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Potential for shale-hosted massive sulfides in the Permian Dollarhide Formation, south-central Idaho

By

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Contents

ILLUSTRATIONS

ABSTRACT

The upper member of the Permian Dollarhide Formation is a discrete tectonostratigraphic unit within the "Idaho Black Shale Belt" as defined by W.E. Hall in 1985. It can be traced approximately 20 miles from the town of Bellevue to Dollarhide Mountain. Along this trend more than 20,000,000 ounces of silver and associated base metals have been recovered from epigenetic fault-controlled veins. The upper member is highly carbonaceous, hosts many silver-lead-zinc veins, and is associated with a syngenetic barite horizon. These relations suggest a high potential for undiscovered massive sulfide deposits exists in the upper member. Southwest of Bellevue, the northeast-trending Hailey Gold belt intersects the northwest-trending zone of Ag-Pb-Zn epigenetic veins in the upper member of the Dollarhide Formation. This area has potential for undiscovered gold deposits.

INTRODUCTION

Geologic mapping and related studies by Wavra and others (1986) on sedimentary rocks near Sun Valley, Idaho, have shown that many of the silver-lead-zinc mineral deposits west of the Big Wood River are associated with the upper member of the Dollarhide Formation. This report discusses the spatial distribution of these deposits with respect to the upper member and proposes a syngenetic massive sulfide origin for the metals.

In general, the upper member of the Dollarhide Formation (part of the Idaho Black Shale Belt" of Hall (1985)) consists of allochthonous fine-grained Paleozoic clastics, which are carbonaceous-rich and highly metalliferous. There are two principal mineralized areas within the upper member of the Dollarhide Formation: 1) a large region west of the towns of Hailey and Bellevue, and 2) a small area near the old town site of Carrietown. Approximately 20,000,000 ounces of silver plus associated base metals have been recovered from the mines near Hailey-Bellevue and 1,000,000 ounces of silver from the Carrietown mines (Ross, 1930). The silver ore mined from these locals has come from high-grade, shallow depth, fault-controlled vein deposits.

GEOLOGY OF THE MINES IN THE HAILEY-BELLEVUE AREA

There has been considerable confusion about the formational name of the host rocks for the silver-lead-zinc deposits near the towns of Hailey and Bellevue. Lindgren (1900) was the first to study the silver veins and sedimentary host rocks in the Hailey-Bellevue area, and he placed them in the Wood River Formation. Umpleby and others (1930) later studied the geology and ore deposits near Hailey and Bellevue and recognized that the silver veins in sedimentary rocks were hosted by both a new unit they called the Milligen Formation, and also by the Wood River Formation. Anderson and others (1950) confirmed the observations by Umpleby and others (1930). Hall and others (1978) suggested that the main ore-bearing unit near Hailey-Bellevue was the Milligen Formation, and that only a subordinate amount of lead-silver lodes was hosted by the Wood River Formation. In the summer of 1984, Hall began to recognize that the ore deposits near Hailey and Bellevue were hosted by the Lower Permian Dollarhide Formation, and not by the Milligen or Wood River Formations; yet no formal stratigraphic unit of the Dollarhide Formation was assigned as an ore-hosting unit. Recent mapping by Wavra and others (1986) has shown that the Ag-Pb-Zn veins near Hailey and Bellevue are

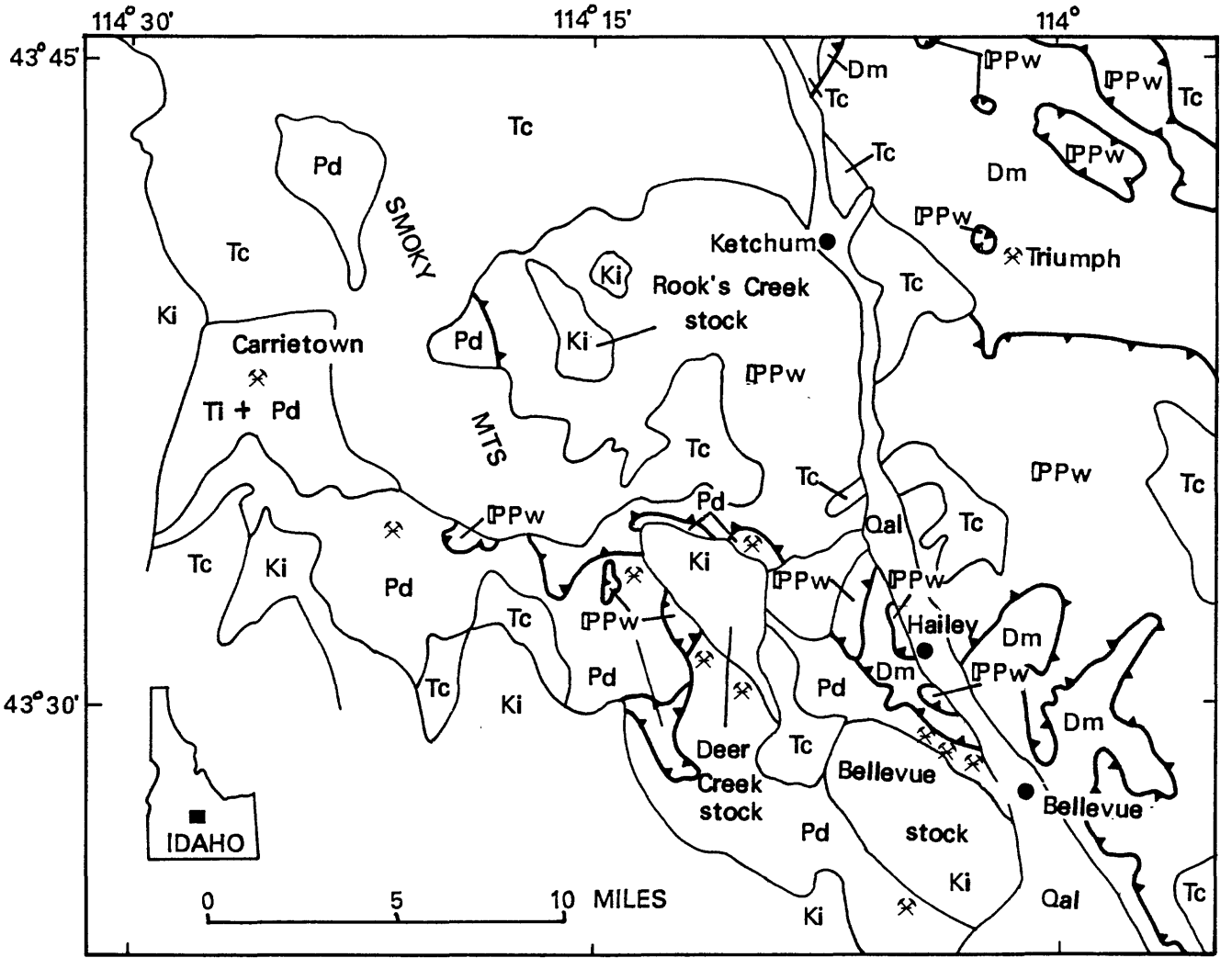

Figure 1. General geologic map showing the outcrop distribution of the Lower Permian Dollarhide Formation, Wood River region, central Idaho. Qal = Quaternary alluvium, Ti = Tertiary intrusions, Tc = Challis-related (Eocene) volcanics, Ki = Cretaceous intrusions, Pd = Lower Permian Dollarhide Formation, PPw= Pennsylvanian-Permian Wood River Formation, Dm = Devonian Milligen Formation. Sawteeth on upper plate along low-angle faults. Geology from Hall (1985).

stratigraphically contained within the upper member of the Dollarhide Formation. The metals in the epigenetic veins were probably derived from syngenetic shale-hosted metal deposits.

GEOLOGY OF THE CARRIETOWN AREA

Umpleby (1915) was the first to describe the geology in and around the Carrietown mining district. He concluded that the lead-silver veins of the Carrietown district were hosted by Paleozoic sedimentary rocks. Ross (1930) later studied the mines in the Carrietown district and assigned the sedimentary rocks of the district to the Pennsylvanian age Wood River Formation. Hall (1985) was the first to assign the name Dollarhide and Carrietown Formations to the sedimentary rocks in the Carrietown area. Geologic mapping by Hall (unpublished) shows that the silver-lead veins near Carrietown are localized near a low angle fault contact between the Dollarhide and Carrietown Formations. Darling (1988) studied the geology and mineralogy of the deposits of the Carrietown district. Wavra (unpublished data) concludes that the upper member of the Dollarhide Formation is present in the Carrietown area and that it is very similar to the upper member of the Dollarhide Formation in the Hailey/Bellevue area.

PERMIAN DOLLARHIDE FORMATION LITHOLOGIES

The Lower Permian Dollarhide Formation was first named and recognized as a discrete sedimentary unit within the Big Wood River region by Hall (1985). The type section of the Dollarhide Formation is located 32 miles west of Ketchum, Idaho, near Dollarhide summit. Wavra (1985) was the first to assign an informal stratigraphy to the Dollarhide Formation, and assigned lower, middle, and upper members. In general, the Dollarhide Formation represents a slope sequence and consists of banded-carbonaceous, siliceous, calcareous siltite interbedded with sandy limestone/calcareous sandstone, calcareous quartzite, black carbonaceous limestone, minor conglomerate, and carbonaceous-pyritic argillite. Sedimentary structures are ubiquitous in the formation and consist mainly of convolute beds, crossbeds, and laminations. The lower and middle members were deposited in a slope environment, while the upper member was deposited in either a restricted facies (graben?) within the slope environment, or in a more basinal facies - distal from the slope environment. Banded rocks are common and distinctive of the lower and middle members of the Dollarhide Formation. The term 'banded' refers to the alternating dark and light gray colors the unit displays at the outcrop. Also, a syngenetic barite horizon locally marks the facies change from the middle to upper member near Panther Gulch and at the North Fork of Deer Creek.

The ore-hosting upper member

The outcrop distribution of the upper member of the Dollarhide Formation forms a N30W trending belt, which can be traced from the town of Bellevue northward into the Carrietown area (fig. 2). Many Ag-Pb-Zn veins, together with syngenetic barite, are found along this trend (fig. 2).

In general, the upper member of the Dollarhide Formation consists mainly of graphitic, siliceous argillite, with micaceous quartzite, marble, and siliceous siltite. Also, locally apatite-rich beds are present in the graphitic argillite and quartzite. Wavra and others (1986) reported that the upper member of the Dollarhide Formation was non-calcareous. Their

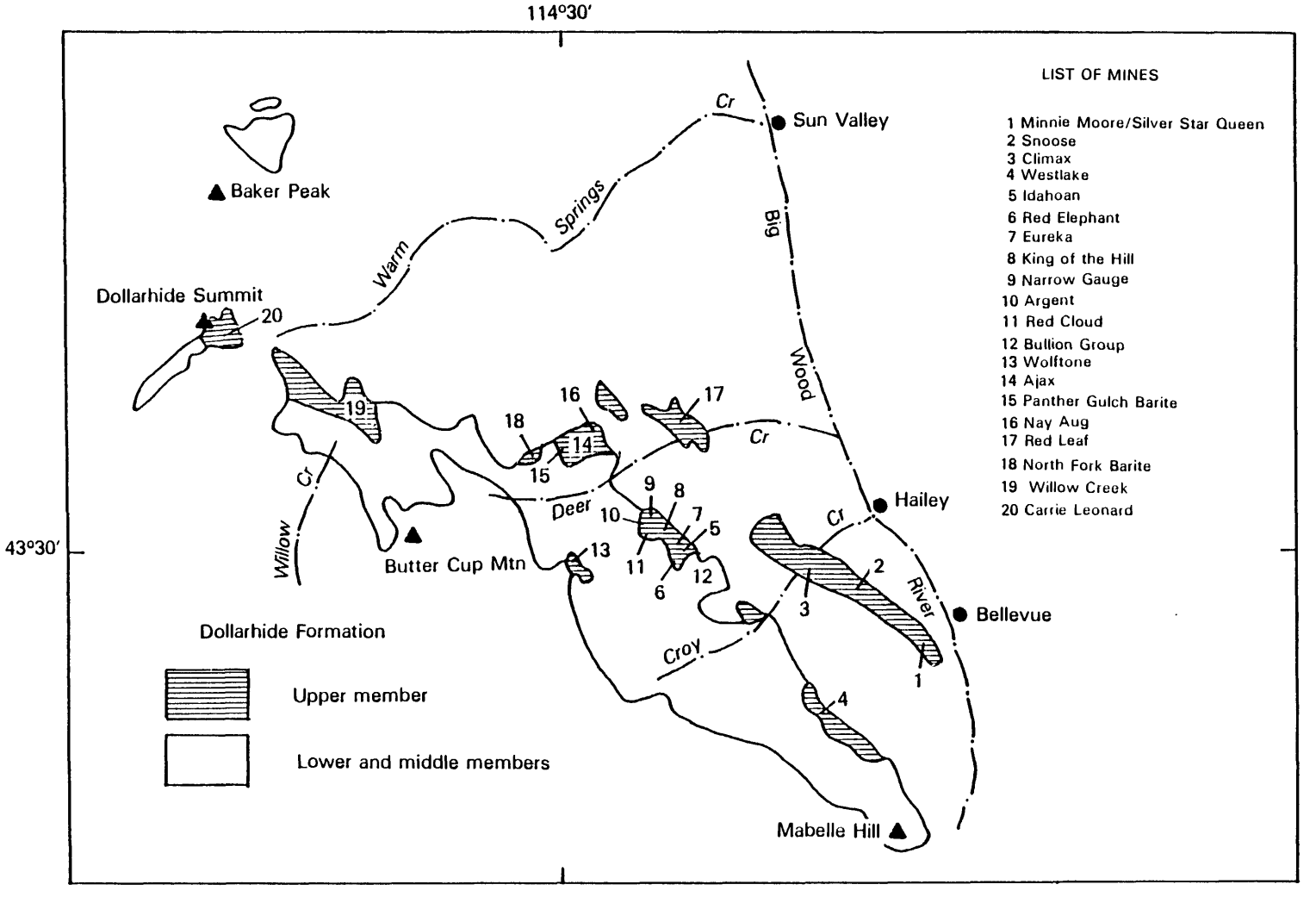

Figure 2. Outcrop distribution of the upper member of the Dollarhide Formation and associated Ag-Pb-Zn and barite mines. Approximate scale 1:270,000.

observations applied where they studied the unit proximal to intrusive bodies. However, the upper member of the Dollarhide Formation in the Willow Creek/Carrietown area is locally calcareous. Where Wavra and others (1986) studied the upper member, the intrusive bodies may have driven the carbonate out of the unit during contact metamorphism.

Recent data from fossils, collected by Betty Skipp (personal communication, 1989) from the rock called upper member in this report, have shown the unit to contain Pennsylvanian age fusilines. I believe these fossils possibly represent reworked material which has been transported into the Dollarhide Formation litho-package during Permian time. The Salmon River sequence serves as an excellent example of a unit which contains reworked older fossils. The unit has fossils which range in age from Cambrian through Mississippian. The Salmon River assemblage has been dated as a Mississippian age unit and not Cambrian per se. What the Pennsylvanian age fossil assemblage does show is that the rocks cannot belong to the Milligen Formation. Field criteria also support this claim (see text below). This relation is of supreme importance in understanding the mineralized zones in the region. More than one occurrence of Pennsylvanian fusilines should be used before the upper member of the Dollarhide Formation is given a final age assignment. There is more evidence on lithologic grounds (discussed below) which supports the upper member as being a Permian unit rather than a Pennsylvanian one. Furthermore, the paleogeographic setting of the upper member rocks fits better into Permian depositional settings than the Pennsylvanian. Much more work is needed to delineate the age of the unit.

The upper member of the Dollarhide Formation is similar to parts of the Devonian Milligen Formation. Both units are markedly dark colored owing to their high carbonaceous content and they are difficult to distinguish from one another if they are structurally juxtaposed; e.g. as near the Snoose mine (fig. 2). However, there are marked differences between these two units. The Dollarhide Formation does not show a pervasive penetrative cleavage, phyllitic sheen, nor abundant small scale isoclinal folds, which are common in rocks of the Milligen Formation, but is massive and (or) structureless. Where it occurs near plutons, the upper member of the Dollarhide Formation shows an incipient mica cleavage, boudinaged quartz-rich layers, locally has a bleached appearance, and contains small euhedral green tourmaline crystals. Also, the upper member of the Dollarhide Formation may be found in conformable contact with the banded facies of the middle member, as noted at Bullion Gulch (sec. 23, Richardson Summit 7.5′ quadrangle), near the drainage divide between Willow and Deer Creeks (sec. 30-31, Buttercup Mtn. 7.5′ quadrangle), and at Narrow Gauge and Panther Gulches (secs. 9 and 36, Mahoney Butte 7.5′ quadrangle).

Some geologists recently working in the area have argued that rocks referred to in this report as the upper member of the Dollarhide Formation belong to the Devonian Milligen Formation and not the Dollarhide Formation. Their main criteria for this is the similarities of the Milligen Formation stratigraphy near Triumph with rocks referred to in this report. This author believes there is a marked difference, in terms of structural fabrics, between the Milligen Formation and the upper member of the Dollarhide Formation. Though the Milligen Formation is stratigraphically heterogeneous, phyllitic units are characteristic of this formation. In the strictest sense many of the Milligen Formation phyllites are non- to semi-phyllitic, but are strongly cleaved. The rocks referred to as the upper member of the Dollarhide Formation in this report lack the phyllitic units for the entire outcrop area shown in figure 2, and furthermore, banded rocks similar to those

characteristic of the lower and middle members of the Dollarhide locally occur within the upper member of the Dollarhide Formation; e.g. along the Willow Creek/Deer Creek divide (sec. 25, Buttercup Mtn. 7.5' quadrangle) and in Panther Gulch (sec. 31, Mahoney Butte 7.5' quadrangle) and on the ridge to Dollarhide Mtn. (sec. 15, Dollarhide Mtn. 7.5' quadrangle).

The upper member of the Dollarhide Formation is associated with a barite horizon. It can be traced discontinuously nearly 1 mile along the upper/middle member contact, at the North Fork of Deer Creek and near the headwaters of Panther Gulch (secs. 31 and 36, Mahoney Butte 7.5' quadrangle). In general, the barite is white to cream in color, contains thin laminations of pyrite and has small scale slump folds. Silicification of the barite is common locally. The maximum thickness of the barite horizon is 60 feet in section 36 at an open cut. Howe and Hall (1985) reported a $\delta^{34}S$ value of +13.2 per mil for the barite horizon and noted it was nearly identical to that of Permian seawater sulfate. The localized nature of the barite may be explained in terms of a brine pool sink which deposited syngenetic barite under the proper conditions at the North Fork of Deer Creek and Panther Gulch areas. Locally the barite has a crosscutting nature to the enclosing sediments which reflects local remobilization of barite into available open space created by post-barite-deposition tectonic activity. An epigenetic origin for the barite is discredited based on the criteria listed above.

GEOCHEMISTRY OF THE DOLLARHIDE FORMATION

Geochemical analyses of samples from the lower and middle members of the Dollarhide Formation, along Wolftone Creek (secs. 7, 18, Mahoney Butte 7.5' quadrangle) have shown these rocks to be anomalous in Ag-Co-Cr-Mn and Mo (Wavra and others, 1986). Geslin (1986) noted similar geochemical values from rocks of the Dollarhide Formation, west of the Hailey-Bellevue area, near Willow Creek (secs. 31, 36, Buttercup Mtn. 7.5' quadrangle). Detailed chemical analyses on rocks of the upper member of the Dollarhide Formation are lacking. Exxon Company geologists (oral communication, 1984) noted that geochemical values of Ag-Pb-Zn-Ba increased significantly near the barite horizon at Panther Gulch, when sampled stratigraphically across the horizon, beginning in the footwall-banded middle member upsection into the hanging wall rocks of the upper member. Samples of the Dollarhide Formation collected by Wayne Hall near the Snoose and Red Elephant mines contain the following values (fig. 2):

	Snoose Mine	Red Elephant Mine
	ppm	ppm
Ag	13	<2
Ba	1,500	1,600
Zn	1,070	<50
Pb	790	86

Analytical results from a series of samples collected by Wavra near Sky Ranch Flat (T1N, R18E, sections 9 and 16, Bellevue 7.5-minute quadrangle) from the upper (SKR2-SKR5) and middle (SKR1) members of the Dollarhide Formation are listed below.

	Cu ppm	Au ppb	Mo ppm	Zn ppm	Ag ppm	As ppm	Hg ppb	Sb ppm
SKR1	3,250	200	<1	6,700	25.0	245	1,000.	985
SKR2	44	<5	2	75	1.1	<5	10.	12
SKR3	36	<5	12	305	1.8	26	70.	<5
SKR4	520	45	3,758	2,200	13.1	23	350.	<5
SKR5	70	<5	17	95	2.6	202	20.	<5

Eleven additional samples run by a mining company near Sky Ranch Flat gave the following results: 31 ppb Au, 0.7 ppm Ag, 35 ppm Pb, 359 ppm Zn, 53 ppm Cu, 6 ppm As, and 43 ppb Hg.

POTENTIAL FOR SHALE-HOSTED MASSIVE SULFIDE IN THE UPPER MEMBER

A shale-hosted massive sulfide horizon may be present in the argillites of the upper member of the Dollarhide Formation. Possible evidence for this is: 1) the association of syngenetic barite with the upper member; 2) stratigraphic confinement of the Ag-Pb-Zn veins to the upper member; and 3) the carbonaceous-rich nature of argillites from the upper member. In many respects the geologic setting of the ore deposits near the Hailey-Bellevue and Carrietown areas is very similar to the Selwyn Basin base metal deposits in the Northwest Territories, Canada (Carne and Cathro, 1981). Large (1981) described the main criteria in evaluating an area for having shale-hosted massive sulfide potential as (1) a carbonaceous-rich shale host, (2) epithermal veins proximal to the massive sulfide deposit, and (3) syngenetic barite. All of these criteria are present in the Dollarhide Formation near Hailey-Bellevue. Hall and others (1978) has shown through isotopic work that the metals in the Ag-Pb-Zn veins near Hailey-Bellevue were probably derived from the surrounding sedimentary rocks and that they were remobilized into economic concentrations during later plutonism. Detailed studies are needed to determine if the Ag-Pb-Zn veins near Hailey-Bellevue were remobilized from potentially economic or non-economic horizons and if an economic horizon did exist, is part of it still intact today? These questions can only be answered by detailed stratigraphic and geochemical work on the ore-hosting upper member of the Dollarhide Formation. Wavra (unpublished data) has collected syngenetic mineral sulfides from the upper member on the Willow and Deer Creek drainage divide, south of Dollarhide summit. Similarly, syngenetic mineral textures (Exxon geologists, personal communication, 1984) have been noted at the Snoose mine waste dumps (fig. 2). Such mineral textures suggest that stratiform/stratabound metal rich horizons do exist in the area.

CONCLUSIONS

In summary, the upper member of the Dollarhide Formation is a discrete stratigraphic unit which hosts the Ag-Pb-Zn veins and syngenetic barite near Hailey-Bellevue and the Carrietown area. Although the age of the unit is still in doubt, I believe field evidence supports a Permian age for the upper member, and that the current fossil data represent reworked material. Available geochemical information suggests, furthermore, that the upper member carries significant minimum background values, as follows: Zn (100 ppm), Cu (35 ppm), Ag (1-5 ppm), Pb (10-15 ppm), and Mo (5+ ppm). The association of carbonaceous-rich argillites, syngenetic barite, and the abundance of rich Ag-

Pb-Zn veins in the upper member argillites suggests potential for a shale-hosted massive sulfide deposit. Exploration targets for shale-hosted massive sulfides are present in the upper member of the Dollarhide Formation, (1) in areas not mineralized by epithermal vein type deposits, and (2) proximal to the epithermal vein deposits. It is also suggested that the southern end of the outcrop belt of the upper member may have potential for gold (see Sky Ranch Flat geochemical values), as this area is a point of intersection for the northeast-trending Hailey Gold Belt with the northwest-trending zone of Ag-Pb-Zn veins.

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