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Geology, Mineralogy and Paragenesis of the Pride of America Mine, Lake City, Hinsdale County, Colorado

by

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ABSTRACT

The Pride of America Mine exposes two classic fissure-type veins in the Eureka Tuff and Picayune Megabreccia Members of the Sapinero Mesa Tuff. This small mine in the Galena District principally produced Ag, which occurs in freibergite, acanthite, and native silver. Three stages of mineralization formed the veins and adjacent wall rock alteration: quartz-sericite-pyrite, base metals, and barite-rhodochrosite-quartz. Adjacent stages show significant overlap. Minor local fracturing and brecciation accompanied the beginning or end of precipitation of certain minerals. The sequence of mineralization from the first to the last stage shows a regular and continuous evolution with only small perturbations marked by fracturing and brecciation. Thus the three stages appear to be evolving parts of one major episode of mineralization. Qualitative factor analysis of elements across one of the veins and altered wall rock shows that the elements can be grouped into 3 main associations and 10 subordinate associations that are correlated with particular minerals and hydrothermal processes.

INTRODUCTION

The Pride of America Mine is located 10 km west of Lake City, Colorado, in Hinsdale County (Fig. 1) and belongs to the Galena District (Irving and Bancroft, 1911; Burbank, 1947), one of many Ag-Au mining districts in the San Juan Mountains. The district lies within and on the northern side of the 28 m.y. Uncompahgre caldera, which is one of about 18 large calderas in the San Juan volcanic field (Steven and Lipman, 1976). The district lies close to and just north of the northern margin of the 23 m.y. old Lake City caldera which occupies the center of the Uncompahgre caldera. Production from the district was estimated at about $13 million, equivalent to about $200 million today, most of which was extracted between 1890 and 1903 (Irving and Bancroft, 1911). The Ute-Ulay Mine, studied in detail by Slack (1976, 1980), accounted for the bulk of this production. The Pride of America is one of several smaller but significant producers in the district. In many ways, it is more typical of the veins in the district than is the Ute-Ulay. The Pride of America Mine has also been studied by Korzeb (in press).

This detailed study is part of a larger study of the igneous and hydrothermal evolution of the Lake City area by the U.S. Geological Survey. The geology and development of the Lake City caldera has been worked out by Ken Hon (unpublished data) whose mapping is the latest in a long history of USGS work in the area (e.g. Irving and Bancroft, 1911; Lipman and others, 1973; Lipman, 1976; Sanford and others, in press, a). Geophysical work by V. J. S. Grauch (1985, and unpublished data) has defined the subsurface extent of several intrusive bodies whose relationship with hydrothermal veins is currently being investigated. Reynolds and others (1983, 1986) showed that

Lake City caldera events spanned the time of one paleomagnetic reversal, about 300,000 years. Lipman and others (1976) and Grauch and others (1985) have discussed multiple events of mineralization in the area. Bove (1984) studied the alunite deposit on Red Mountain. The goal of this project is to define precisely the timing of geological and hydrothermal events and to use these data to understand in detail the processes and forces behind the development of a caldera system from the time of initial magma emplacement through caldera formation to the circulation of hydrothermal fluids and the precipitation of base and precious metals. Ultimately the vein studies will include data from the other important deposits in the area, which will serve as a basis for area-wide studies of $^{40}Ar-^{39}Ar$ ages, Pb isotopes, fluid inclusions, element distributions, mineral zoning, paragenesis, etc., some of which studies are underway.

GEOLOGY OF THE MINE AREA

The local geology is summarized mainly from Lipman (1976) and from Lipman and others (1973). The oldest rocks in the are are Precambrian granitic rocks exposed south and west of the Lake City caldera. In Oligocene time, intermediate composition lavas and breccias were erupted from volcanic centers now exposed outside the topographic wall of the Uncompahgre caldera. The Uncompahgre caldera along with the San Juan caldera in the Silverton area were formed at about 28 m.y. with the eruption of the rhyolitic Sapinero Mesa Tuff. The part of the Sapinero Mesa Tuff that fills the Uncompahgre caldera is known as the Eureka Member. Coincident with and very shortly after this eruption, failure of the walls of the caldera resulted in giant landslides and rock avalanches that formed the Landslide Breccia and Picayune Megabreccia Members respectively, of the Sapinero Mesa Tuff. The megabreccia consists of blocks locally up to 500 m across of pre-caldera rocks in a matrix of tuff. Most clasts are intermediate composition lavas, and fragments are typically a few centimeters to 1 m across. The Eureka Tuff and megabreccia matrix is typically green to pale green due to propylitic albite-chlorite-calcite-epidote alteration and contains 5-10 percent primary phenocrysts of plagioclase, sanadine and biotite. The Pride of America Mine is at the contact of the Eureka Tuff and Picayune Megabreccia. On top of the Sapinero Mesa Tuff and filling the Uncompahgre caldera are several 27-28 m.y. ash flow sheets. At about 23 m.y., the Lake City caldera formed with the eruption of the rhyolitic Sunshine Peak tuff in the middle of the Uncompahgre caldera. Shortly afterwards, quartz syenite intrusions formed a resurgent dome, and post-caldera lavas were extruded along the eastern margin of the Lake City caldera.

Veins in the Western San Juan volcanic field range from 30 to 10 m.y. in age (Lipman and others, 1976). In the Lake City area, the only dated veins are the Golden Fleece at 27.5 m.y. (Hon and others, 1985) and the Ute-Ulay at 21.8 m.y. (Lipman and others, 1976; Hon and Mehnert, 1983). The Pride of America veins cannot be older than the 28 m.y. host rocks, but could be as much as 10 or 20 m.y. younger.

MINE WORKINGS AND PRODUCTION HISTORY

The mine is at an elevation of 10,000 feet, about 500 feet above Henson Creek on the south side of the canyon. The following description of the mine layout and production is from Irving and Bancroft (1911); H. Martin Davis, principal owner of the mine in 1982; and two of the authors' (RFS and HO'B) mapping in the summer of 1982. Early workings were accessed through a 60 ft.

shaft, now filled with water, in Big Casino Gulch. This route led circuitously to the upper level workings that lie above the present portal level and that are partly accessible through a raise in the portal level. The portal level workings, developed mostly in 1968 and shown in Fig. 2, as well as the upper level workings (not mapped), expose two veins. The "94" vein strikes 5-10^{o} east of north and dips about 70^{o} to the west. Its northern projection can be seen at the surface in a cut on the hillside 100 ft northeast of the portal. The Pride of America--Big Casino vein has a strike of N70E and dips 70^{o} south on the northeast end and curves over a distance of 300 ft to N34E dipping 68^{o} southeast at the southwest end. The Pride of America--Big Casino vein is intersected by the main drift 250 feet in from the "94" vein. The two veins probably intersect, but the intersection is not exposed.

Early production figures are not available; however, Irving and Bancroft (1911) report assays up to 412 ounces of Ag per ton. The mine was inactive from 1911 to 1954. Intermittent production took place between 1954 and 1969 during which time the ore averaged about 10 ounces of Ag per ton, 10-17 percent Pb and Zn, 1 percent Cu, and traces of Au (H. Martin Davis, personal communication). The most recent output consisted of about 500 tons of ore shipped to the Ute-Ulay mill during 1965 and 400 tons of ore shipped to Silverton for milling and refining during 1968-1969. Since 1969 the mine has been inactive. Davis (personal communication) reports that the grade of Ag increased upward in the mine, whereas Zn grade increased downward.

MINERAL DESCRIPTIONS

Overview of Mineralogy

Three stages of mineralization formed the vein assemblages at the Pride of America Mine. The first stage is characterized by quartz, sericite and pyrite (QSP). This stage grades into the base metal (BM) stage with the appearance of sphalerite, galena, chalcopyrite and tetrahedrite and the disappearance of sericite, then pyrite. During deposition of the BM stage, the vein was partly brecciated at least twice, as shown by fragments of earlier assemblages cemented by later minerals. Toward the end of the BM stage, first sphalerite, then galena, chalcopyrite and tetrahedrite disappear, and concurrently barite and rhodochrosite appear followed by rare jarosite in the barite-rhodochrosite-quartz (BRQ) stage. Low temperature oxidation and alteration resulted in a suite of oxides, carbonates, and sulphates. The characteristics of individual minerals are described next, followed by a description of the textures and inferred paragenetic relations.

Methods

Minerals were identified in hand specimen, in thin section under the microscope, and by electron microprobe analysis. Electron microprobe analyses were semi-quantitative only and used to identify small grains and to determine qualitatively the more important "impurities". Whole rock chemical analyses were done using induction coupled argon plasma atomic emission spectroscopy (most elements), atomic absorption (Au only), X-ray fluorescence (major elements and Zr), and delayed neutron activation (U and Th). Details of the analytical techniques are reported in Sanford and others (in press, b) and Sanford and Seeley (in press). Geochemical results for samples from the Pride of America Mine are listed under location number 127 in Sanford and others (in press, b). A few preliminary fluid inclusion temperatures were measured on a modified USGS stage.

Primary Sulfides

Pyrite occurs as euhedral to subhedral crystals commonly associated with quartz and sulfides of the QSP and BM stages. It is a major phase in the QSP and BM stages in the veins and a common mineral disseminated and in clots in altered wall rock. It commonly has inclusions of several sulfide minerals especially the less common ones, and it is intimately intergrown with the other major sulfides as well as quartz. Locally it forms colliform growths on the edges of veins.

Galena is mostly in the BM stage, but locally overlaps or grades into both QSP and BRQ stage. Some parts of the vein consist of more than 90% galena, but normally galena is mixed with significant amounts of quartz, sphalerite, pyrite, tetrahedrite, chalcopyrite, and barite. Sphalerite, pyrite, tetrahedrite, and chalcopyrite commonly form inclusions in galena. Intimate intergrowth of tetrahedrite and galena are common. In places where the vein consists mainly of quartz, galena and the other major sulfides are disseminated in the vein quartz.

Sphalerite forms anhedral masses intergrown with quartz and other sulfides and also occurs as euhedral crystals growing into vugs. Typically it is semi-transparent with a honey yellow color. The red-brown variety seen elsewhere in the Lake City area has only been observed from the Pride of America Mine in the form of rare reddish-brown bands in green sphalerite (S. L. Korzeb, personal communication). Microprobe analysis shows no elements other than Zn and S. Locally sphalerite is the dominant mineral in the vein, but typically it is intergrown with and includes grains of galena, pyrite, chalcopyrite, tetrahedrite, and barite. Where quartz is the dominant vein mineral, sphalerite is disseminated throughout. Traces of sphalerite also occur in altered wall rock.

Chalcopyrite is less common than pyrite, galena, or sphalerite and therefore typically occurs along grain boundaries and as inclusions in these phases. It also occurs disseminated in vein quartz. It tends to be later than the other sulfides as shown by its enveloping pyrite and filling fractures in sphalerite. Locally, euhedral chalcopyrite in vugs is perched on sphalerite and quartz (S. L. Korzeb, personal communication). Rarely, chalcopyrite occurs in altered wall rock as inclusions in sphalerite.

Tetrahedrite invariably forms anhedral crystals, and, like chalcopyrite, typically occurs along grain boundaries and as inclusions in the major sulfides. It is most commonly associated with galena as intimately interlocking intergrowths. Compositionally it varies from end-member tetrahedrite to the Ag-rich variety, freibergite, which also contains significant Zn.

Acanthite is rare and forms anhedral inclusions in and thin replacement rims on galena. Acanthite, freibergite, and native silver, probably of secondary origin (Korzeb, 1986) are the ore minerals for silver and account for an analysis of 3000 ppm Ag in one sample.

Gangue Minerals

Quartz is by far the main non-sulfide mineral. Commonly it is the dominant vein phase, but its abundance varies greatly. Locally, it occurs in trace amounts. Crystals are euhedral to subhedral. Typically the first quartz to form on the surfaces of wall rock is fine-grained and anhedral. Beyond a few grain diameters it forms radiating coarse euhedral crystals growing into open spaces. Growth zones of fluid inclusions parallel to crystal faces are prominent in the latter stages of the quartz crystals.

Where sericite is abundant, quartz typically forms numerous fine-grained anhedral crystals, but precipitation of quartz without sericite yields fewer euhedral crystals. These relations suggest that sericite precipitation facilitates quartz nucleation. Because quartz is in all stages, it shows a wide variety of relationships with other minerals; for example euhedral QSP quartz is overgrown with base metal sulfides, but fractures in these sulfide grains are cut by late BRQ-quartz. Within each stage, many apparently conflicting relationships suggest, in general, simultaneous growth. The latest quartz is typically euhedral, with only rare inclusions, and grows into open spaces.

Sericite occurs only in the QSP stage at the Pride of America. It is typically very fine-grained, about 0.03-0.10 mm, and is disseminated in fine-grained massive quartz. Locally it forms monomineralic "clots" that suggest either altered wall rock fragments or flocculation of sericite flakes from solution. Where these clots wrap around euhedral quartz crystals, it is definitely hydrothermally precipitated. However, many clots lack any definitive evidence, and their origin is therefore ambiguous. Locally, sericite appears to replace quartz, although this may be just an intergrowth.

Rhodochrosite and barite both occur as subhedral to euhedral late fracture-filling and vug-filling minerals. A one millimeter wide veinlet in country rock next to the main vein consists of quartz and smithsonite. The smithsonite contains minor amounts of Mn, Fe, and Ca. Lack of crosscutting relationships precludes determining the relationship of the smithsonite to the other vein minerals. Anhydrite forms rare inclusions in galena.

Secondary Vein Minerals

Covellite, chalcocite, and a Cu-sulfate form replacement rims and overgrowths on chalcopyrite and tetrahedrite as well as fracture-filling in galena and sphalerite. Native silver occurs as minute wires on a light tan clay mineral(?) and on chalcopyrite (S. L. Korzeb, personal communication). Anglesite replaces galena and fills the last fractures and veinlets that cut other vein minerals. S. L. Korzeb (personal communication) has found cerussite and wulfenite coating fractures and crystal faces of galena and sphalerite. Jarosite is rare and forms later than the BM stage. Fe-rich chlorite(?) appears to replace smithsonite along cleavage planes. The relations among these secondary minerals is unknown, because they almost never occur together. Whereas chalcocite, Cu-sulfate and anglesite are most probably due to supergene alteration or weathering, jarosite and covellite could be late BRQ-stage replacements rather than supergene alteration.

Wall-rock Minerals

Wall rock adjacent to the vein and fragments of wall rock incorporated in the vein are highly altered to quartz, sericite, pyrite, and rare chlorite. Typically, the form of the phenocrysts is preserved; however, relict primary minerals are rare. These include plagioclase, sanidine, microcline(?), zircon, apatite, and allanite. Probable former plagioclase and biotite are completely altered. Former biotite is locally shown by sphene, which is further altered to very fine-grained rusty-colored, Fe-Ti oxides and jarosite.

Phenocrysts are replaced mainly by quartz with lesser sericite in some samples, and in other samples, sericite is dominant in the pseudomorphs. Former glassy matrix is replaced by variable mixtures of quartz and sericite. Locally, quartz and sericite form radiating spherules. Sericite analyses show wide variations in K and Fe, but there is no systematic relation with grain size or texture. The highest Fe contents are in sericite adjacent to Fe-rich alteration minerals such as jarosite. Pyrite is typically disseminated throughout. Megascopically, wall rock samples vary in color from dark to pale green to white, and in hardness, but there is no apparent correlation with variations in mineralogy.

Fluid Inclusion Data

Homogenization temperatures and freezing points of four secondary fluid inclusions from euhedral sphalerite from the east end of the Pride of America - Big Casino vein were measured. Homogenization temperatures range from 244-247^{o}C and freezing point depression from -3.6 to -11.1^{o}C corresponding to 6-15 equivalent weight percent NaCl.

PARAGENESIS

Quartz-Sericite-Pyrite (QSP) Stage

Fig. 3 shows the generalized paragenesis for the Pride of America. Quartz alone grows out from the altered wall rock into the vein, generally starting as an anhedral mosaic, then turning into radiating euhedral crystals. Distinctive growth zones composed of fluid inclusions and locally very fine grained sericite coincide with the appearance of sericite and pyrite. Quartz then becomes finer grained and more subhedral to anhedral.

Base Metal (BM) Stage

The QSP stage grades into the BM stage as sericite disappears and sphalerite appears. The assemblage of intergrown quartz, pyrite and sphalerite marks a transition zone. Within the BM stage, sphalerite, galena, chalcopyrite, and tetrahedrite are all intergrown. Sphalerite is the first mineral to appear at the beginning of this stage as well as the first to disappear at the end of this stage.

The relative proportions of this stage and of minerals within this stage vary considerably from place to place along the vein. Locally, the entire vein consists of massive sulfides, for example in the 50 ft high stope on the north-trending "94" vein (fig. 2). Elsewhere, such as at the west end of the "Big Casino--Pride of America" vein, the vein consists of quartz with sparse sulfides.

At least one and perhaps two periods of fracturing and brecciation occur within the BM stage as shown by fragments of BM vein and by fractures in the BM assemblage. Fracturing generally coincides with the appearance or disappearance of minerals (Fig. 3). For example, barite and rhodochrosite first appear in a set of fractures in the BM assemblage. As also noted by Irving and Bancroft (1911), tetrahedrite commonly occurs in fractures in galena. A later set of fractures occurred after the end of precipitation of galena, chalcopyrite, and tetrahedrite.

Barite-Rhodochrosite-Quartz (BRQ) Stage

Minerals of this stage typically occur in veinlets cutting the BM assemblage and as euhedral crystals growing in vugs. There is some overlap of the BM and BRQ assemblages as shown by local intergrowths of barite with pyrite and chalcopyrite. However, there is no overlap of the QSP and BRQ stages, i.e. sericite and barite are never found together. Barite and rhodochrosite locally occur together, but typically the minerals of this stage are not intergrown. Thus it is difficult to correlate the minerals of the BRQ stage with certainty. Jarosite and covellite may overlap with rhodochrosite and barite, however they may belong to a later, supergene, stage.

Late, Supergene Alteration

Chalcocite, Cu-sulfate, hematite, goethite, and anglesite all occur as replacements of primary minerals and are almost certainly due to supergene alteration and weathering. Jarosite and covellite may also belong to this group. Because the secondary copper minerals are so conspicuous, and therefore collected by mineral hunters, little remains of these minerals on the outcrop or in the dumps. They are seen only as rare, isolated grains in thin section.

Discussion

No evidence exists for separation of the stages by long intervals of time except for supergene alteration and weathering which was probably a recent event. Rather, the overlap of adjacent stages suggest a continuous evolution of the depositing fluid during one extended event. During this time, tectonic activity, as shown by fractures and brecciation, coincided with the beginning or ending of the precipitation of certain minerals. If these fractures were filled with a separate assemblage suggesting a major change in conditions (for example, if the BRQ stage were followed by a repeat of the QSP stage), then we might propose two separate episodes of mineralization. However, the persistence of many of the same minerals across the times of fracturing and the lack of any one fracturing event that is correlatable through all the samples, suggest that mineral deposition was a single event in which the hydrothermal fluid continuously evolved.

GEOCHEMISTRY

Twelve samples were analyzed for 65 elements. The first 11 samples (A-K) are from across the "94" vein and adjacent wall rock exposed east of the portal as shown in Figs. 2 and 4, and the last sample (L) is from the wall rock on the northeast side of the portal. Sample F is the highest grade sample in the center of the vein, and the others are on either side as shown (fig. 4).

A qualitative visual "factor analysis" was performed on the data. Profiles of each element across the zones were grouped according to visual similarity. As shown in Fig. 5, the elements were ordered starting with those having the highest concentrations in the vein and ending with those most concentrated farthest from the vein. Their recurring peaks or distinctive sets of peaks were identified and, if possible, correlated with known minerals or assemblages of minerals. In this way ten "factors" accounting for most of the variation in concentration were isolated. They are listed in Table 1.

Factor 1 consists of elements exclusively or dominantly associated with precipitated hydrothermal minerals, principally galena and tetrahedrite-freibergite. Petrographic observations allow identifications of many of the "host" phases, but some trace elements cannot be correlated with specific minerals. Factor 2 includes elements most concentrated in Sample D. Cd and Ga are known to substitute for Zn. Thus, factor 2 mainly represents sphalerite or minor smithsonite. The close association of Bi suggests that Bi may also substitute for Zn, although it could be in a separate phase which is closely associated with sphalerite. Factor 3 is SiO_2, i.e., quartz, which behaves geochemically unlike any other species. It makes up most of the vein in sample D and is also concentrated in silicified wall rocks adjacent to the vein. Th, U and Nb are probably in a relict mineral in the altered wall rock. Factor 5 is characterized by high Li in sample E. No single element shows the same isolated peak in this sample, but several elements are high in this sample as well as in other samples. We currently have no explanation for this "Li" factor. Factor 6 is distinguished by Zr, which is high in the country rock, especially samples E and H, and low in vein samples D and F. Clearly Zr, and probably Y, represent zircon. Similarly, As has a major peak in sample H and a lower peak in sample E. No arsenic minerals were identified, but arsenopyrite and tetrahedrite are the most likely candidates. Other As minerals are also possible. Fe in this factor is mainly due to pyrite. Factor 7 is characterized by V, Co, and Ni which have almost identical patterns, similar to those of Fe and Cr. These elements probably represent primary magnetite which has altered in situ to oxides and sulfides. A closely related group is factor 8, characterized by high Na, Mg, Sc, and P in sample I. Several elements show affinities with both factors 7 and 8. Each of these factors probably represents a suite of primary and alteration minerals that behave similarly. Ca and K, which both show peaks in sample J, possibly represent plagioclase and sericite. Factor 10, represented by a single peak in Mn, is most likely due to leached Mn reprecipitated as rhodochrosite.

These 10 factors belong to 3 broader groups. Factors 1 and 2 represent hydrothermally precipitated minerals in veins and open spaces, i.e. galena, tetrahedrite, sphalerite, etc. These elements have been transported totally by solution and are thus the most mobile for this environment. Factor 3, SiO_2 in quartz, is unique because it is a major constituent in both the host rock and the vein. Redistribution of SiO_2 has been considerable. Factors 4 through 10 represent elements and minerals confined mainly to the host rock. They encompass a range of mobilities from Zr in zircon, which was probably virtually immobile, to Fe, which migrated considerably.

This unsophisticated analysis will serve as a starting point for future more rigorous investigations of wall rock alteration processes and hydrothermal mineral associations. It is obvious that there are many fewer independent processes operating than are imaginable from the large number of elements and minerals. Future work will investigate the physical and chemical bases for these processes and will help to identify further the host phases for many trace elements.

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Table 1. Element associations and host minerals

Association (Factor No. & Sample letter)	Part of element abundance accounted for by association: Major	Significant	Minor	Phase
	Pb			Galena
	Cu,Ag,Sb			Tetrahedrite
	Ag			Acanthite
1. High in F	Au			Native?
	Hg			?
"Pb group"	Ba,Sr			Barite
	Mo			Molybdenite?
	Cu			Covellite, Chalcocite
	Cd			?
			Zn	Sphalerite
	Zn,Cd,Ga			Sphalerite
2. High in D	Bi			?
"Zn group"	All in V-Co-Ni group			Various
3. High in C-H	SiO_2			Quartz
	U,Th,Nb		Y,P	?
4. High in D&G	SiO_2			Quartz
		TiO_2		Sphene, rutile
"U-Th group"		Cr,La,Ce,Nd		Allanite?
			K_2O,Al_2O_3,SiO_2	Sericite, sanidine
			Fe,V,Co,Ni,Cr	Altered magnetite?
	Li			?
5. High in E	Cu		Fe	Chalcopyrite
	Zr,Y			Zircon
"Li group"	SiO_2			Quartz
		As		Arsenopyrite?
		Fe		Pyrite, hematite
	Zr	Y		Zircon
6. High in E&H	As,Fe			Arsenopyrite?
	Fe			Pyrite
"Zr group"		SiO_2		Quartz
			Mo	Molybdenite?
	V,Co,Ni,Cr,Fe			Altered magnetite?
7. High in I,	TiO_2			Altered ilmenite, sphene
Less high in D	Al_2O_3			Sericite, sanidine
	La,Ce,Nd,Cr			Allanite?
"V-Co-Ni group"	All in Zn group			Sphalerite

	Na	CaO, Al_2O_3		Plagioclase
8. High in I	Mg	Al_2O_3		Chlorite
	P,Sc	CaO		Apatite
"Na-Mg-P group"	All in V-Co-Ni group			Various
		K_2O, Al_2O	SiO_2	Sericite, sanidine
		Mn		Rhodochrosite?
	K_2O	Al_2O_3	SiO_2	Sericite, Sanidine
	CaO	Al_2O_3	SiO_2	Plagioclase
9. High in J	All in V-Co-Ni group			Various
"K_2O-CaO group"	Zr,Y			Zircon
		MgO, Al_2O_3	SiO_2	Chlorite
		CaO,P,Sc		Apatite
		Mn		Rhodochrosite?
		Fe		Pyrite, hematite
			Cu	?
			U,Th	?
	Mn			Rhodochrosite?
10. High in K		Zn,Cd,Ga		Sphalerite
		SiO_2		Quartz, sericite
"Mn group"			Li	?
			CaO,La	Apatite

FIGURE CAPTIONS

Figure 1.--Location map for the Pride of America Mine, from Lipman and others (1976).

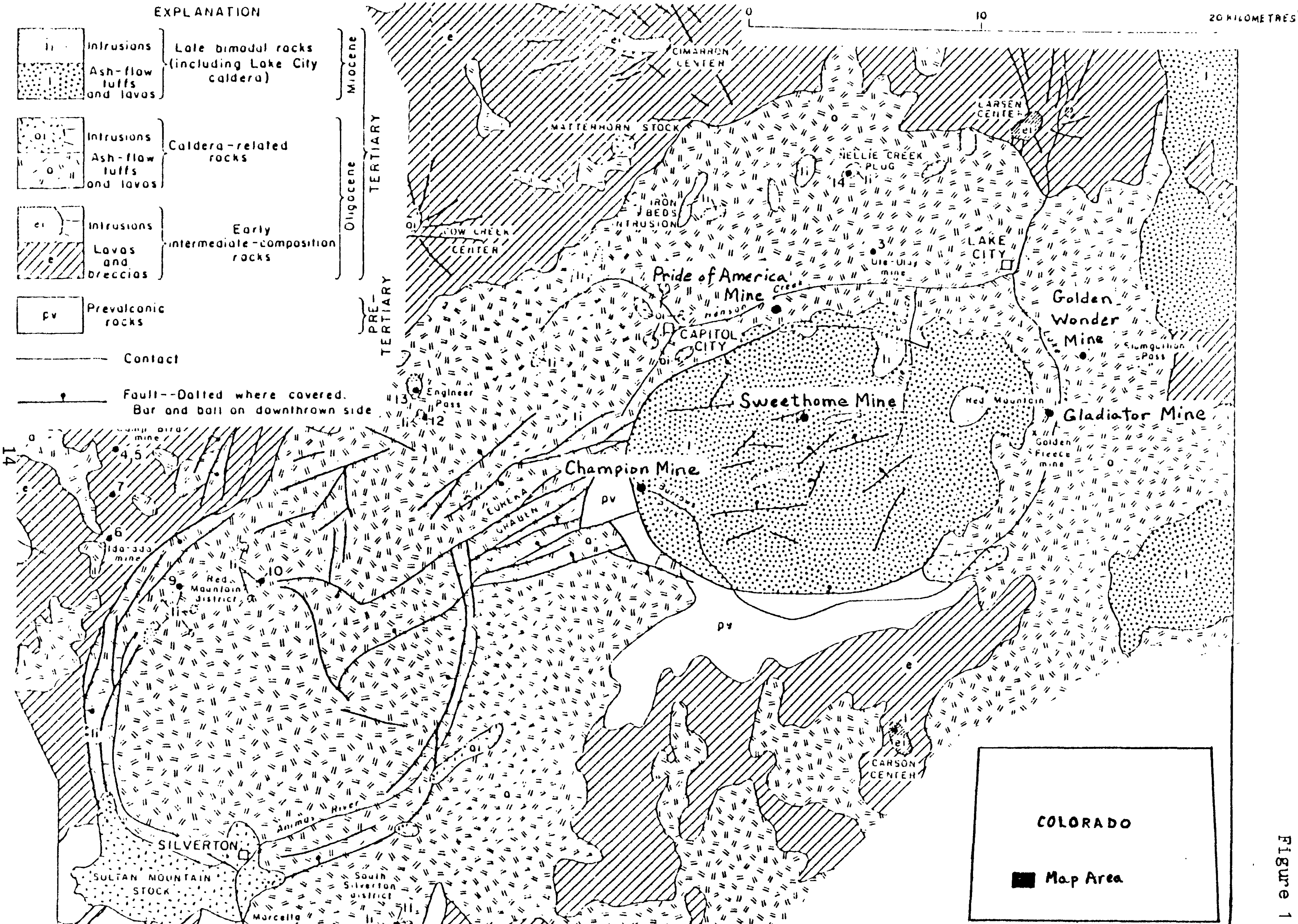
Figure 2.--Map of portal level of the Pride of America Mine.

Figure 3.--Generalized paragenetic diagram for vein samples from the Pride of America Mine.

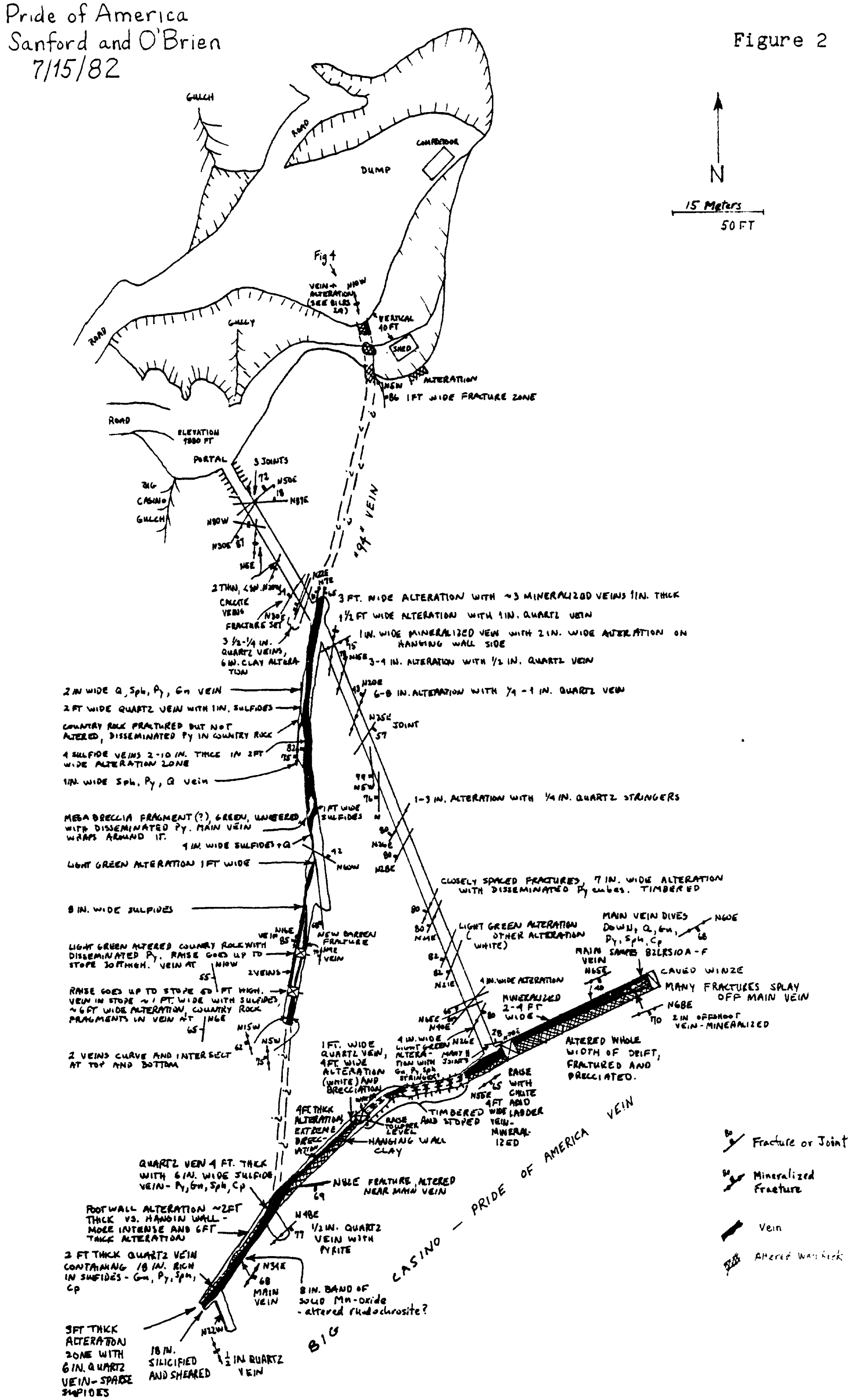
Figure 4.--Sketch of the "94" vein exposed at the surface and locations of samples. Samples A and L are from propylitically altered host rock least affected by alteration associated with the vein. Samples B, C, I, J, and K are from slightly sericitized and silicified host rock. Samples E and H are from intensely sericitized and silicified host rock. Sample D is from a 6 inch quartz vein that contains rare breccia fragments of wall rock. Sample F is from a stringer of galena-dominated vein. Sample G is from a quartz vein containing abundant intensely altered breccia fragments of wall rock.

Figure 5.--Chemical analyses of samples A-L plotted across the vein and wall rock. Shading shows rock type: dark shading, quartz vein (sample D) and galena vein (F); medium shading, intensely sericitized and silicified wall rock (E, G, and H); unshaded, slightly altered wall rock (B, C, I, J, and K); light shading, least altered wall rock (A and L). For horizontal displacement see Fig. 4. Vertical scale is in ppm except where marked percent. D.L. stands for detection limit.

Figure 1



EXPLANATION
Intrusions
Ash-flow tuffs and lavas
Late bimodal rocks (including Lake City caldera)
Miocene
Intrusions
Ash-flow tuffs and lavas
Caldera-related rocks
Intrusions
Lavas and breccias
Early intermediate-composition rocks
Oligocene
TERTIARY
Prevolcanic rocks
PRE-TERTIARY
Contact
Fault--Dotted where covered. Bar and ball on downthrown side
0
10
20 KILOMETRES
CIMARRON CENTER
LARSEN CENTER
MATTERHORN STOCK
NELLIE CREEK PLUG
IRON BEDS INTRUSION
COW CREEK CENTER
LAKE CITY
Ute-Ulay mine
Pride of America Mine
CAPITOL CITY
Golden Wonder Mine
Slumgullion Pass
Engineer Pass
Sweethome Mine
Red Mountain
Gladiator Mine
Golden Fleece mine
Champion Mine
Ida-ado mine
Red Mountain district
Animas River
SILVERTON
SULTAN MOUNTAIN STOCK
South Silverton district
Marcella mine
CARSON CENTER
COLORADO
Map Area



Pride of America
Sanford and O'Brien
7/15/82
N
15 Meters
50 FT
GULCH
ROAD
COMPRESSOR
DUMP
Fig 4
VEIN + N10W ALTERATION (SEE BILES 2A)
VERTICAL 40 FT
SHED
GULLY
ROAD
ALTERATION
1 FT WIDE FRACTURE ZONE
ROAD
ELEVATION 1880 FT
PORTAL
3 JOINTS
BIG CASINO GULCH
"94" VEIN
3 FT. WIDE ALTERATION WITH ~3 MINERALIZED VEINS 1IN. THICK
1½ FT WIDE ALTERATION WITH 1IN. QUARTZ VEIN
1 IN. WIDE MINERALIZED VEIN WITH 2 IN. WIDE ALTERATION ON HANGING WALL SIDE
3-4 IN. ALTERATION WITH ½ IN. QUARTZ VEIN
6-8 IN. ALTERATION WITH ¼ - 1 IN. QUARTZ VEIN
JOINT
2 THIN, CALCITE VEINS
FRACTURE SET
3 ½-¼ IN. QUARTZ VEINS, 6 IN. CLAY ALTERATION
2 IN WIDE Q, Sph, Py, Gn VEIN
2 FT WIDE QUARTZ VEIN WITH 1IN. SULFIDES
COUNTRY ROCK FRACTURED BUT NOT ALTERED, DISSEMINATED Py IN COUNTRY ROCK
4 SULFIDE VEINS 2-10 IN. THICK IN 2 FT WIDE ALTERATION ZONE
1IN. WIDE Sph, Py, Q VEIN
1-3 IN. ALTERATION WITH ¼ IN. QUARTZ STRINGERS
MEGA BRECCIA FRAGMENT (?) GREEN, UNALTERED WITH DISSEMINATED Py. MAIN VEIN WRAPS AROUND IT.
1 FT WIDE SULFIDES
1 IN. WIDE SULFIDES + Q
LIGHT GREEN ALTERATION 1 FT WIDE
CLOSELY SPACED FRACTURES, 7 IN. WIDE ALTERATION WITH DISSEMINATED Py cubes. TIMBERED
8 IN. WIDE SULFIDES
LIGHT GREEN ALTERATION (OTHER ALTERATION WHITE)
MAIN VEIN DIVES DOWN, Q, Gn, Py, Sph, Cp
MAIN SAMPS 82LRS10A-F
CAVED WINZE
MANY FRACTURES SPLAY OFF MAIN VEIN
2 IN OFFSHOOT VEIN-MINERALIZED
NEW BARREN FRACTURE
LIGHT GREEN ALTERED COUNTRY ROCK WITH DISSEMINATED Py. RAISE GOES UP TO STOPE 30 FT HIGH. VEIN AT
2 VEINS
RAISE GOES UP TO STOPE 60 FT HIGH. VEIN IN STOPE ~1 FT. WIDE WITH SULFIDES, ~6 FT WIDE ALTERATION, COUNTRY ROCK FRAGMENTS IN VEIN AT
4 IN. WIDE ALTERATION
MINERALIZED 2-4 FT WIDE
ALTERED WHOLE WIDTH OF DRIFT, FRACTURED AND BRECCIATED.
2 VEINS CURVE AND INTERSECT AT TOP AND BOTTOM
1 FT. WIDE QUARTZ VEIN, 4 FT WIDE ALTERATION (WHITE) AND BRECCIATION
4 IN. WIDE LIGHT GREEN ALTERATION WITH Gn, Py, Sph STRINGERS
RAISE WITH CHUTE AND LADDER
4 FT WIDE VEIN - MINERALIZED
TIMBERED AND STOPED
4 FT THICK ALTERATION EXTREME BRECCIATION
RAISE TO UPPER LEVEL
HANGING WALL CLAY
CASINO - PRIDE OF AMERICA VEIN
BIG
QUARTZ VEIN 4 FT. THICK WITH 6 IN. WIDE SULFIDE VEIN - Py, Gn, Sph, Cp
FEATURE ALTERED NEAR MAIN VEIN
FOOTWALL ALTERATION ~2 FT THICK VS. HANGIN WALL - MORE INTENSE AND 6 FT THICK ALTERATION
½ IN. QUARTZ VEIN WITH PYRITE
2 FT THICK QUARTZ VEIN CONTAINING 18 IN. RICH IN SULFIDES - Gn, Py, Sph, Cp
MAIN VEIN
8 IN. BAND OF SOLID Mn-oxide - altered rhodochrosite?
3 FT THICK ALTERATION ZONE WITH 6 IN. QUARTZ VEIN - SPARSE SULFIDES
18 IN. SILICIFIED AND SHEARED
½ IN QUARTZ VEIN
Fracture or Joint
Mineralized Fracture
Vein
Altered Wall Rock

Figure 2

Figure 3

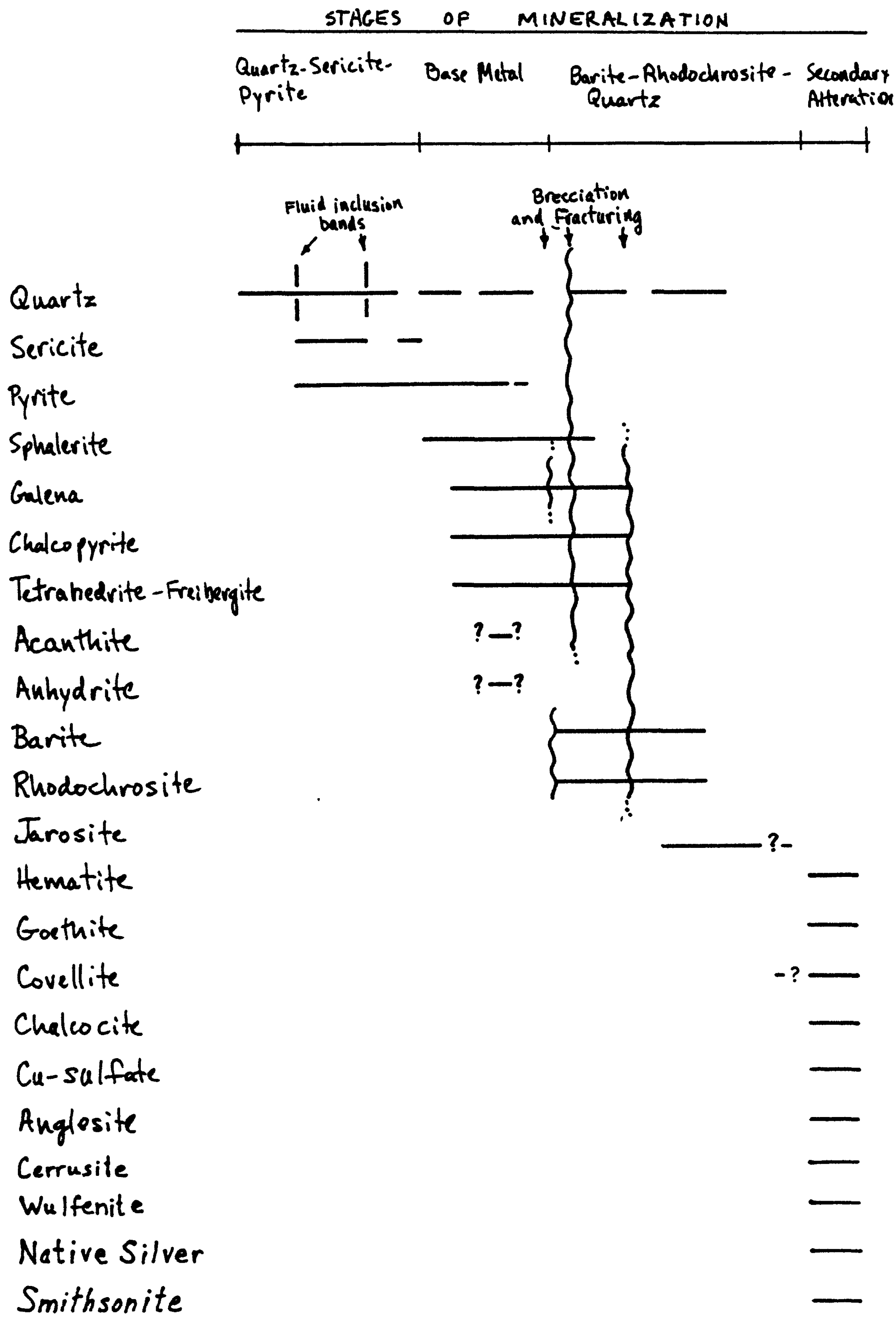
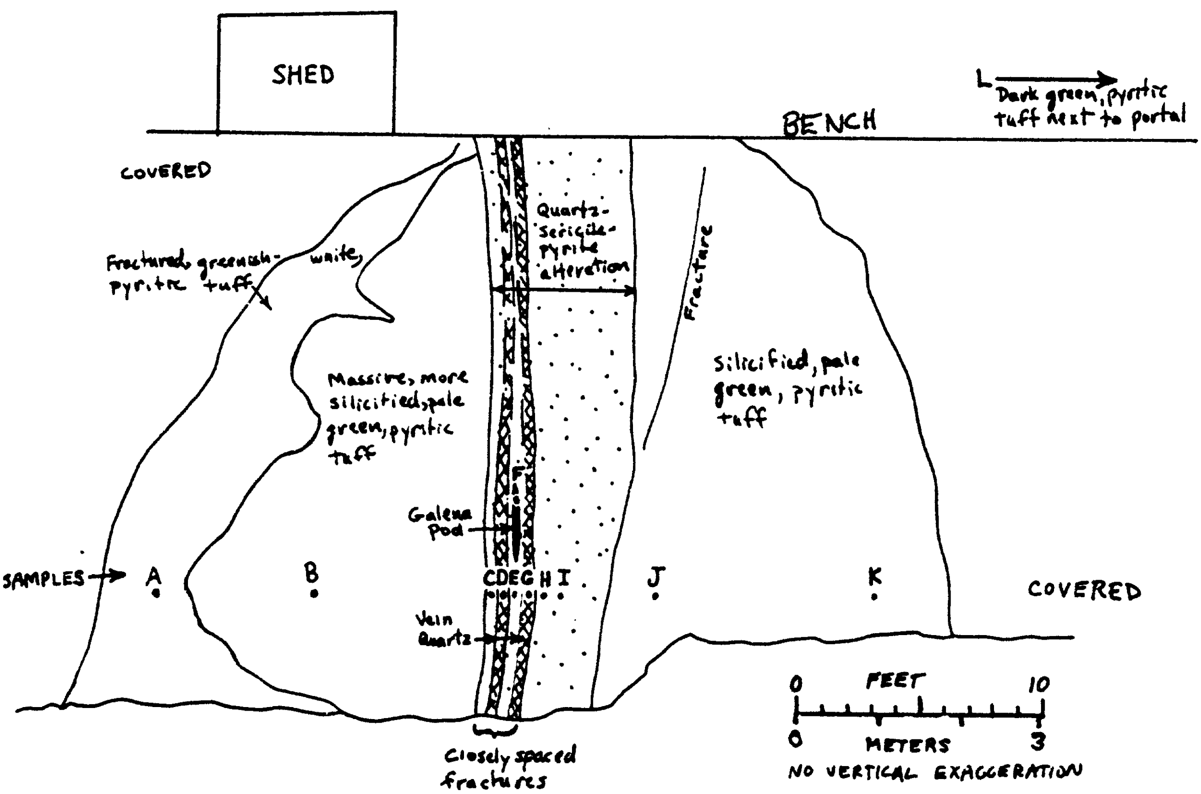
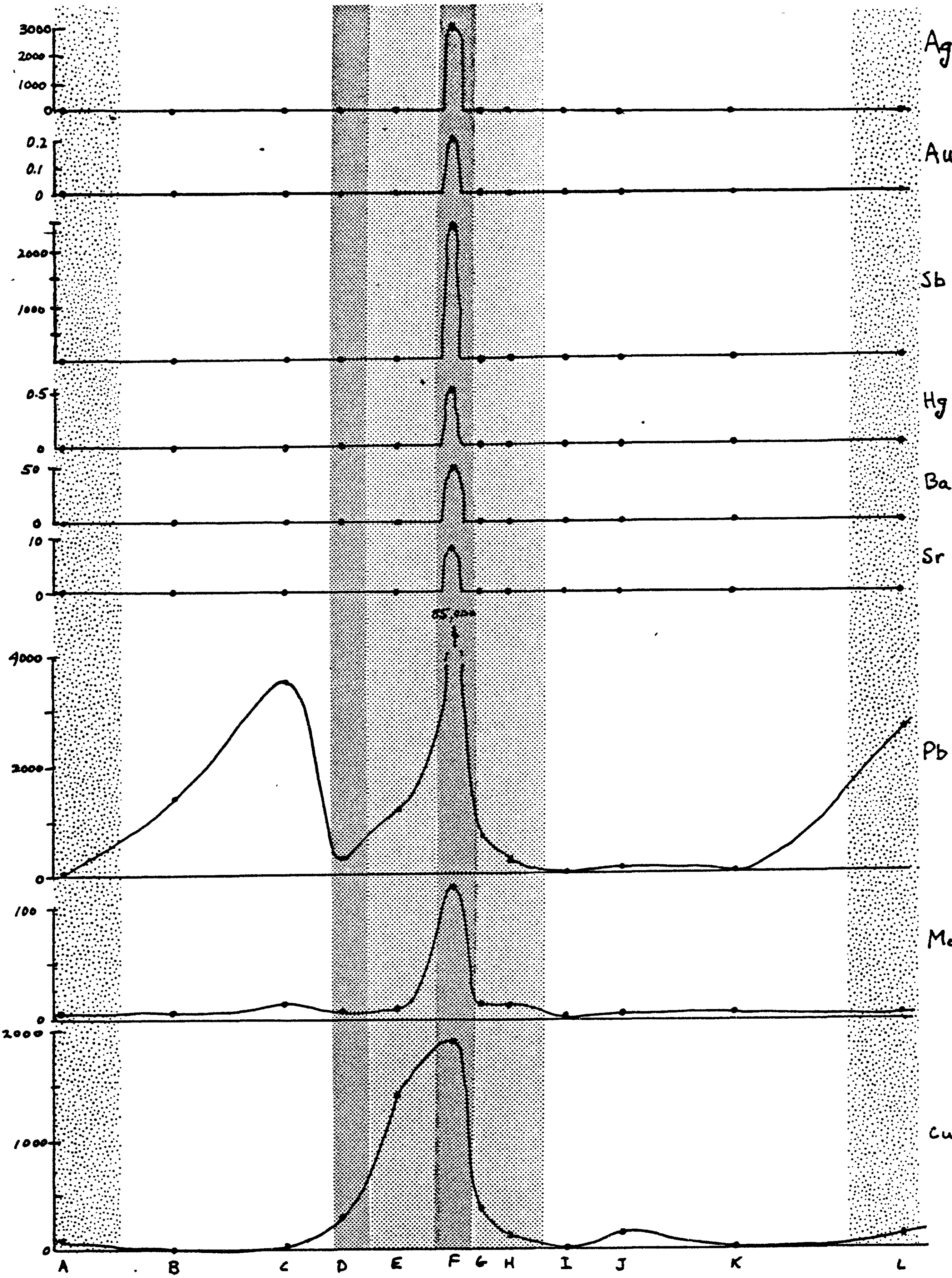

STAGES OF MINERALIZATION
Quartz-Sericite-Pyrite
Base Metal
Barite-Rhodochrosite-Quartz
Secondary Alteration
Fluid inclusion bands
Brecciation and Fracturing
Quartz
Sericite
Pyrite
Sphalerite
Galena
Chalcopyrite
Tetrahedrite-Freibergite
Acanthite
Anhydrite
Barite
Rhodochrosite
Jarosite
Hematite
Goethite
Covellite
Chalcocite
Cu-sulfate
Anglosite
Cerrusite
Wulfenite
Native Silver
Smithsonite

Figure 4

Pride of America Mine

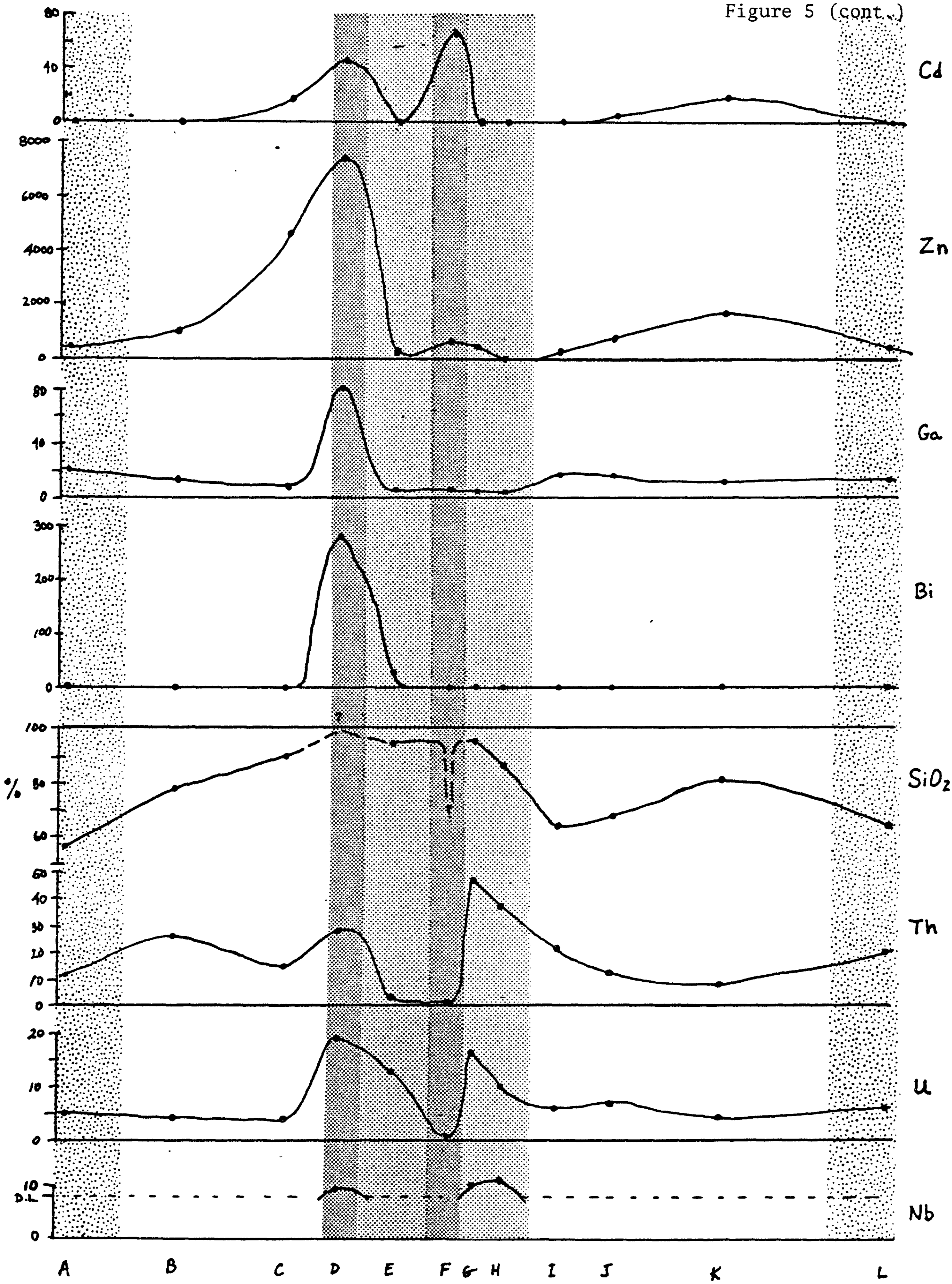
SKETCH OF "94" VEIN EXPOSED 100' EAST OF PORTAL

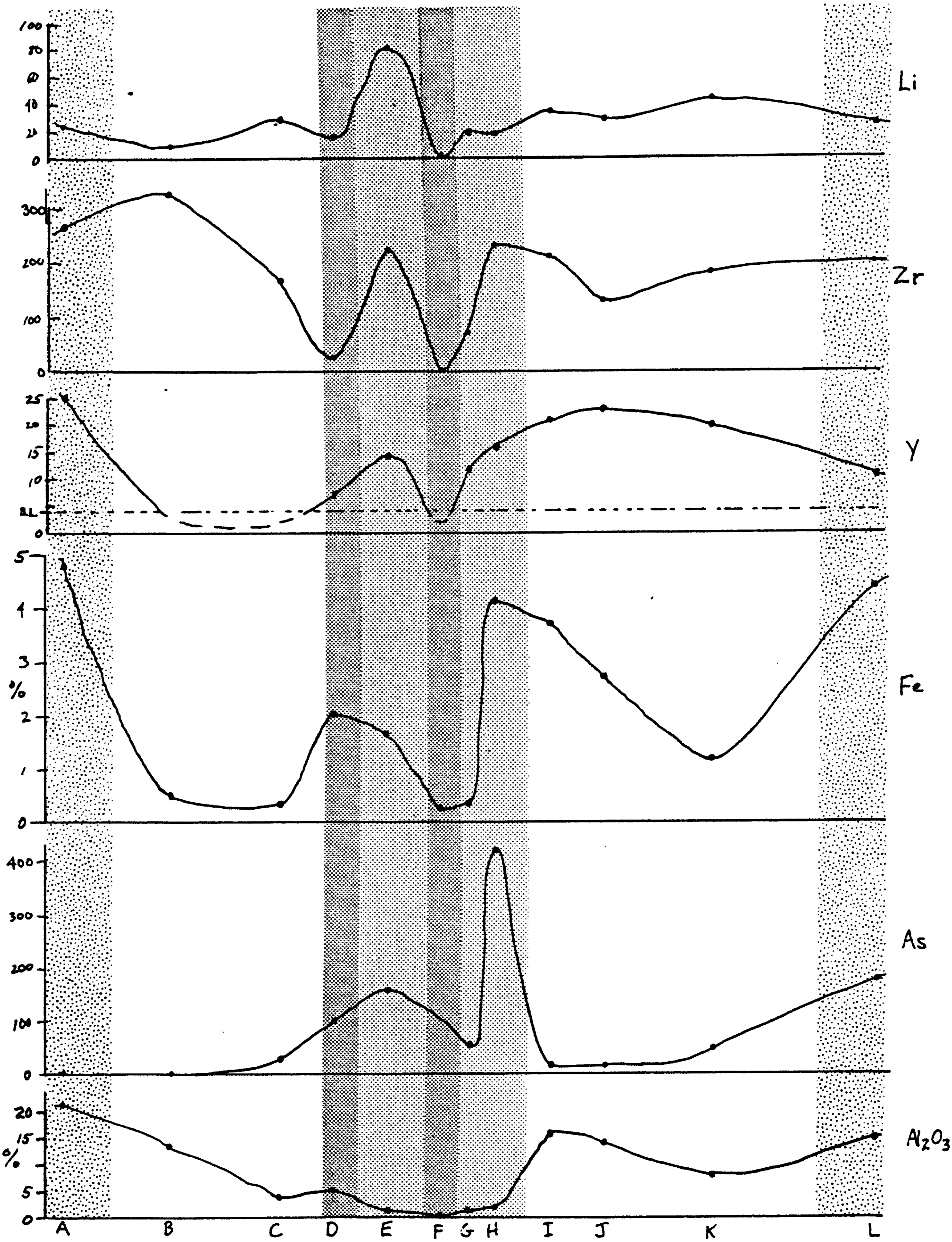


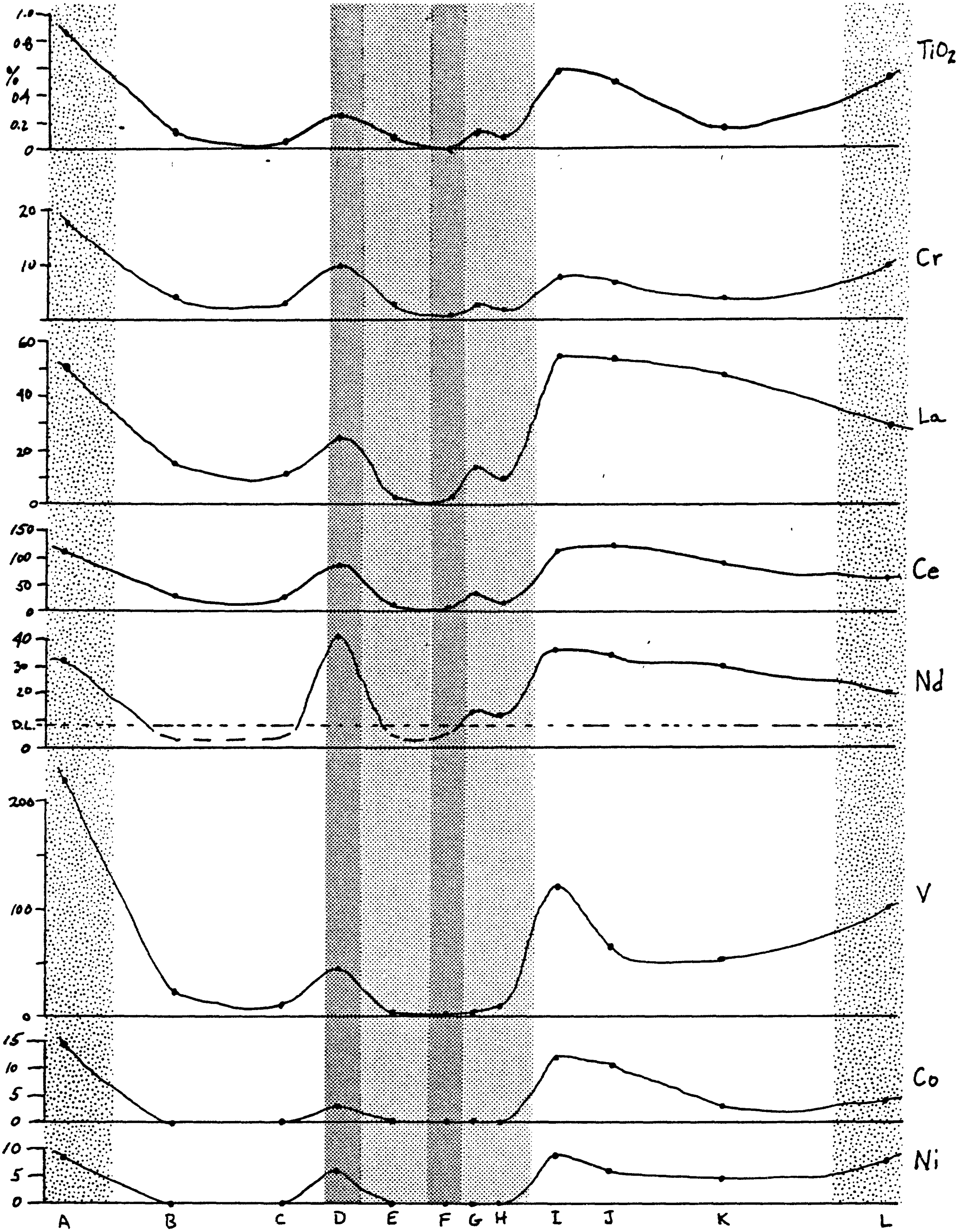


Ag
Au
Sb
Hg
Ba
Sr
Pb
Mo
Cu
3000
2000
1000
0
0.2
0.1
0
2000
1000
0.5
0
50
0
10
0
4000
2000
0
100
0
2000
1000
0
A
B
C
D
E
F
G
H
I
J
K
L

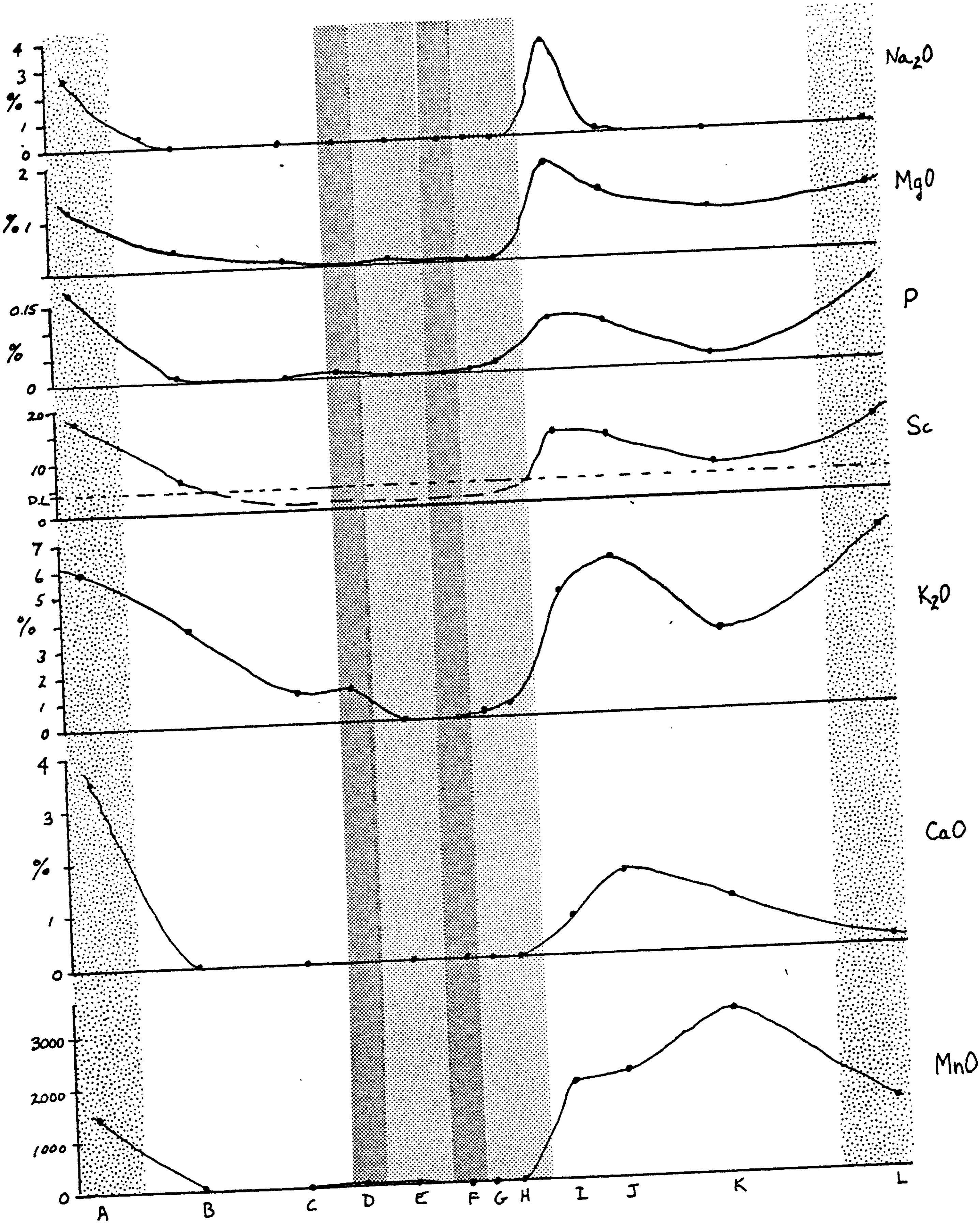
Figure 5 (cont.)




Li
Zr
Y
Fe
%
As
Al_2O_3
%
A
B
C
D
E
F
G
H
I
J
K
L



TiO2
%
1.0
0.8
0.4
0.2
0
Cr
20
10
La
60
40
20
Ce
150
100
50
Nd
40
30
20
D.L.
V
200
100
Co
15
10
5
Ni
A
B
C
D
E
F
G
H
I
J
K
L


Na2O
MgO
P
Sc
K2O
CaO
MnO
%
0.15
D.L.
3000
2000
1000
A
B
C
D
E
F
G
H
I
J
K
L