadwood, which has a total net thickness of 342 feet above the quartzite. Dips range from 6^{o}–9^{o} to the northwest or west. The sills appear to be wedging out to the northwest, so dips on the lower contact zone may be one or two degrees less.

The Cleopatra property represents the farthest northwest commercial mineralization of the Deadwood formation (Fig. 7). It is 9,000 feet north northwest of the Dacy shaft at Ragged Top, 3,000 feet east northeast of Victoria, and 4,000 feet west southwest of the Iron Hill mine at Carbonate. The presence of mineralization at the Cleopatra encourages exploration in the Deadwood beneath the Pahasapa ore bodies at Ragged Top, Victoria, and Carbonate.

The Cleopatra Gold Mining Company acquired the ground subsequently patented as the Cleopatra Group (M.S. 1224) between December 1887 and December 1888. Prospecting consisted of trenches and short drifts exposing mineralized verticals in the Deadwood, Whitewood, Englewood and Pahasapa formations. Most attention was paid to the interval below the Scolithus quartzite, at or just below the normal position of the upper contact ore horizon of the Deadwood formation.

A group from eastern South Dakota, headed by R. B. Hughes (then Surveyor General for South Dakota) purchased the group of 13 lode claims from Wendel Kohner in 1896. Exploratory drifting started in 1897, and by December 1898, approximately 400 feet of drifting had been done parallel to, and cross-cutting a series of mineralized verticals in the upper Deadwood formation.

The original group of 13 claims (143) acres) was put up for patent in May 1899. In late 1899, the reported discovery of $3,500 per ton ore samples on the nearby Pocahontas claim caused the company to acquire the Bahia, Bahia Fraction, Lemure,,and half of the Little Ellen claim east of their original holdings.

Continued exploratory drifting indicated that the ore followed a series of four northwest trending verticals spaced at approximate 50- to 75-foot intervals. These verticals are actually shear planes trending N. 40°-55° W., and dipping steeply (63° to 80°) to either the southwest or northeast. O'Harra (1902, p. 33) reports displacements along the shear zones of 4 to 30 feet. The dominant joint direction, both in the Deadwood at the mine, and in the Pahasapa up hill behind the mine, is between N. 40° and 50° W.

The ore bodies were generally 4 to 6 feet thick, 6 to 15 feet wide, and 200 or more feet in length. Apparently the ore occasionally extended along the verticals above or below the main ore horizon, suggesting the possibility of mineralization at other favorable horizons within the Deadwood formation. In hope of finding additional ore shoots, an exploratory drift was driven to the northeast, at right angles to the dominant bearing of the verticals. This drift ultimately reached a length of 1,100 feet, crossed several more verticals, and two porphyry dikes, but apparently no commercial ore bodies were encountered.

Simultaneously with the development of the upper contact ore bodies, a shaft was started at about the middle of the Deadwood formation. It is located just west of the mill building and 35 feet above the creek. Sinking started in the spring of 1898. The shaft had reached a depth of 75 feet by August, but was shut down pending installation of a hoist capable of handling the water encountered below creek level. A new hoist was installed in September 1899, and sinking continued to a depth of 170 feet by early December. The shaft remained at that depth until the company was reorganized in the summer of 1902. Sinking resumed in August, and the shaft was bottomed on the basal quartzite by December 1, 1902. A sump and station were cut in the quartzite, then drifting started north and south on top of the quartzite. Drifting to the southwest was extended only 12 feet, to prevent future damage to the station pump should further drifting in that direction become desirable. A northeasterly drift was driven 75 feet before funds were exhausted. Two minor verticals, believed to be the same ones encountered on the upper level, were barren on both levels. The deeper workings did not extend beneath the upper ore bodies. An approximate log of the shaft, pieced together from old reports and the present field work, is given in Appendix V and VI.

Following extensive laboratory and pilot mill tests on extraction by cyanide leaching, a 40-ton mill was built. It included two crushers with a daily combined capacity of 100 tons, and six 40-ton leaching vats. With a 6-day leaching period, one vat was cleaned out and refilled each working day. Cost of the mill is variously given as $22,000 to $30,000. The first mill run was in August 1900 (Fulton, 1902, p. 55). The mill is reported to have run for 15 months and to have recovered $30,000 in gold. Gold recovery apparently did not cover mining and milling costs, and the operation was shut down. Efforts to locate additional ore of higher grade continued until at least 1909.

References: Irving, 1904, pp. 152, 252; O'Harra, 1902, p. 31 ff.

Eagle Bird Group

The Eagle Bird Group totals eight claims on 75 acres in the SE 1/4 sec. 22, T. 5 N., R. 2 E. on Squaw Creek. The country rock is a large mass of porphyry which is cut by mineralized fractures. Some exploratory work was done, reportedly totaling 2,600 feet of drifting, and a small amount of ore is reported to have been hand sorted for shipment to a local mill. No further data is available.

References: Atlas, p. 59; Lincoln, 1937, p. 100; State Mine Inspector, 1911, 1921, 1926.

Old Ironsides

Over a wide area along Squaw Creek, especially in secs. 21, 22, and 27, T. 5 N., R. 2 E., the thick basal quartzite of the Deadwood formation is split by a persistent phonolite sill averaging 30 feet in thickness. At the Old Ironsides mine, in the northeast corner of sec. 21, two pairs of drifts explore the contacts between the sill and the quartzite. The more extensive workings are below the sill. Both lower drifts encountered a vertical fracture zone trending approximately N. 80° W. which cuts both the phonolite and the Deadwood. There appears to be hydrothermal alteration of the phonolite, accompanied by some mineralization. Irving (1904, p. 97) reported sylvanite. A sample of altered, iron and manganese stained phonolite, taken near the intersection of the right hand drift and the long cross drift, yielded 1.2 ppm gold and a trace of silver. This fracture has been explored for several hundred feet by a cross-drift mentioned above, and one winz and several raises indicate that it was explored in vertical extent as well. A sample of Deadwood fracture filling, taken from the small stope just to the left inside the left portal showed a trace of silver and no gold.

Two small drifts above the sill, higher and to the south of the lower workings, appear to have followed irregular mineralized streaks within the Deadwood.

A steam compressor plant was built along the creek below the mine in 1899 by the South Dakota-Colorado Consolidated Company, according to accounts in the Black Hills Mining Review. The purpose was to supply air for exploration and development work. No mill was built and there is no record of ore shipment by that company. Its successor, the Ironsides Company, shipped some ore to Denver in 1913-14. There is no record available as to the smelter returns (Atlas, p. 80-81), and no report of activity at the property after 1915.

4.9 Two Bit Mining District

4.91 Introduction

The Two Bit Mining District includes the area along Two Bit Creek from its head in sec. 12, T. 4 N., R. 3 E., to its junction with Boulder Creek in the NE corner of sec. 21, T. 5 N., R. 4 E. With the exception of the Puritan mine, all the mines of the district are located in Two Bit Gulch.

4.92 Geology of the Two Bit Mining District

The ore bodies of the Two Bit District occur in the lower and upper contact zones of the Deadwood formation and in the masses of Tertiary igneous rocks which cut the section. The lower contact zone has less dolomite in the Two Bit District than in other areas of the northern Black Hills, and most of it occurs in dolomitic shales or as cement in sandstones rather than in beds of pure dolomite. As a result, the ore shoots tend to be narrower and smaller than those of other mining districts in the area because there are few horizons in which extensive replacement could occur.

The gold ores of the Two Bit District are much higher in pyrite and somewhat lower in gold content than those of other northern Black Hills mining districts.

4.93 Mines of the Two Bit Mining District

Black Diamond - Gold Mountain

The Black Diamond - Gold Mountain Group consists of 21 claims totaling 211 acres located on Two Bit Creek in secs. 29 and 30, T. 5 N., R. 4 E. The mine was opened by a 185-foot shaft and numerous drifts and open cuts. The ore occurs in the upper contact zone of the Deadwood formation following a series of north-south shoots.

References: Allsman, 1940, p. 50; Atlas, p. 35; Lincoln, 1937, p. 102.

Mascot (Deadwood-Heidelberg Group)

The Deadwood-Heidelberg Group is located on Two Bit Creek in the NW 1/4 sec. 29 and the SW 1/4 sec. 20, T. 5 N., R. 4 E. The property consists of nine unpatented claims.

The ore access is the upper contact zone of the Deadwood formation. Numerous sills occur in the section in this area, and one of these apparently capped the ore. Five shoots, 2 to 3 feet wide and striking northeast, were located and the workings followed these.

References: Allsman, 1940, p. 50; Atlas, p. 40; Lincoln, 1937, p. 110; State Mine Inspector, 1912-17.

Monarch

The Monarch property consists of 6 claims in Two Bit Gulch totaling 56 acres. It is located along the north edge of sec. 1, T. 4 N., R. 3 E., and in adjacent parts of secs. 35 and 36, T. 5 N., R. 3 E.

The ore occurs in the lower contact zone of the Deadwood formation. No data is available regarding the orientation of the ore shoots, but their dimensions can be inferred from the observation that one stope was mined to a total of 50 feet in length, 15 feet in width, and a height of 20 feet.

Development work consists of a 200-foot adit, a 125-foot shaft and up to 3000 feet of drifts and crosscuts.

References: Allsman, 1940, pp. 48-49, Atlas, p. 41; Baldwin, 1904, p. 173; Lincoln, 1937, pp. 96, 111; State Mine Inspector, 1922, p. 5.

Puritan

The Puritan Group consists of 56 acres of claims in the W 1/2 sec. 12, T. 4 N., R. 3 E. near the head of West Strawberry Creek. The ore body was a lead-silver deposit occurring as a replacement of dolomite in the lower contact zone of the Deadwood formation.

Production from the Puritan is recorded only for 1906, the last year in which the mine was operated. However, some ore was probably produced before that date. The mine was reopened in 1916-17, but closed before any ore was extracted.

References: Atlas, p. 42; Baldwin, 1904, p. 173; State Mine Inspector, 1904, 1906, 1916, 1917.

S. R. Smith

The S. R. Smith Group is located along Two Bit Creek near the center of sec. 1, T. 4 N., R. 3 E. It consists of four claims totaling 50.17 acres.

The description of the ores has been given in the section on tungsten ores. Seven small north-south verticals were encountered in the mine, but drifting along four of these disclosed that the mineralization is limited in extent.

The only production recorded is for the year 1916 and consisted of 1600 lbs. of hand-picked, high-grade tungsten ore.

References: Atlas, p. 45; Connolly and O'Harra, 1929, p. 204; Cummings, 1936, p. 25; Lincoln, 1937, pp. 97, 115.

5. PRODUCTION DATA

The list below includes only those mines for which production data ~~is~~ are available. It is apparent that far fewer mines appear on the list than were described earlier in this report and many of those absent were cited in the literature as "important" or "extensive" producers. In addition, in most cases, the data given below do not represent the total production of the particular mine. This is especially true of those mines which were in operation prior to 1900. The totals below should therefore be regarded as minimum production figures.

Production data are usually given in the literature in ounces of gold and silver or in the dollar value of metals produced. The figures are given below in the same manner without attempting to convert from dollars to ounces or ounces to dollars. Where data ~~appears~~ appear in both ounces and dollars they are cumulative. The number in parentheses indicate the years for which data ~~is~~ are available.

	Gold (Ounces)	Silver (Ounces)	Dollar Value
Carbonate District			
Carbonate Consolidated Mines Inc.			2,000*
Iron Hill *	83**	18,511**	667,218
Spanish R			50,000
Sub-Total	83	18,511	719,218
Galena District (Lead-Silver)			
Double Rainbow (Richmond-Sitting Bull) (few years only)			452,000
Merritt #1			7,000
Silver Queen (4 years only)			125,000
Sub-Total			584,000

* Recovered by reworking of dump material
** 183,191 lbs. of lead also recovered from dump

	Gold (Ounces)	Silver (Ounces)	Dollar Value
Galena District (Gold-Silver)			
Gilt Edge (inc. Oro Fino and Rattlesnake Jack) (1893, 1900-02, 1905-16, 1937)	41,267		
Golden Crest			100,000
Hoodoo-Union Hill			150,000
Sub-Total	41,267		250,000
Garden-Maitland District			
Carrol Group			50,000
Minnesota Group (1907-10)			59,355
Penobscot (Maitland Co.; Canyon Corp.) 1902-1937	91,617	76,249	
All others combined			1,000,000
Sub-Total	91,617	76,249	1,109,355
Lead District			
Alder Creek (Little Blue Frac.)	9,816	7,412	
Harrison (1897)			41,107
Hawkeye-Pluma			188,724
Wasp #2 (1901-1920)	100,819	158,780	
Sub-Total	110,635	166,192	229,831

Portland District (Bald Mtn)	Gold (Ounces)	Silver (Ounces)	Dollar Value
Alameda	1,969	3,682	
American Eagle (1909)	41	429	
Apex (1891, 1919)	40	56	279
Bald Mountain (inc. Trojan)	634,579	1,889,348	
Clinton (prior to 1911)	7,088	4,695	
Crown Hill	331	365	
Dakota Group	27,215	7,718	
Dakota Midget	2,753	2,138	
Decorah (Upper)	912	894	
Dividend (Lower Decorah) (1897, 1906-07)	313	842	63,000
Folger (1919)	232	174	
Imperial (Bald Mountain Operations)	55,232	86,127	
Juno	50	57	
Leopard-Jessie Lee	49		
Marco Polo	126	89	
Ofer (Monday Group)	25,071	83,027	
Reliance (to 1916)	27,002	10,090	
Snowstorm	380	804	
Two Johns (Rua Group)	1,469	1,821	
Sub-Total	784,852	2,092,356	63,279

	Gold (Ounces)	Silver (Ounces)	Dollar Value
Ragged Top District			
American Mining Co.			90,000
Balmoral Group			60,000
Deadwood Standard	11,983		
Eva H. and Silver Tongue			12,000
Spearfish Gold Mining Co.	48,614.8		
Victoria			14,673
Ulster			50,000
Sub-Total	60,598		226,673
Ruby Basin District (Bald Mtn)			
Dark Horse and General Grant (1919)	10	31	
Golden Reward	371,382	734,223	
Gold Dollar	323	671	
Great Mogul	212,679	440,495	
Lundberg, Dorr and Wilson (1902-13)	43,617	60,088	
Ross-Hannibal (1891)			13,125
Sub-Total	628,011	1,235,508	13,125
Squaw Creek District			
Cleopatra			200,000
Sub-Total			200,000

Two Bit District	Gold (Ounces)	Silver (Ounces)	Dollar Value
Gold Mountain (1892-94)			1,726
Mascot			2,800
Monarch (1902-36)	4,312	2,715	
Sub-Total	4,312	2,715	4,526

SUMMARY

District			
Carbonate	83	18,511	719,218
Galena (Lead-Silver)			584,000
Galena (Gold-Silver)	41,267		250,000
Garden-Maitland	91,617	76,249	1,109,355
Lead	110,635	166,192	229,831
Portland	784,852	2,092,356	63,279
Ragged Top	60,598		226,673
Ruby Basin	628,011	1,235,508	
Squaw Creek			200,000
Two Bit	4,312	2,715	4,526
Totals	1,721,375	3,591,531	3,386,882

6. SUMMARY OF POTENTIAL AND SUGGESTIONS FOR FUTURE INVESTIGATIONS

6.1 Introduction

The potential for future production of specific properties is discussed in the text where applicable, as are recommendations for further prospecting. The discussion which follows is intended to apply to all of the mining districts in the Paleozoic rocks of the northern Black Hills in general, and more specifically to the area which was studied most intensively during this project.

6.2 Ore Reserves

Ore reserves of the area are impossible to estimate accurately. Connolly and O'Harra (1929) and Miller (1963) indicate several mines in which substantial tonnages of gold or silver ores were known to be present when the mines closed, and these are mentioned in the text. In general there are few mines which were reported to have closed because ore reserves were depleted. In most cases, operations were terminated for one or more of the following reasons:

A. Litigation involving ownership. The Galena Mining District was virtually closed down in 1883 because of such problems, and little mining has been done there since that time.

B. Serious labor shortages developed in the northern Black Hills during both World Wars so that even major producers were forced to close, and many never resumed production (Golden Reward in 1918, Maitland in 1942).

C. Ore grade dropped below that necessary for profitable operation at existing costs. This has been accented in recent years by the combination of the fixed gold price and rising costs of operating. The Bald Mountain mine was closed in 1959 for this reason.

An additional factor to be considered in the question of the quantity of ore remaining in the area is the potential for successful treatment of the "blue ore" discussed in the text. The ore is highly refractory, and could not be successfully processed during most of the years in which mining was done in the northern Black Hills. Recovery from blue ore seldom reached 20% and never exceeded 35%. As a result, it was usually regarded as country rock and left in place, although it is of comparable grade to those ores which were mined.

6.3 Suggestions for Further Work

The results of this study suggest several areas and stratigraphic units which merit further examination.

As noted in section 4.16, exploration in the Deadwood formation has been concentrated in the upper and lower contact zones. While other potential host horizons are present within the unit they have received relatively little attention. In addition, the Whitewood formation was found to be mineralized in both the Carbonate and Bald Mountain Mining Districts during the present study, although no report of mineralization in the Whitewood was found in the literature. Low values of silver were discovered in the Pahasapa formation in the two drill holes at Ragged Top (RTM-1, 2, see Appendix III and IV) and on the divide between Lost Camp Gulch and Annie Creek (see Appendix VII).

Some of the igneous rocks are certainly older than the mineralization, and these may have served as host rocks in areas other than the Galena Mining District (Section 4.44). Very little work was done on the igneous rocks during the present study, but it was noted that some deposits were localized along the contact of the igneous rocks and the Paleozoics. Examples were given both from the Carbonate and the Bald Mountain Mining Districts. Many such contacts are unexplored.

The distribution of mining districts around the Lead-Deadwood dome (Fig. 4) shows an obvious gap along the northeast edge of the dome from Maitland to Carbonate. The area has not been mapped, and in general, the outcrop is poor. The Paleozoic section is intruded by thick sills over most of this segment of the dome, but the basal quartzite and lower contact zone are present as are variable thicknesses of the remainder of the Deadwood formation. Mapping and geochemical sampling of this segment of the margin of the dome should be considered. In addition, field studies should be carried north of the Carbonate Mining District across the axis of the dome (see sample results from this area in Appendix VII).

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APPENDIX I. MINE INDEX

MINE INDEX - Con't.

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MINE INDEX - Con't.

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APPENDIX II. PUBLISHED CLAIM MAPS COVERING MINING DISTRICTS IN PALEOZOIC ROCKS, NORTHERN BLACK HILLS

(Examination Copies Available at Dept. of Geol. & Geol. E., S.D.S.M.&T.)

Hopkins, George S.	Map of the Carbonate Mining District, Lawrence County, Dakota, 1887
McIntyre and Foote	Mining Claims of the Principal Mineral Belt of the Black Hills and a Portion of the Spruce Gulch Mining Claims, Whitewood Mining District, Lawrence County, Dakota, June 1879
Merrill, C. W.	Map of a Portion of the Ragged Top Mining District, Lawrence County, Black Hills, South Dakota. (Modified from Vincent)
Peck, Frank S.	Map of the Principal Mines of the Siliceous Gold Ore Region Bald Mountain and Ruby Basin, Whitewood Mining District, Lawrence County, South Dakota, 1895
Peck, Frank S.	A General Map of Bear Butte, Ida Gray, Carbonate, and Whitewood Mining Districts, Lawrence County, South Dakota. Deadwood, 1900
Peck, Frank S.	Map of Ore District of the Northern Black Hills, Lawrence County, South Dakota, 1904
Robinson, Edward J.	Robinson's Map of Lawrence County, South Dakota Mines, 1897, Sheets 3, 4
Skill, Seth	Map of Whitewood Mining District, Black Hills, Dakota, 1881.
Vincent, H. S.	Map of the Northern Ore District of the Black Hills, Lawrence County, South Dakota, 1898

APPENDIX III. TABULATION OF DRILL HOLE DATA

A. Homestake-Anaconda Drilling Program, 1965-66

Name and Location	Collar Elev.	Total Depth	Claim and Company Name	Geological Information
HA-1 1380 FNL 1650 FEL sec. 18, T. 4 N., R. 3 E.	5928.5	475		Vertical
HA-2 1440 FNL 1650 FEL sec. 18, T. 4 N., R. 3 E.	5928.5	474		Inclined 80° due west
HA-3 220 FSL 800 FEL sec. 7, T. 4 N., R. 3 E.	5866.9	412		Vertical
HA-4 240 FSL 840 FEL sec. 7, T. 4 N., R. 3 E.	5868.4	452		Vertical
HA-5 250 FNL 910 FEL sec. 18, T. 4 N., R. 3 E.	5889.2	451		Vertical
HA-6 225 FNL 860 FEL sec. 18, T. 4 N., R. 3 E.	5888.3	455		Vertical
HA-7 1440 FNL 1880 FEL sec. 18, T. 4 N., R. 3 E.	5935.6	453		Vertical
HA-8 1380 FNL 1870 FEL sec. 18, T. 4 N., R. 3 E.	5930.5	514		Inclined 65°, N. 65° E.

Name and Location	Collar Elev.	Total Depth	Claim and Company Name	Geological Information
HA-9 1675 FNL 1890 FEL sec. 18, T. 4 N., R. 3 E.	5960.2	496		Inclined 80°, N. 69° E.
HA-10 1820 FNL 1960 FEL sec. 7, T. 4 N., R. 3 E.	5770	336		Vertical
HA-11 2240 FNL 1850 FEL sec. 7, T. 4 N., R. 3 E.	5790	342		Vertical
HA-12 860 FSL 2600 FWL sec. 7, T. 4 N., R. 3 E.	5880.6	207		Vertical
HA-13 1250 FSL 2520 FWL sec. 7, T. 4 N., R. 3 E.	5890.2	222		Vertical
HA-14 1650 FSL 2405 FWL sec. 7, T. 4 N., R. 3 E.	5871	197		Vertical
HA-15 2040 FSL 2300 FWL sec. 7, T. 4 N., R. 3 E.	5868	172		Vertical
HA-16 1240 FSL 2300 FWL sec. 7, T. 4 N., R. 3 E.	5904	220		Vertical

Name and Location	Collar Elev.	Total Depth	Claim and Company Name	Geological Information
HA-17 1250 FSL 2400 FWL sec. 7, T. 4 N., R. 3 E.	5896	213		Vertical
HA-18 1260 FSL 2620 FWL sec. 7, T. 4 N., R. 3 E.	5886	191		Vertical
HA-19 1225 FSL 2020 FWL sec. 7, T. 4 N., R. 3 E.	5917	507		Vertical
HA-20 1980 FNL 2120 FWL sec. 7 T. 4 N., R. 3 E.	5844	147		Vertical
HA-21 1390 FSL 225 FEL sec. 7, T. 4 N., R. 3 E.	5865	362		Vertical

B. Other Drill Holes

Name and Location	Collar Elev. (Feet)	Total Depth (Feet)	Claim and Company Name	Remarks
Dacy 1400 FNL 1325 FEL sec. 29, T. 5 N., R. 2 E.	5768	1013	Flora E No. 1 American Mining Company	S. D. Geol. Survey, Bull. 3, p. 32. Beeler Rept. (8/30/25 says top quartzite at 1045 T.D. 1106. This fits better with RTM #1 and #2
Dacy RTM #1 1610 FNL 1625 FEL sec. 29, T. 5 N., R. 2 E.	5686	1185	Far West No. 1. U.S.G.S.	Drilled by Longyear 1968
Dacy RTM #2 605 FNL 730 FEL sec. 29, T. 5 N., R. 2 E.	5758	1215	Silver Tongue U.S.G.S.	Drilled by Longyear 1968
Golden Reward 119 (GR-1) 770 FSH 300 FEL sec. 1, T. 4 N., R. 2 E.	5990	416+		Scaled vert. component of DDH dipping 68 1/2°, bearing S. 69 1/2° W.
Golden Reward No. 2 800 FSL 150 FEL sec. 6, T. 4 N., R. 3 E.	5968	416	Golden Reward	
Portland No. 1 2020 FNL 1690 FEL (?) sec. 2, T. 4 N., R. 2 E.		711	Ashland Cl.	Hummel, 1952, p. 73. Also an old map by Dolbear.
Portland No. 2 2250 FEL 670 FSL sec. 35, T. 5 N., R. 2 E.	6335	437		Hummel, 1952, p. 73. Also an old map by Dolbear. Miller, 1962

Name and Location	Collar Elev. (Feet)	Total Depth (Feet)	Claim and Company Name	Remarks
Raun SE 1/4 NE 1/4 sec. 32 T. 5 N., R. 2 E.	5040	375	Alaska No. 3 or No. 4	Entire hole in porphyry. Ref. Irving, 1899, p. 216, Pl. 13 Drilled 1897
Reliance 150 FSL 1900 FEL sec. 34, T. 5 N., R. 2 E.	6149.8	753	Katy Claim	Log scaled from old Dolbear Report
Silver Reef Exact location unknown SW 1/4 SW 1/4 (?) sec. 6, T. 4 N., R. 3 E.		217	Silver Reef Claim	Source: Smith, 1897, p. 422. Location uncertain

APPENDIX IV. LOGS OF SIGNIFICANT DRILL HOLES

Note: For locations, elevations, source, etc. refer to Appendix III and to Plate 12.

Homestake-Anaconda-Golden Reward Drilling Program

	Thickness	Depth	
HA-1			
Deadwood	39	39	
porphyry	9	48	
Deadwood	2	50	
porphyry	2	52	
Deadwood	87	139	
porphyry	228	367	
Deadwood	81	448	
Precambrian	27	475	TD
HA-2			
Deadwood	40	40	
porphyry	10	50	
Deadwood	92	142	
porphyry	220	362	
Deadwood	103	465	
Precambrian	9	474	
HA-3			
Deadwood	79	79	
phonolite	231	310	
Deadwood	132	442	TD
HA-4			
Deadwood	74	74	
porphyry	221	315	
Deadwood	117	432	
Precambrian	20	452	TD
HA-5			
Deadwood	83	83	
porphyry	247	330	
Deadwood	110	440	
Precambrian	11	451	TD

	Thickness	Depth	
HA-6			
casing	11	11	
mud (?)	9	20	
Deadwood	60	80	
porphyry	245	325	
Deadwood	123	448	
Precambrian	7	455	TD
HA-7			
Deadwood	55	55	
porphyry	12	67	
Deadwood	98	165	
porphyry	206	371	
Deadwood (stopped in congl.)	74	445	TD
HA-8			
Deadwood	52	52	
porphyry	13	65	
Deadwood	104	169	
porphyry	239	408	
Deadwood	94	502	
Precambrian	12	514	TD
HA-9			
Deadwood	206	206	
porphyry	186	392	
Deadwood	89	481	
Precambrian	15	496	TD
HA-10			
Deadwood	21	21	
porphyry	113	134	
Deadwood	2	136	
porphyry	63	199	
Deadwood	2	201	
porphyry	29	230	
Deadwood	3	233	
porphyry	15	248	
Deadwood	82	330	
Precambrian	6	336	TD

	Thickness	Depth	
HA-11			
Deadwood	35	35	
porphyry	60	95	
Deadwood	1	96	
porphyry	159	255	
Deadwood	87	342	
Precambrian	8	350	TD
HA-12			
Deadwood	26	26	
porphyry	76	102	
Deadwood	46	148	
porphyry	7	155	
Deadwood	39	194	
Precambrian	13	207	TD
HA-13			
Deadwood	47	47	
porphyry	75	122	
Deadwood	33	155	
porphyry	1	156	
Deadwood	40	196	
porphyry	26	222	TD
HA-14			
Deadwood	29	29	
porphyry	69	98	
Deadwood	42	140	
porphyry	57	197	TD
HA-15			
Deadwood & porphyry rubble	20	20	
porphyry	88	108	
Deadwood	18	126	
porphyry	46	172	TD
HA-16			
Deadwood	59	59	
porphyry	98	157	
Deadwood	37	194	
porphyry	8	202	
Deadwood	4	206	
porphyry	14	220	TD

	Thickness	Depth	
HA-17			
Deadwood	57	57	
porphyry	76	133	
Deadwood	32	165	
porphyry	1	166	
Deadwood	28	194	
porphyry	21	215	TD
HA-18			
Deadwood	26	26	
porphyry	79	105	
Deadwood	16	121	
porphyry	7	128	
Deadwood	6	134	
porphyry	57	191	TD
HA-19			
Deadwood	84	84	
porphyry	91	175	
Deadwood	34	209	
porphyry	5	214	
Deadwood	2	216	
porphyry	249	465	
Deadwood	32	497	
Precambrian	10	507	TD
HA-20			
porphyry	52	52	
Deadwood	54	106	
porphyry	41	147	TD
HA-21			
Deadwood	30	30	
porphyry	231	261	
Deadwood (in congl. at base)	101	362	TD

Dacy (American Mining Company) (not very reliable)

	Thickness	Depth
limestone (shaft)	505	505
limestone	70	575
sandy lime shale	80	655
variegated shale	167	822
black shale	5	827
green sandy shale	5	832
black shale	17	849
phonolite	37	886
black shale	18	904
variegated shale	19	923
black shale	3	926
variegated shale	19	945
sand rock	5	950
quartzite	23	973
trachyte, not passed thru	40	1013

Dacy RTM #1

Pahasapa formation	335	335
Englewood formation	52	387
Whitewood formation	49.5	436.5
Winnipeg formation		
Roughlock member	43.8	480.3
porphyry sill	3.2	483.5
Winnipeg formation		
Ice Box member	60.5	544
Deadwood formation	320	864
porphyry sill	57.7	921.7
Deadwood formation	54.1	975.8
porphyry sill	94.2	1070.0
Deadwood formation	61.5	1131.5
porphyry sill	5.3	1136.8
Deadwood formation	10.2	1147.0
Precambrian amphibolite (?)	38.0	1185.0

Dacy RTM #2

Pahasapa formation	430	430
Englewood formation	46	476
Whitewood formation	36.5	512.5
Winnipeg formation		
Roughlock member	50.5	563
Ice Box member	59.5	622.5
Deadwood formation	292	914.0
porphyry sill	23	937
Deadwood formation	74.6	1011.6
porphyry sill	93.3	1104.9
Deadwood formation	75.1	1180.0
porphyry sill	3.0	1183.0
Deadwood formation	20.5	1203.5
Precambrian amphibolite	11.5	1215.0

Golden Reward Area (scaled vertical component of inclined DDH)

Golden Reward 119 (GR-1)

	Thickness	Depth
rhyolite	30	30
sandy dolomite	59	89
flat pebble conglomerate	4	93
calcareous sandstone	9	102
flat pebble conglomerate; shaly	22	124
porphyry	84	208
shale, brown	13	221
dolomite, gray	10	231
shale, gray	37	268
shale, buff	12	280
shale, gray	16	296
dolomite, sandy, glauconitic	14	310
shale, gray	23	333
flat pebble conglomerate	10	343
dolomite, brown, sandy	20	363
shale	6	369
dolomite, sandy	2	371
quartzite	12	383
conglomerate	17	400
Precambrian		

Golden Reward No. 2

unlogged	382	382
dolomite	5	387
quartzite-conglomerate	29	416
Precambrian schist		

Portland No. 1 (scaled from Dolbear)

sand rock and shales	4	4
sandstones, banded with thin shales	69	73
quartzite ore	2	75
gray silicified shale	7	82
sandstones and shale	7	89
siliceous shale	2	91
tan and brown shales	36	127
quartz porphyry	27	154
shales and sandy shales	22	176
quartz porphyry	2	178
blue shales and sandy shales	66	244
dolomite	4	248
blue shales	11	259
glauconitic sandstone	3	262
blue shales	12	278
brown sand rock	3	281
blue limestone	3	284

	Thickness	Depth
Portland No. 1 (cont'd)		
blue shales and dolomite	8	292
brown and blue shales	8	300
sandy brown shales, interbedded sandrock	20	320
quartzite	22	342
blue quartz porphyry	2	344
brown quartz porphyry	55	399
quartzite	17	416
quartz porphyry	182	598
altered porphyry	3	601
schist	110	711
Portland No. 2 (after Hummel)		
phonolite	15	15
shale	2	17
quartz monzonite	67	84
shale and dolomite	157	241
lower contact	9	250
quartz monzonite	148	398
quartzite	26	424
schist	13	437
Portland No. 2 (scaled from Dolbear)		
brown quartz and porphyry, broken	15	15
sandy shale	2	17
gray quartz porphyry	50	67
brown porphyry	10	77
porphyry	7	84
sandrock shales	2	86
sandy shales, dolomite	14	100
dolomites	2	102
blue shales and dolomites	13	115
thin bedded blue shale & dolomite	25	140
blue shale and dolomite	26	166
dolomite, glauconitic	5	171
blue mud shales	26	197
tan shales	20	217
sandy shales, dolomite	8	225
tan shales	16	241
brown dolomite	9	250
quartz porphyry, decomposed	10	260
quartz porphyry	34	294
rhyolite porphyry	30	324
quartz porphyry	74	398
quartzite	21	419
quartzitic conglomerate	6	425
white quartz	6	431
sericite schist	6	437

	Thickness	Depth
Reliance		
vertical ore	8	8
quartzite	9	17
silicified shale	57	74
brown porphyry	215	289
andesite porphyry	67	356
blue porphyry	18	374
brown porphyry	73	447
sandrock	29	476
brown porphyry	34	510
mud shale	33	543
brown porphyry	55	598
mud shale	29	627
sandrock, shale	10	637
brown porphyry	63	700
sandrock-shale	10	710
quartz porphyry	3	713
sandrock-shale	3	716
dolomite	8	724
quartzite and dolomites	8	732
quartzite and conglomerate	21	753

Silver Reef	Ft.	In.	Ft.	In.
rhyolite	43	0	43	0
hard and soft lime shales, pudding-stone variety	16	8	59	8
same as above	12	10	72	6
dark mud shales, split on exposure	10	0	82	6
hard pudding lime shales	8	0	90	6
hard lime shales	9	0	99	6
alt. bands of hard lime shales and green lime shales, also traces of blue ore	14	0	113	6
hard blue clay shales	7	0	120	6
glauconitic shales with pyrite	2	6	123	0
blue clay shales and pudding lime shales	14	0	137	0
hard pudding shales, 8" hard blue-black limestone and 6" of hard pudding shales	20	0	157	0
uniform yellow clay. True cap of ore	6	0	163	0
Pottsdam sandstone; red and yellow on top. True ore-bearing rock	17	10	180	10
Brilliant red gouge	1	6	182	4
True quartzite	19	0	201	4
Sand rock	5	0	206	4
Cemented sand and quartz pebbles	2	0	208	4
Archean slates	8	8	217	0

APPENDIX V. TABULATION OF DATA FROM SHAFTS

A. Tabulation of Deeper Shafts, T. 4 N., R. 2 E. (By Section)

Name and Location	Collar Elev. (Feet)	Total Depth (Feet)	Claim and Company Name	Remarks
Tornado 1250 FSL 350 FEL sec. 1	5852	315	Minnie	Bottoms in basal Cambrian quartzite
Baltimore 2200 FNL 1000 FEL sec. 1		230	Baltimore Golden Reward	See Appendix VI for log
Plutus sec. 1	5778	92	Yuba Golden Reward	
Snowstorm on line between secs. 1 & 2 2620	6200	374	Snowstorm No. 4	See Appendix VI. Log in Smith, 1897, p. 410
Dakota 550 FNL 1500 FWL sec. 2	6429	584	Vulcan	DDH to 910 ft. See Appendix VI for log
Foley 2380 FSL 2020 FWL sec. 2	6417	349	Foley	DDH to 793 ft. See Appendix VI for log
Mogul 350 FNL 220 FEL sec. 12	5897	305	Great Mogul Golden Reward	No record
Troy 460 FNL 1120 FEL sec. 12	6030		Great Mogul Golden Reward	No record

Name and Location	Collar Elev. (Feet)	Total Depth (Feet)	Claim and Company Name	Remarks
Horseshoe 220 FNL 2330 FEL sec. 12	6136			No record
Delaware sec. 13	6042			No record
Welcome 860 FSL 1980 FEL sec. 1				No record

B. Tabulation of Deeper Shafts, T. 4 N., R. 3 E. (By Section)

Name and Location	Collar Elev. (Feet)	Total Depth (Feet)	Claim and Company Name	Remarks
Fannie 620 FSL 2100 FWL sec. 6	5834	265	Fannie Golden Reward	See Appendix VI for log
Bottleson 1380 FSL 470 FWL sec. 6	5808	180	Maybury Golden Reward	No record
Sundance 200 FSL 1300 FWL sec. 6	5818	245 or 265	Sundance Golden Reward	No record
Alpha sec. 6	5740	52	Alpha Golden Reward	No record
Lucile sec. 7	5770		Golden Reward	No record
Sunset sec. 7	5846	315	Golden Reward	No record
Union sec. 7	5647	107	Carthage Golden Reward	Appendix VI for log
Astoria sec. 7	5835	345	Grove Golden Reward	See Appendix VI for log, Plate 9 for working of Astoria mine

Name and Location	Collar Elev. (Feet)	Total Depth (Feet)	Claim and Company Name	Remarks
National (Zipp) sec. 8	5862			Line between Golden frac. and Andes. No record
Monarch sec. 1			Monarch MS 908	

C. Tabulation of Deeper Shafts, T. 5 N., R. 2 E. (By Section)

Name and Location	Collar Elev. (Feet)	Total Depth (Feet)	Claim and Company Name	Geological Information
Yankee 1380 FSL 1450 FWL sec. 10	5511		Yankee Eureka Company	Starts in Whitewood. Roughlock, Ice Box and porphyry on dump
Key West 550 FSL 2450 FEL sec. 10	5605		Key West Key West Co.	Collar in Pahasapa. Dump is limestone, some pink, some silicified. Timbered.
Little Ellen 2000 FSL 100 FWL sec. 14	5680±	230	Little Ellen Titanic Co.	Collar in Deadwood. See log section.
Empire 200 FNL 400 FEL sec. 15	5518		Hendrick, now Virginia Cl. Emp. Carb. Co.	Collar in porphyry. Dump all porphyry
Hartshorn 170 FNL 325 FWL sec. 15	5678		Hartshorn Hartshorn Co.	Dump all black dolomite. Collars in Pahasapa. On north vertical
Surprise 290 FNL 750 FWL sec. 15	5640		Surprise Enterprise Company	Collar in Pahasapa. Englewood and Whitwood on dump
Rialto (?) 625 FNL 1070 FWL sec. 15	5590		Rialto Rialto Co.	Collar in Pahasapa. Englewood on dump
Wilkinson 510 FNL 1960 FWL sec. 15	5665±		Wilkinson Wilkinson Company	Collar in Pahasapa. Dump all Pahasapa

Name and Location	Collar Elev. (Feet)	Total Depth (Feet)	Claim and Company Name	Geological Information
Rattler 600 FNL 2400 FWL sec. 15	5615		Rattler Rattler Co.	Pahasapa-porphyry contact in collar
Far West 680 FNL 2580 FWL sec. 15	5600		Far West Far West Co.	Collar in porphyry. Dump mostly jasperoid and Pahasapa dolomite
800 FNL 1800 FEL sec. 15	5552		Little Giant ? Trent Co. ?	Collar in Pahasapa. Dump all Pahasapa
Darboy 940 FNL 1250 FEL sec. 15	5647		Darboy Darboy Co.	
Brooklyn sec. 15			Brooklyn	At least 3 shallow shafts on Iron Hill vertical
Adelphia 1520 FNL 1420 FWL sec. 15	5675		Adelphia	Pahasapa-porphyry contact at collar. Dump is on Iron Hill vertical
Albe Holmes 1600 FNL 1700 FWL sec. 15	5660±		Holmes Fr.	On Iron Hill vertical
Combination (New Titanic) 1815 FNL 1850 FWL sec. 15	5636	300+	Carbonate Titanic Co.	Collar in porphyry On Iron Hill vertical

Name and Location	Collar Elev. (Feet)	Total Depth (Feet)	Claim and Company Name	Geological Information
Iron Hill 1670 FNL 2310 FWL sec. 15	5683	470	Utica Iron Hill Company	Collar in Pahasapa with porphyry sill just below. Old report lists "white line" (Roughlock?) 350-400 ft. On Iron Hill vertical
Seabury 1700 FNL 2560 FWL sec. 15	5690	240	Seabury Seabury-Calkins Co.	Collar in Pahasapa. On Iron Hill vertical
Segregated Iron Hill 1740 FNL 2380 FEL sec. 15	5690±		Ultimo Seg. Iron Hill Company	Collar in Pahasapa over porphyry sill. Some Pahasapa, mostly porphyry on dump. On Iron Hill vertical
Liberty 2100 FNL 1200 FEL sec. 15	5621	165	Orig. Independent, later Liberty Liberty Co.	Collar in Roughlock. Roughlock, porphyry, Ice Box and Deadwood on dump
Mugwump 2325 FNL 800 FEL sec. 15	5684	140	On line between Pilgrim and Creston. Now Republic M. Co.	Collar in Roughlock. Roughlock, Ice Box, porphyry and Deadwood on dump. Timbered through Ice Box
Spanish R #1 1920 FNL 600 FWL sec. 15	5490	425	Richmond Spanish R Company	Collar in porphyry. Reportedly hit Cambrian (Winnipeg?) at 300 ft. Scolithus on dump
Spanish R #2 1930 FNL 690 FWL sec. 15	5500±	150+	Richmond Spanish R Company	Collar in porphyry

Name and Location	Collar Elev. (Feet)	Total Depth (Feet)	Claim and Company Name	Geological Information
Home Run sec. 15	5700±	60	Utica Iron Hill Company	Collar in Pahasapa cut by porphyry dike
Buntz sec. 15	5700±		Utica Iron Hill Company	Collar in Pahasapa, cut by porphyry dike
Cleopatra 2000 FSL 1850 FEL sec. 16	4800±	227 1/2	Cleopatra Cl. Cleopatra G.M. Co.	Collar in Deadwood, bottom in basal quartzite. See log section. Sunk 1898-1902
American 2600 FNL 100 FEL sec. 19	4880±	360	American Mining Co.	Collar in Deadwood, bottoms on basal quartzite
Po 1900 FSL 650 FEL sec. 20	5720±	est 100	Po Claim	Collar in Pahasapa. Dump all Pahasapa
Badger 1800 FSL 2200 FEL sec. 29	5880±	360	Badger No.	Collar in Deadwood, bottom in porphyry. See log section

APPENDIX VI. LOGS OF SIGNIFICANT SHAFTS

Note: For location, elevation, etc., refer to Appendix V and Plate 12.

	Thickness	Depth
Astoria Shaft		
shale	40	40
ore	5	45
porphyry	250	295
shale and dolomite	20	315 TD
Badger Shaft		
Cambrian shales	316	316
porphyry	44	360 TD
Baltimore Shaft		
grorudite	60	60
Cambrian shale	40	100
Eruptive rock	20	120
Cambrian shale and dolomite	110	230 TD
Cleopatra Shaft		
dolomite and shale	20±	20±
porphyry sill	30±	50
shale and limestone, not recorded	134.5	184.5
porphyry	27	211.5
dolomite and shale	16	227.5
quartzite		227.5 TD
Dakota Shaft (and Drill Hole below 584)		
shale and dolomite ("intermediate contact")	75	75
shale	95	170
porphyry ("Clinton" sill)	270	440
shale	80	520
porphyry	20	540
quartzite	80	620
porphyry	170	790
quartzite	40	830
conglomerate	30	860
schist	50	910 TD

	Thickness	Depth	
Fannie Shaft			
Cambrian shales	70	70	
Cambrian shales containing a little ore	6	76	
Cambrian shales	4	80	
trachytoid phonolite	165	245	
Cambrian shale and dolomite	12	257	
ore	10	267	TD
Foley Shaft (and Drill Hole below 349 feet)			
talus	30	30	
shale	46	76	
phonolite	174	250	
grorudite	77	327	
shale and dolomite	35	362	TD
quartz monzonite	220	582	
shale, tan and blue	27	609	
lower contact (impure dolomite and shales)	34	643	
quartzite	18	661	
syenite	39	700	
quartzite	12	712	
grorudite	81	793	TD
Snowstorm Shaft			
porphyry	124	124	
shale	10	134	
porphyry	85	219	
shale	30	249	
porphyry	4.5	253.5	
shale	87	340.5	
porphyry	0.5	341	
lime shale	15	356	
sand rock	12	368	
quartzite	6	374	TD
Sunset Shaft (questionable log)			
shale	15	15	
prophyry (quartz aegirite)	160	175	
shales	54	229	TD
Union Shaft			
phonolite	80	80	
shale and dolomite	20	100	
quartzite	7	107	TD

APPENDIX VII

Results of Geochemical Surveys

The results of the geochemical sampling program have been introduced above, wherever the data applied to properties discussed in the text. Additional sampling was done both in areas outside of those mapped and, to provide more detail on specific localities within the mapped area. The results of these investigations are presented below.

Citadel Rock Area—About 50 samples were collected from altered zones in the Deadwood formation and quartz monzonite porphyry mass at Citadel Rock. No evidence of sulfide mineralization was found on the surface in the area, and only trace values of gold and silver were present in the samples. Arsenic values were also low, with only three samples containing more than 100 ppm. Ten of the samples were run for mercury, and of these, three collected in the upper part of the Deadwood formation on the northwest side of the dome contained 1.60, 2.50 and 1.75 ppm of mercury. Arsenic values in these samples were 75, 150 and 600 ppm respectively.

Squaw Creek-Labrador Gulch Area—A total of 78 samples were collected along upper Squaw Creek, Labrador Gulch, and the small, unnamed gulch just west of Labrador Gulch. The area lies in parts of sections 21, 22, 27, 28, 33 and 34 of T. 5 N., R. 2 E. Most of the samples came from the Deadwood formation, but the Tertiary igneous rocks, Whitewood formation and Pahasapa formation are also represented.

Gold values in samples from the Deadwood formation were generally less than 1 ppm. A value of 1.4 ppm Au was obtained from a prospect pit near the east-west offset close to the line between sections 27 and 28, and 2.4 ppm Au was found in one sample from the contact of the basal quartzite and a porphyry dike on upper Squaw Creek.

Three samples were collected from the remnant of Whitewood formation on the ridge in the NW 1/4 NW 1/4 sec. 34, and these contained 0.0, 0.2 and 0.4 ppm of gold. However, some ore has apparently been removed from an old mine excavation of the remnant.

A sample of Pahasapa formation was collected from a prospect pit along the contact of the Pahasapa and igneous rock just west of the Whitewood formation remnant. Manganese oxide was abundant in the pit, and the sample contained 5 ppm of silver and over 1000 ppm of arsenic.

Axis of the Lead-Deadwood dome north of Carbonate—Twenty-three samples were collected from scattered outcrops of the Deadwood formation along the projection of the axis of the Lead-Deadwood dome north of Carbonate as far as Spearfish Canyon. Most of these contained gold with values ranging from a trace to 5 ppm. Included in the total were five samples from Spearfish Canyon just south of Spearfish Peak. Pyrite was observed in the upper contact zone of the Deadwood formation in Spearfish Canyon in the northwest corner of sec. 4, T. 5 N., R. 2 E. The area north of Carbonate has not been mapped, however, so that the horizons from which the samples came is not known.

Galena District—Samples were collected on the corners of a quarter-mile grid coverning the entire district and several sample lines were collected across the Deadwood formation. As expected, the upper and lower ore horizons could be identified in all the sections based on the presence of lead, zinc and silver. Maximum values obtained from the Deadwood formation were 1,500 ppm of zinc, 15,000 ppm of lead and 150 ppm of silver. Of potential interest, however, are anomalous values of silver found in the Pahasapa formation in the SW 1/4 sec. 10, T. 4 N., R. 4 E.

Lost Camp Gulch—Eight sample lines were run across the Paleozoic section from the upper contact zone of the Deadwood formation into the lower Pahasapa formation in Lost Camp Gulch. The lines are located between the confluence of Annie Creek and Lost Camp Creek in the SW 1/4 sec. 3, T. 4 N., R. 2 E. and Dutch Flats, one mile to the southeast. Samples from the upper contact zone generally contained from a trace to 0.2 ppm of gold, and comparable silver values were scattered throughout the Pahasapa formation. Samples from two mine dumps at the mouth of Lost Camp Gulch yielded 2.6 and 2.7 ppm of gold.

Terry Peak—One hundred and seventeen samples were collected from the slope of Terry Peak in the SW 1/4 sec. 1, T. 4 N., R. 2 E. Of these, only eleven did not contain gold, while the highest value found was 33 ppm. Gold values ranged from a trace to 1.0 ppm in 84 samples, from 1.0 to 10 ppm in 30 samples. and over 10 ppm in 3 samples.

The bulk of the samples came from south of a large cut which was opened just west of the dike in the E 1/2 SW 1/4 sec. 1, T. 4 N., R. 2 E. (Plate 5) and the results show that the mineralization extends at least 500 feet south of the cut. The remainder of the samples were taken from the knob in which the Mogul Cuts were developed (Plate 11), and from the southeastern extension of the offset which passes just south of the cuts.

The 33 ppm Au sample came from a limonite filled fracture in one of the workings of the Mogul Cuts, and the higher values in general, came from this area. The sample results also suggest that the mineralization may extend southeastward along the offset for a few hundred feet.