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A compilation of fluid inclusion and stable isotope data on selected precious- and base-metal epithermal deposits

By

Daniel O. Hayba[1]

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Introduction

This report is a tabulation of the fluid inclusion temperature, salinity, and chemical analyses, and the oxygen, deutrium and sulfur isotope data from a compilation of the lithotectonic, mineralogical and geochemical traits of 15 epithermal, volcanic-hosted districts (Heald-Wetlaufer et al., 1983). Of the 15 districts, the following 14 have some or all of the above types of geochemical information: Colqui, Peru; Comstock, Nevada; Creede, Colorado; Goldfield, Nevada; Guanajuato, Mexico; Lake City, Colorado; Julcani, Peru; Oatman, Nevada; Pachuca-Real Del Monte, Mexico; Red Moutain, Colorado; Round Mountain, Nevada; Sunnyside mine, Eureka district, Colorado; Summitville, Colorado; and Tonopah, Nevada. No data were found for the Silver City - De Lamar, Idaho district.

The purpose of this report is to make this compilation of fluid inclusion and stable isotope data available. The interpretations and conclusions drawn from this data have been abstracted in Heald-Wetlaufer et al. (1983) and will be presented in a subsequent publication.

Fluid Inclusion Data

Fluid inclusion studies have been done on fourteen of the fifteen districts but seven of these studies were only cursory examinations. For the other seven deposits, the data have been grouped by paragenetic stage and host mineral of the inclusion (Table 1). Stages where there is evidence for boiling have been noted. Except where indicated, all the data are from primary inclusions.

Inclusion fluids were extracted for analysis for five districts. The results of the analyses for salts and metals are listed in Table 2. Analyses were made on leachates from crushed samples using atomic absorption techniques except for the neutron activation analyses by Czamanske et al. (1963), and the single inclusion laser microprobe analyses by Tsui and Holland (1979).

The gases liberated from fluid inclusions by crushing were measured and then analyzed by mass spectrometry for samples from Colqui (Kamilli and Ohmoto, 1977) and Sunnyside (Casadevall and Ohmoto, 1977). Analyses were made by high sensitivity gas chromatography on quartz and sphalerite from Creede by Roedder and Andrawes (unpub. data, 1981). For all three districts, CO_2 was the dominant (and usually only) gas in the fraction condensed by liquid nitrogen. H_2S, and SO_2 were also detected in a stage IV sample from Sunnyside and H_2S was found in stage IV sphalerite from Colqui. No gaseous sulfur compounds were detected in any sample from Creede. N_2, Ar, H_2 and CH_4 (noncondensable gases) were also found at Colqui and Sunnyside. At Creede, N_2, Ar, and H_2 were detected in primary, two phase (liquid-vapor) inclusions, but no noncondensable gases were found in large primary "vapor" inclusions which Roedder (1970) suggests is evidence for boiling.

Stable Isotope Data

Table 3 lists the δD and $\delta^{18}O$ data from mineral and fluid inclusion analyses. No whole rock analyses are included since they cannot be used to calculate the isotopic composition of the hydrothermal fluid. For consistency the water values have been recalculated from the mineral data using the following mineral-water fractionation factors: quartz (partial equilibrium data of Clayton et al., 1972, as suggested by Taylor, 1974); rhodocrosite and siderite (approximated by the calcite data of O'Neil et al., 1969); muscovite, chlorite and alkalic feldspar (summarized by Taylor, 1974, Figures 2 and 4). Also for internal consistency, the calculations were made using the average temperature for each paragenetic stage. No corrections were made for activity effects due to salinity which may be as much as -2.0 per mil for the more saline deposits, Creede and Colqui (Truesdell, 1974). Where no mineral or temperature data is given, the fluid data was determined directly from fluid inclusions.

The sulfur isotope data for six deposits is listed in Table 4. As with the other types of data included in this report, there is a wide range in the degree of comprehensiveness of the $\delta^{34}S$ studies. Only a few data are reported for Lake City and Julcani, while at Creede approximately 200 analyses have been made. These include detailed sampling of sphalerite growth zones from localities PMB-CA-246-65 and NJP-X-59.

Summary

Of the 15 deposits included in the epithermal compilation of Heald-Wetlaufer et al. (1983), Creede, Colqui, and Sunnyside have the most geochemical data available. Lake City, Pachuca, Tonopah, and Guanajuato all have had fluid inclusion studies but little stable isotopic work data. The remaining eight districts have a paucity of geochemical data. Thus less than half of the "better studied" epithermal deposits (this also includes mineralogical and lithotectonic information) have sufficient data on which to make geochemical comparisions.

Acknowledgments

As noted in the introduction, this tabulation is only a part of a compilation of epithermal characteristics. Contributions by P. Heald-Wetlaufer, N.K. Foley, and J.A. Goss to that compilation were certainly beneficial to this report.

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Appendix A: Mineral Abbreviations

adl	adularia
alb	alabandite
anh	anhydrite
bar	barite
bnd	banded
brn	bornite
cal	calcite
carb	carbonate
chl	chlorite
cpy	chalcopyrite
daws	dawsonite
eng	enargite
f.gn.	fine grained
fl	florite
gal	galena
gyp	gypsum
H_2O	water
hal	halite
hem	hematite
ill	illite
lev	level
phylosil	phyllosilicate
py	pyrite
pyrgy	pyrargyrite
qtz	quartz
rhd	rhodocrosite
sid	siderite
ser	sericite
slfd	sulfide
sph	sphalerite
syl	sylvite
S&Q	sphalerite and quartz
tell	telluride
ten	tennantite
tet	tetrahedrite
unkn	unknown
vn	vein

Table 1. Fluid inclusion data.

STAGE & MAJOR PHASES	INCL. HOST PHASE	TEMPERATURE OF HOMOGENIZATION RANGE	AVG	#	TYPE	SALINITY wt.% NaCl eq. RANGE	AVG	#	INCLUDED PHASES	EVIDENCE GIVEN FOR BOILING
COLQUI, PERU (Kamilli and Ohmoto, 1977)										
VII sph,gal	qtz,sph	189-202	195	11		5.7- 6.6	6.2	10		
barite	sph	140-158	150	3		4.6	4.6	1		
VI sph,gal	qtz,sph	170-195	180	6		6.8- 7.9	~ 7.0	6		
V qtz	qtz	218-258	240	39		0.2- 2.4	~ 2.0	9	daws	
	qtz					6.1-13.0	~ 9.0	25	common	
IV sph,gal	qtz	268-299		7		6.7- 9.2		5		
	sph	234-276	260	49		5.7-10.7	~ 8.0	40		
III qtz	qtz	251-284	270	50		0.2- 8.2	<2.0	25	daws	
II qtz,Ag&	sph	271-284		3		8.6- 8.8	8.7	2		Great variation
base metals	qtz	250->390†	270††	83	*	0.2- 3.7	~ 2.5	13	rare	in
	qtz					7.6-10.8	~ 9.0	31	daws	filling temps for
I qtz	qtz	255-291	270	73		0- 2.0	~ 1.0	37	ubiquit.	Stage II
	qtz					7.6- 9.7	~ 8.8	18	daws	
LAKE CITY, COLORADO (Slack, 1980)										
IIa barite,	qtz	215-330†	~ 250††	47	*				few	Coexist.
sulfosalt	sph	206-385†	~ 250††	51	*	1.3-12.4	~ 2.5	10	captd.	liq &
ores	bar[a]	208-316[a]	263[a]	10					phases	vapor-rich
1d qtz,carb,fl	fl	165-203	~ 183	32	*	0.0- 0.4	0.1	17		incls.
1c massive	qtz	204-241	221	15						
rhd	sph	193-254	208	41		0.8- 3.2	1.8	13		
1b bnd-qtz,	qtz	202-283	~ 243	73						
slfd ore	sph	212-279	~ 234	49		1.1-7.2	~ 5.6	10		

STAGE & MAJOR PHASES	INCL. HOST PHASE	TEMPERATURE OF HOMOGENIZATION RANGE	AVG	#	TYPE	SALINITY wt.% NaCl eq. RANGE	AVG	#	INCLUDED PHASES	EVIDENCE GIVEN FOR BOILING
CREEDE, COLORADO (Woods et al., 1982; Robinson, 1981; and Roedder, 1970)[b]										
D-OYW sph,	sph	195-232	219	75		5.1- 7.9	6.4	63		Variable
D-OB gal,	sph	213-274	249	218		5.2-12.5	9.0	214	cpy?	filling
D-IYW &	sph	225-270	253	61		7.2-10.1	8.7	25		temps for
D qtz	qtz	190->400†	270††	150	*	1.1-10.0	6.1	26		D-stage qtz
C qtz,	qtz	255-276	~ 263	~ 20						
fluorite	fl	213-229	217	~ 50		6.1-11.1	10.7	~ 110		No
	fl	247-268	260	~ 60						detectable amounts of
B f.gn.slfds	sph	214-241	234	8		6.1-10.2	6.9	9		non-cond.
B-h.lev Amy vn	qtz	140-210	170	~ 100		2.0-10.0	6.2	~ 75		gases,
B-m.lev Amy vn	qtz	150-250	~ 215	~ 200		3.0-14.0	~ 7.0	~ 200		such as Ar
B-l.lev Amy vn	qtz	170-260	238	~ 100		6.0-13.0	9.5	~ 80		in vapor-rich incls.
A qtz,rhd,	qtz	192-263	237	12						- purged
chl,slfd	rhd	185-249	214	18		9.3-10.6	9.8	3		by boiling
A-l.lev Amy vn	qtz	175-235		32		3.8- 9.6		32		
SUNNYSIDE MINE, EUREKA DISTRICT, COLORADO (Casadevall and Ohmoto, 1977)										
VI qtz,fl,	fl	172-242	196	24		0.0- 0.2	0.1	14	unkn.	Variable
carb	qtz	180-322†	240††	35	*	0.0- 0.1	0.1	4	phase	liq/vapor
sulfate ores	rhd	203-237	225	4		0.1	0.1	4		ratio for coexist.
V Mn ores	qtz	262-323	295	98		0.2- 3.6	1.3	39		incls. in Stage IV
IV Au-tell,qtz	qtz	265-314	288	70		0.3- 2.2	0.9	23		
III slfds,hem	qtz	267-317	285	13		1.0- 2.2	1.5	7		
II slfd,bnd-qtz	qtz	270-321	298	27		0.7- 1.0	0.8	9	unkn. phase	
I py, qtz	qtz	267-306	285	34		0.1- 0.6	0.2	15		
Deep qtz veinlet	qtz								anh, hal	

STAGE & MAJOR PHASES	INCL. HOST PHASE	TEMPERATURE OF HOMOGENIZATION RANGE	AVG	#	TYPE	SALINITY wt.% NaCl eq. RANGE	AVG	#	INCLUDED PHASES	EVIDENCE GIVEN FOR BOILING
PACHUCA-REAL DEL MONTE DISTRICT, MEXICO (Drier, 1976)										
stringers	qtz	180-250	200	136	*	0.4- 1.7	1.0	25		
above veins	cal	205-208		1						Highly variable liquid/ vapor ratios[d]
vein sph	sph	220-230	225	6						
vn clear qtz	qtz	210-280†	247[c]	251	*	0.4- 5.7	1.5	80	sulfide?	
vn cloudy qtz	qtz	220-310†	262[c]	136	*	0.4- 1.7	0.9	27	f.hal	
GUANAJUATO, MEXICO (Buchanan, 1979)										
ORE Post-Ag	cal	231->360†	230††	35	*	0.7[e]			few hal & syl, phylosil?	Variable liquid/ vapor ratios[f]
ORE Ag-stage	qtz,	225->360†	230††	203	*	0.5-2.6[e]				
	cal	228->360†	230††	41						
PRE-ORE	cal	231->360†		11	*PS	2.9[e]				
Rayas mine										
Above deep	qtz	258-360†		22	*					
Deep	qtz,	261-385		17						
	sph	282		1						
TONOPAH, NEVADA (Fahley, 1981; and Vikre, 1980)										
late barren	qtz	190->350	~ 250	228	*	0.0-1.8		21	daws or gyp in S incl	Coex. liquid & vapor rich incls.[f]
	cal	142-246		24						
silver stage	qtz	227->350	264	202	*	0.6-1.8	1.0	10	ser	
	pyrgy	230-270		1						
early barren	qtz	240-350	262	92	*	0.6-2.6		16		
ROUND MTN., NEVADA (Nash, 1972)										
	qtz	250-260		2		0.2-1.4		2		

STAGE & MAJOR PHASES	INCL. HOST PHASE	TEMPERATURE OF HOMOGENIZATION RANGE	AVG	#	TYPE	SALINITY wt.% NaCl eq. RANGE	AVG	#	INCLUDED PHASES	EVIDENCE GIVEN FOR BOILING
COMSTOCK, NEVADA (Nash, 1972)										
	qtz		295	1			3.1	?		
	qtz	240-258		?	S	2.7-3.6		?		
JULCANI, PERU (Petersen, 1972; Bruha and Noble, 1983; and Noble and Silberman, written comm., 1983)										
Mimosa	?	320-365		?						
Herminia	?		325	?						
500 level[g]	qtz	190-210		?						
lower level[h]	qtz	161-275		?	S	5- 24	12	?		
GOLDFIELD, NEVADA (Bruha and Noble,1975)[h]									up to	
	qtz	250-290		?	S	5- 18	7	?	5 phases	
SUMMITVILLE, COLORADO (Bruha and Noble,1975)[h]									up to	
	qtz	231-276		?	S	0.8-1.6	10	?	5 phases	
OATMAN, ARIZONA (Clifton et al., 1980)										highly variable
Kokomo vein	?[i]		200-220	?						homogenization
Tom Reed vein	?		220-240	?	*				hal?	temperatures
RED MTN., COLORADO (Nash, 1975)[j]										
	qtz	216-268		5		0.8-1.6		2		

† Th values above temperature of boiling are meaningless.
†† Temperature of boiling
* Indicates evidence for boiling was noted.
PS Pseudosecondary inclusions; S Secondary inclusions
a Temperature measurements from barite are not considered reliable.
b Woods et al. (1982) report hundreds of other inclusions which are PS or S or lack paragenetic control.
c Drier believes that the vein tops were boiling at about 250°C.
d Drier reports this for samples from the top of the Dios Te Guie vein but no Th or Tm data were given.
e Determined from leach analyses.
f Several other types of evidence for boiling are given that are of questionable value.
g Data from J. Benavides (oral comm., 1981) in Noble and Silberman (written comm., 1983).
h Data on secondary inclusions in quartz pheneocrysts in alunitically altered rocks.
i About two dozen samples of quartz, calcite and fluorite were collected around the district.
j Data from the National Belle, Longfellow and Koehler mines.

Table 2. Chemical analyses of fluid inclusions.

Stage	Host	Na (ppt)	K/Na (Atomic ratios)	Ca/Na (Atomic ratios)	Mg/Ca (Atomic ratios)	Cu (ppm)	Zn (ppm)	Mn (ppm)	Other (ppm)	Gases: Cond. (mole fraction)	Gases: Noncond. (mole fraction)
COLQUI, PERU (Kamilli and Ohmoto, 1977; Tsui and Holland, 1979)											
VII	?[a]	9.3	.16							.0009	.0007
VI	?	15								.0207	.0006
V	?	9.8-12	.08-.21	.07-.25	.23-2.7					.0042-.0250	.0023-.0069
IV	?	14-26	.05-.15							.0057-.0072	.0003-.0031
III	?	6-8.5	.06-.10	.05-.09	.3					.0034-.0044	.0009-.0070
II	?	7.3-12								.0044	.0017
I	?	7.8-19	.03-.17	.04-.13	0-.99	<1-300[b]		<2-<120		.0023-.0040	.0014-.0020
	qtz[c]	5-29		.02-.51	.01-.12						
CREEDE, COLORADO (Roedder, 1965 and pers. comm., 1983; Tsui and Holland, 1979; Czamanske et al., 1963; Rye, pers. comm., 1982; Roedder and Andrawes, unpub. data, 1981 (abstr. in Woods et al., 1982))											
D	sph	~ 20	.1-.13	.12-.23	.12 .0100					<.0001-	
	qtz		.07-.1	.07-.17						<.0080	
	qtz[c]	17-28		.02-.5	.01-.19	<1-20[b]		10-90			
	qtz[d]					60	410	620			
GUANAJUATO, MEXICO (Buchanan, 1979)									Pb		
Post Ore	cal	.05	.56-.76	(22.3)	0	3.2-8.7	.2-.7	.01-.05	16.5-19.7		
Ore Stage	qtz	.10-1.0	.54-3.9	.34-4.8	0-.18	5.7-60	7.2-91	.05-.09	14.5-158		
Pre-Ore	cal	.23	.5	(26.8)	0	101		.92	600		

Stage	Host	Na (ppt)	K/Na	Ca/Na	Mg/Ca	Cu (ppm)	Zn (ppm)	Mn (ppm)	Other (ppm)	Gases: Cond. (mole fraction)	Gases: Noncond. (mole fraction)
			(Atomic ratios)								
SUNNYSIDE MINE, EUREKA DISTRICT, COLORADO (Casadevall and Ohmoto, 1977)									Fe		
VI	qtz	1.2-8.7	.03-.07	.14-1.9	.07-.13	<100-135	220-470	910-1340	110-720	.0002-.0007	.0002-.0067
	cal	.3	.42		.03	<100	<10		230		
V	qtz	2.5-2.7	.07-.35	.44-1.9	.07-.29	<100-1770	530-680	2140	130-530	.0035-.0036	.0010-.0034
IV	qtz	2.3	.32	.33	.15	<100		720	220	.0003	.0010
III	gal	.6-1.3	.11-.12	.37-1.6	.02-.09	<100-300			380	.0004	.0003
II	sph-gal	3.9	.12	3.46	.02	<100			630	.0029	.0010
I	qtz	3.3	.12	.06	.25	<100	50	150	<100		.0010
LAKE CITY, COLORADO (Slack, 1980 and pers. comm., 1982)											
IIa	qtz		.27	.02	1.3		176				
	sph		.28	.09	.7		84				
	bar		.13	.1-2.1	.12-.45		4-500				
Id	fl		.32	(14.8)	(.07)		1				
Ic	qtz,sph rhd		.16	.25	.27		8				
Ib	qtz		.21-.23	.16-.36	.18-.43		20-37				
	qtz,sph		.12-.31	.18-.56	.37-.5		240-400				

Parentheses indicate questionable analyses

[a] Kamilli and Ohmoto used samples of quartz, sphalerite, galena and polymineralic stage II ore

[b] Possibly due to contamination.

[c] laser microprobe analyses

[d] Neutron activation analyses

Table 3. δD and $\delta^{18}O$ data.

SUNNYSIDE MINE, EUREKA DISTRICT, COLORADO

Sample	Min.	Stage	Mineral Data δD	Mineral Data $\delta^{18}O$	Temp.	Fluid Data δD	Fluid Data $\delta^{18}O$
9-18-3	QTZ	1		1.7	290		-6.8
9-19-3	QTZ	1		0.6	290	-132.0	-7.9
9-18-2	QTZ	1		1.8	290		-6.7
7-28-38	SER	2		-5.7			
9-20-9C	QTZ	2		0.4	290		-8.1
9-20-9B	QTZ	2		0.0	290		-8.5
9-20-9A	QTZ	2		-0.4	290		-8.9
72-18-1	QTZ	2				-119.1	
72-18-2	QTZ	2				-126.6	
TC-15-73	GAL	3				-134.6	
TC-21-73	QTZ	3		0.2	290		-8.3
2180/204	QTZ	4		1.1	290	-119.0	-7.4
2340EL1	QTZ	4		0.6	290		-7.9
2340EL2	QTZ	4		-0.6	290		-9.1
9-20-8	QTZ	5		-0.3	290		-8.8
SUNNYSD	QTZ	5		-1.2	290	-120.7	-9.7
9-18-5B	QTZ	5		0.8	290	-100.4	-7.7
2090-1	QTZ	5				-120.5	
DS-1-72	QTZ	5		-3.6	290	-96.4	-12.1
9-18-8	QTZ	6		-3.5	240	-116.0	-14.3
9-11-1	QTZ	6		-5.0	240	-113.0	-15.8
TC-9-73	QTZ	6		-4.5	240		-15.3
9-14-3	QTZ	6		-0.4	240		-11.2
FL-2260	QTZ	6		-0.9	240		-11.7
B-1-1203	QTZ	?		2.8			
TC-1-74	RHD	6		-4.1	200		-13.1
DK-1-74	RHD	6		-2.2	200		-11.2
DK-2-74	RHD	6		-4.3	200		-13.3
9-18-7	CAL	6		2.0	200		-7.0
270-336	CAL	WR		4.6	200		-4.4
2070-ATL	RHD	6		-4.1	200		-13.1
2700 FL	RHD	6		-2.0	200		-11.0
2340 EL	CAL	6		1.6	200	-123.5	-7.4
2260 FL	RHD	6		-3.7	200		-12.7
2340 EL	RHD	6		-5.0	200		-14.0
2090 GL	RHD	6		-4.6	200		-13.6
1880 GL	RHD	6		-3.2	200		-12.2
2150 FL	RHD	6		-2.6	200		-11.6
1900 FL	RHD	6		-5.0	200		-14.0
9-18-8	QTZ	6				-116.0	
1870	QTZ	6				-125.2	
9-7-2	FL	6				-129.1	
SURFACE WATER	H2O					-119.0	-16.0†

Data from Casadevall and Ohmoto, 1977; and Casadevall, written comm., 1982.
† Value from Casadevall and Ohmoto, Figure 19, 1977.

CREEDE, COLORADO

Sample	Vein	Min.	Stage	Mineral Data δD	Mineral Data $\delta^{18}O$	Temp.	Fluid Data δD	Fluid Data $\delta^{18}O$
PMB-CE-251-65	OH	ILL	D	-91.0	4.8	250	-53.0	0.2
PMB-DL-277-67	OH	ILL	D	-88.0	3.0	250	-50.0	-1.6
PMB-DM-279-67	OH	ILL	D	-92.0	4.0	250	-54.0	-0.6
PMB-BA-200-65	OH	ILL	D	-89.0	3.2	250	-51.0	-1.4
PMB-BC-206-65	OH	ILL	D	-88.0	3.9	250	-50.0	-0.7
PMB-KP-588-71	HW	ILL	D	-100.0	5.8	250	-62.0	1.2
PMB-KO-557-71	BD	ILL	D	-96.0		250	-58.0	
PBB-108-32D-68	P	ILL	D	-93.0	3.7	250	-55.0	-0.9
PMB-X-94-59	OH	QTZ	D		8.0	250	-92.0	-2.3
PMB-AA-109-59	OH	QTZ	D		6.0	250		-4.3
PMB-BY-244-65	OH	QTZ	D		7.9	250	-86.0	-2.4
PBB-67-16-67	OH	QTZ	D		9.3	250		-1.0
PBB-449-131-59(1)	AM	QTZ	D		5.2	250		-5.1
PBB-449-131-59(2)	AM	QTZ	D		6.7	250		-3.6
PBB-449-131-59(3)	AM	QTZ	D		4.4	250		-5.9
PMB-FX-332-68	HW	QTZ	D		7.9	250		-2.4
MB-S-182-59	OH	QTZ	C/D		7.5	250	-97.0	-2.8
MB-S-188-59(a)	OH	SPH	D				-78.0	-10.1
MB-S-188-59(b)	OH	SPH	D				-81.0	-10.1
ER-127-65(a)	OH	SPH	D				-54.0	-5.8
ER-127-65(b)	OH	SPH	D				-55.0	-5.8
MB-K-93-59(a)	OH	SPH	D				-55.0	-4.5
MB-K-93-59(b)	OH	SPH	D				-65.0	-4.5
MB-K-93-59(c)	OH	SPH	D				-67.0	-4.5
PMB-KE-547-71(a)	OH	SPH	D				-62.0	-5.4
PMB-KE-547-71(b)	OH	SPH	D				-70.0	-5.4
PBB-40-199-59	OH	SID	C		16.7	250		9.9
ER-65-119	OH	SID	C		16.4	250		9.6
PMB-BO-227-65	OH	SID	C		14.9	250		8.1
PBB-28-90-59	OH	SID	C		14.6	250		7.8
PMB-K-50-59	OH	SID	C		11.7	250		4.9
PBB-112-36-59	OH	SID	C		16.5	250		9.7
PMB-AA-109-59	OH	CHL	B	-108.0	1.8	250	-61.0	0.8
PBB-33-106-59	OH	CHL	B	-111.0	-0.5	250	-64.0	-1.5
PMB-N-58-59	OH	CHL	B	-108.0	-0.2	250	-61.0	-1.2
PBB-13-46-59	OH	CHL	B	-102.0	0.5	250	-55.0	-0.5
NJP-IX-59	OH	CHL	B	-102.0	-0.4	250	-55.0	-1.4
PBB-25-83-59	OH	CHL	B	-110.0	0.0	250	-63.0	-1.0
NJP-IV-59	OH	CHL	B	-102.0	1.5	250	-55.0	0.5
PBB-8-30-59	OH	CHL	B	-103.0	-0.2	250	-56.0	-1.2
NJP-VI-59	OH	CHL	B	-102.0	-1.2	250	-55.0	-2.2
PMB-JJ-518-77	HW	CHL	B	-102.0	-0.3	250	-55.0	-1.3
PBB-27-86-59	OH	QTZ	A		7.4	250		-2.9
PMB-CA-246-65(1)	OH	QTZ	A		8.9	250		-1.4
PMB-CA-246-65(2)	OH	QTZ	A		8.1	250		-2.2
PMB-CA-246-65(3)	OH	QTZ	A		8.7	250		-1.6
PBB-66-15-67(a)	OH	QTZ	A		8.3	250	-96.0	-2.0
PBB-66-15-67(b)	OH	QTZ	A		8.3	250	-95.0	-2.0
PMB-J-47A-59	OH	QTZ	A		6.0	250		-4.3

Sample	Vein	Min.	Stage	Mineral Data δD	Mineral Data $\delta^{18}O$	Temp.	Fluid Data δD	Fluid Data $\delta^{18}O$
PMB-KA-542-71	BD	QTZ	A		10.1	250		-0.2
PBB-145-37-74	BD	QTZ	A		12.1	250		1.8
PBB-147-50-74	BD	QTZ	A		8.4	250		1.9
PMB-J-47A-59	OH	ADL	A		3.0	250		-4.2
PMB-FW-331-68	HW	RHD	A		11.0	250		4.2
PMB-KA-542-71	BD	RHD	A		13.6	250		6.8
PBB-132-8-74	BD	RHD	A		14.2	250	-78.0	7.4
PBB-145-37-74	BD	RHD	A		15.2	250		8.4
PMB-MU-642-74	BD	RHD	A		14.6	250		7.8
PBB-147-50-74	BD	RHD	A		14.6	250		7.8
PMB-GC-338-68	BD	RHD	A		16.2	250		9.4
PMB-LP-596-74	BD	RHD	A		14.8	250		8.0
PMB-NB-658-74	BD	RHD	A		11.2	250	-82.0	4.4
SURFACE WATER		H20					-109.0	-15.0
PMB-BY-244-65	OH	QTZ	D				-69.0	
PMB-BY-244-65	OH	QTZ	D-PS				-102.0	

Data from Bethke et al., 1979 and Foley et al., 1982.
Abbreviations: OH, OH vein; HW, hanging wall structures of Amethyst vein; AM, Amethyst vein; P, P vein; BD, Bulldog vein; D-PS, pseudoseconday inclusions in D stage.

TONOPAH, NEVADA

Sample	Min.	Stage	Mineral Data δD	Mineral Data $\delta^{18}O$	Temp.	Fluid Data δD	Fluid Data $\delta^{18}O$
	ADL			-5.1	250	-90.1	-12.8
B1000B-q	QTZ	M		-4.5	250		-14.8
B1100B-a	QTZ	M		-1.8	250		-12.1
B1100B-b	QTZ	L		0.7	250		-9.6
B100F-a	QTZ	M		-4.1	250		-14.4
B1100F-b	QTZ	L		-1.4	250		-11.7
B1100S	QTZ	M		-4.2	250		-11.7
B1166	QTZ	M		-5.1	250		-15.4
R1100-q	QTZ	L		-2.6	250		-12.9
ST600	QTZ	L		0.2	250		-10.1
MZ500A	QTZ	L		-2.2	250		-12.5
MZ500B	QTZ	L		-3.2	250		-13.5
WE641-a	QTZ	M		-3.9	250		-14.2
WE641-b	QTZ	L		-2.3	250		-12.6
SG600-q	QTZ	M		-3.4	250		-13.7
B1000 Occ vein	QTZ	M		-3.0	250		-13.3
B1000 Occ vein	QTZ	M		-3.7	250		-14.0
B1000 Occ vein	QTZ	M		-3.3	250		-13.6
B1000 Occ vein	QTZ	M		-3.3	250		-13.6
B1000 Occ vein	QTZ	M		-3.0	250		-13.3
B1000 Occ vein	QTZ	L		-2.8	250		-13.1

Data from O'Neil and Silberman, 1974; and Taylor, 1973.
Abbrevations: M, massive vein quartz; L, late euhedral quartz

COLQUI, PERU

Sample	Min.	Stage	Mineral Data		Temp.	Fluid Data	
			δD	$\delta^{18}O$		δD	$\delta^{18}O$
0379	QTZ	1		0.2	270		-9.2
0901	QTZ	1		0.5	270		-8.9
4228	QTZ	1		-0.6	270		-10.0
0379	QTZ	1		-0.5	270		-9.9
0901	QTZ	1		-0.4	270	-100.0	-9.8
0379	QTZ	1		-0.2	270		-9.6
0901	QTZ	1		0.5	270		-8.9
4228	QTZ	1		0.2	270	-100.0	-9.2
4284	QTZ	1		1.67	270		-7.7
4235	QTZ	1		0.5	270		-8.9
4262	QTZ	1		-0.2	270	-71.0	-9.6
4262	QTZ	1		-0.1	270		-9.5
0379	QTZ	2				-85.0	
0901	QTZ	2		3.6	270	-93.0	-5.8
0906	QTZ	2		3.4	270		-6.0
0906	QTZ	2		2.8	270		-6.6
0909-A	QTZ	2		3.0	270		-6.4
0909-A	QTZ	2		3.3	270		-6.1
0927	QTZ	2		1.6	270		-7.8
4202	QTZ	2		2.6	270		-6.8
4265	QTZ	2		0.5	270	-74.0	-8.9
4284	QTZ	2		5.8	270		-3.6
8721	QTZ	2		2.3	270		-7.1
0379	SPH	2				-85.0	
0901	QTZ	3		1.6	270	-84.0	-7.8
0909-A	QTZ	3		2.8	270		-6.6
4219	QTZ	3		1.4	270		-8.0
4219	QTZ	3		1.4	270		-8.0
4265	QTZ	3		3.6	270	-97.0	-5.8
4284	QTZ	3		1.2	270	-107.0	-8.2
4295	QTZ	3		4.2	270		-5.2
4203	SPH	4				-50.0	
4278(a)	SPH	4				-48.0	
4278(b)	SPH	4				-55.0	
8720	SPH	4				-57.0	
4217-A	QTZ	4		8.0	260		-1.8
4217-B	QTZ	4		7.4	260		-2.4
4217-B	QTZ	4		7.9	260		-1.9
4234	QTZ	4		6.4	260		-3.4
8707	QTZ	4		7.6	260		-2.2
4208	QTZ	5		8.9	240		-1.9
4263(a)	QTZ	5		8.5	240	-99.0	-2.3
4263(b)	QTZ	5		8.5	240	-88.0	-2.3
4263(a)	QTZ	5		9.0	240	-99.0	-1.8
4263(b)	QTZ	5		9.0	240	-88.0	-1.8
4263(a)	QTZ	5		11.1	240	-99.0	0.3
4263(b)	QTZ	5		11.1	240	-88.0	0.3
4208	QTZ	5		10.2	240	-74.0	-0.6
8715	QTZ	5		10.5	240		-0.3

Sample	Min.	Stage	Mineral Data δD	Mineral Data $\delta^{18}O$	Temp.	Fluid Data δD	Fluid Data $\delta^{18}O$
4269	QTZ	5		7.5	240	-99.0	-3.3
4263(a)	S&Q	6		15.5	180	-50.0	0.8
4263(b)	S&Q	6		15.5	180	-69.0	0.8
4288	S&Q	7		11.9	190	-100.0	-2.0

Data from Kamilli and Ohmoto, 1977.

COMSTOCK, NEVADA

Sample	Min.	Stage	Mineral Data δD	Mineral Data $\delta^{18}O$	Temp.	Fluid Data δD	Fluid Data $\delta^{18}O$
Gold Hill	QTZ			2.9	250	-132.5	-7.4
Con. Virginia(C-4)	QTZ			1.2	250	-124.7	-9.1
Savage (C-F)	QTZ			3.2	250	-120.7	-7.1
Dayton	QTZ			1.1	250	-87.5	-9.2
Con Virginia(1200)	QTZ			8.9	295	-68.5	-0.4
37 Mexican mine	QTZ			2.7	250*		-7.6
38 Mexican mine	QTZ			1.2	250*		-9.1
39	QTZ			0.9	250*		-9.4
40 Mexican mine	QTZ			0.7	250*		-9.6
41 Potosi mine	QTZ			0.2	250*		-10.1
COM 34	QTZ			1.5	250		-8.8
COM 55	QTZ			1.6	250		-8.7
COM 56	QTZ			3.0	250		-7.3

Data from O'Neil and Silberman, 1974; Sugisaki and Jensen, 1971; and Taylor, 1973.
*Sugisaki and Jensen (1971) used 225°C from fluid inclusion decrepitation measurements.

OTHER DEPOSITS

Deposit	Min.	Stage	Mineral Data δD	Mineral Data $\delta^{18}O$	Temp.	Fluid Data δD	Fluid Data $\delta^{18}O$
Pachuca	QTZ			5.0	250	-90.0	-5.3
Goldfield	QTZ			-1.2	250		-11.5
Round Mtn	ADL			-8.2	260		-15.6
Oatman	QTZ					-97.0†	

Data on Pachuca, Goldfield, and Round Mtn from O'Neil and Silberman, 1974.
† Value is from Roedder et al. (1963) on a rhyolite vein (converted from Lake Michigan standard to SMOW).

Table 4. $\delta^{34}S$ data.

CREEDE, COLORADO

Sample	Vein	Stage	$\delta^{34}S$ py	sph	gal	cpy	bar
HB-1-67-1	BD	E	3.0				
HB-1-67-2	BD	E	2.2				
HB-1-67-3	BD	E	2.0				
HB-1-67-4	BD	E	-0.3				
HB-1-67-5	BD	E	2.7				
HB-1-67-6	BD	E	-0.4				
HB-1-67-7	BD	E	1.0				
PBB-138-18-74-1	BD						28.2
PBB-138-18-74-2,3	BD			-0.4			23.4
PMB-MS-636-74-3	BD			-1.8			
PMB-MS-636-74-6	BD						28.2
PMB-MS-636-74-7	BD						28.3
PMB-MS-636-74-1,8	BD				-1.1		33.1
PMB-MS-636-74-4	BD						33.2
PMB-MS-636-74-5	BD						32.4
DH-63-1	BD						23.2
DH-63-2	BD						25.4
DH-23	BD						31.6
PMB-GH-342-68-4	BD						27.9
PMB-GH-342-68-1,6	BD				0.4		29.8
PMB-GH-342-68-5	BD						33.8
PMB-MD-619-74-6	BD						27.5
PMB-MD-619-74-5	BD						30.0
PMB-MD-619-74-4,3	BD				-1.3		32.0
PMB-MD-619-74-2	BD			0.7			
PMB-MD-619-74-1	BD						26.1
PBB-143-18-74-3	BD						27.9
PBB-143-18-74-2	BD			-0.7			
PBB-143-18-74-1	BD						26.3
PBB-145-36-74	BD						28.0
PMB-DO-282-67	BD						22.7
PMB-KE-547-71	BD			1.7	-0.9		
PMB-MG-631	BD			0.0	-3.1		
PMB-VB-902-78	BD			0.7	-1.8		
PBB-179-16-78	BD			-1.2	-5.6		
DH-15	BD		-2.7				28.9
PBB-182-25-78-H	BD						28.1
PBB-182-25-78-G	BD						31.8
PBB-182-25-78-F	BD						38.1
PBB-182-25-78-E	BD						36.1
PBB-182-25-78-D	BD						34.6
PBB-182-25-78-C	BD						32.2
PBB-182-25-78-B	BD						32.5
PBB-182-25-78-A	BD						37.5
PBB-147-78-D	BD						42.0
PBB-147-78-C	BD						29.7

Sample	Vein Stage	py	$\delta^{34}S$ sph	gal	cpy	bar
PBB-147-78-B	BD					37.2
PBB-147-78-A	BD					35.2
PMB-PP-730-75-D	BD					26.2
PMB-PP-730-75-C	BD					30.0
PMB-PP-730-75-B	BD					28.5
PMB-PP-730-75-A	BD					27.7
PMB-182-23-78-D	BD					32.8
PMB-182-23-78-C	BD					31.1
PMB-182-23-78-B	BD					29.9
PMB-182-23-78-A	BD					32.4
PMB-MT-640-74-D	BD					29.9
PMB-MT-640-74-C	BD					29.9
PMB-MT-640-74-B	BD					29.9
PMB-MT-640-74-A	BD					30.0
PBB-145-47-74-B	BD					39.8
PBB-145-47-74-A	BD					25.8
PMB-GC-388-68-B	BD					35.3
PMB-GC-388-68-A	BD					32.7
PHW-DD-144-78-B	BD					31.6
PHW-DD-144-78-A	BD					30.1
NJP-VI-59	OH	-0.3				
PBB-13-44-59	OH	-0.3				
ER-65-101	OH	3.5				33.2
ER-65-101(b)	OH	5.5				
ER-65-101	OH	47.8				
ER-65-101	OH	46.2				
PMB-G-31-59	OH	-0.5				
PMB-AD-12-59	OH	-0.9				
PBB-11-3-59	OH	-0.9				
NJP-V-59	OH	-0.8				
PMB-AC-11-59-1	OH	-2.5				
PMB-AC-11-59-2	OH	-3.0				
PMB-AC-11-59-3	OH	-0.3				
PMB-AC-11-59-4	OH	-0.8				
PBB-128-1-60	OH		-1.7	-4.1		
PMB-BS-23-65	OH	-0.1	-0.6			
PMB-BS-23-65	OH		-0.7	-3.5		
PMB-BF-209-65	OH	-0.1	-1.1	-3.9		
PMB-BN-226-65	OH		-1.3	-4.1		
PMB-ER-018-67	P	-0.9				
PMB-JH-71	P	-1.5				
PMB-LK-588-74	P	-0.9				
PMB-NE-66-74	P	-0.6				
PMB-LX-60-74-1	P	-1.1				
PMB-LX-60-74-2	P	-1.0				
PMB-LX-60-74-3	P	3.2				
PMB-DU-289-67	P	-0.8				

Sample	Vein	Stage	$\delta^{34}S$				
			py	sph	gal	cpy	bar
PMB-DH-270-67-0	P		-3.5				
PMB-DH-270-67-1	P		-2.1				
PMB-DH-270-67-2	P		-2.8				
PMB-DH-270-67-3	P		-1.2				
PMB-DH-270-67-4	P		-3.4				
PMB-DH-270-67-5	P		-0.8				
PBB-159-11A-76	P						32.4
PBB-449-131-59	AM			-2.1			
PBB-150-1B-76	AM						22.9
PMB-JM-521-71	AM						26.6
PMB-FY-333-68	HW		-1.4				19.8
PMB-FW-331-68	HW						22.0
PMB-FX-332-68	HW						19.2
PMB-FQ-323-68	HW						17.2
PBB-152-3E-76	HW						25.9
PBB-193-35-78	HM						44.4
PBB-193-35-78	MW						20.9
PBB-193-35-78	K				-4.9		
ROR-1-80	MH						21.0
Cascade 7-76	C						14.2
PBB-165-59	WW						23.7
ER-65-113	SC						22.8
PMB-CA-246-65-A1	OH	D		-1.68			
PMB-CA-246-65-A2	OH	D		-3.08			
PMB-CA-246-65-A3	OH	D		-1.86			
PMB-CA-246-65-B1	OH	D		-0.53			
PMB-CA-246-65-B2	OH	D		-0.86			
PMB-CA-246-65-B3	OH	D		-1.70			
PMB-CA-246-65-C1	OH	D		-1.29			
PMB-CA-246-65-C5	OH	D		0.10			
PMB-CA-246-65-C6	OH	D		-0.85			
PMB-CA-246-65-C7	OH	D		-2.09			
PMB-CA-246-65-C8	OH	D		-2.39			
PMB-CA-246-65-D1	OH	D		-2.76			
PMB-CA-246-65-D2	OH	D		-2.37			
PMB-CA-246-65-D3	OH	D		-2.83			
PMB-CA-246-65-D4	OH	D		-1.85			
PMB-CA-246-65-D5	OH	D		-1.03			
NJP-X-59	OH	E	-0.06				
NJP-X-59-A1	OH	D		-2.08			
NJP-X-59-A2	OH	D		-1.84			
NJP-X-59-A3	OH	D		-2.16			
NJP-X-59-A-5-1	OH	D		-1.02			
NJP-X-59-A-5-2	OH	D		-1.22			
NJP-X-59-A-5-3	OH	D		-0.99			
NJP-X-59-B-2-1	OH	D		-2.72			
NJP-X-59-B-2-2	OH	D		-2.19			

Sample	Vein	Stage			$\delta^{34}S$		
			py	sph	gal	cpy	bar
NJP-X-59-B-3-1	OH	D		-0.58			
NJP-X-59-B-3-2	OH	D		-1.09			
NJP-X-59-B-3-3	OH	D		-0.23			
NJP-X-59-B-3-4	OH	D		-0.38			
NJP-X-59-B-3-5	OH	D		-0.10			
NJP-X-59-B-4	OH	D		-0.09			
NJP-X-59-B-4-1	OH	D		-0.31			
NJP-X-59-B-4-2	OH	D		-0.24			
NJP-X-59-B-5-1	OH	D		0.34			
NJP-X-59-B-5-2	OH	D		-0.01			
NJP-X-59-B-5-3	OH	D		-0.59			
NJP-X-59-B-5-4	OH	D		-0.54			
NJP-X-59-B-5-5	OH	D		-0.47			
NJP-X-59-B-5-6	OH	D		-0.55			
NJP-X-59-B-6-1	OH	D		-0.72			
NJP-X-59-B-6-2	OH	D		-0.96			
NJP-X-59-B-6-3	OH	D		-1.10			

Data from Rye, Barton and Bethke, unpub. data, 1983.
Abbreviations: BD, Bulldog; OH, OH vein; P, P vein; AM, Amethyst; HM, Holy Moses; MW, Midwest; K, Knoess; MH, Monon Hill; C, Cascade; WW, Wagon Wheel Gap; SC, Spar City; HW, hanging wall structures of the Amethyst vein

JULCANI, PERU

Sample	Stage			$\delta^{34}S$				
		py	sph	gal	cpy	bar	eng	ten-tet
7664						19.28	-1.21	
8159						23.3	2.1	
7649						23.1	0.3	
7635						20.5		1.3

Data from Goodell, 1970.

SUNNYSIDE MINE, EUREKA DISTRICT, COLORADO

Sample	Stage	$\delta^{34}S$ py	sph	gal	cpy	bar	other min.	$\delta^{34}S$
9-20-3	R	-1.3						
9-9-5	R	-3.4						
9-19-3	1	1.1						
9-20-8	1	-0.1						
9-18-2	1	0.2						
9-18-3	1	0.6						
TC-8-73	1	2.3						
TC-11-74	1	1.3						
9-20-9A	2		1.1	-0.6				
9-20-9B	2		2.3	-0.8				
9-20-9C	2		0.6	-2.0				
9-20-9-9	2		1.5	-0.9				
9-14-1A	2	-4.6	-0.4					
9-14-5	2	-0.2						
B-1965.6	3		2.7	1.2				
TC-7-74	3		0.0	-3.2				
PB-8-57	3		0.1		0.7			
TC-10-74	3						brn	1.0
TC-6-74	3				0.6			
TC-16-73	3		1.7					
TG-16-73	3				-1.8			
2140-2080	3			-2.7				
9-8-1	3						tet	-3.9
TC-18-73	3				0.2			
TC-12-74	3			-1.0				
TC-13-74	3						tet	-0.2
TC-32-73	3			-1.2				
TC-7-74	3				-0.1			
TC-2-73	5						alb	0.9
9-18-58	5			-1.6				
TC-14-74	5			-2.0				
9-11-1	5		0.9	-1.3				
9-14-3	5		1.5	-2.5	0.3			
TC-10-73	5	-6.3	2.5					
TC-10-73	5	-5.9					anh	16.7
TC-10-73	5						anh	16.6
TC-10-73	5						anh	17.3
TC-10-73	5						anh	16.3
TC-10-73	5						anh	17.6
TC-10-73	5						anh	16.2
TC-6-73	6		1.6	-0.8				
TC-26-73	6						gyp	17.9
TC-26-74	6	1.8						
9-7-1	6	-2.0			-4.9			
PB-10-57	6		2.5					
9-7-2	6		-0.1					
9-13-2	6						gyp	18.6
TC-15-74	?						gyp	19.0
TC-16-74	6					22.0		

Sample	Stage	$\delta^{34}S$					other	
		py	sph	gal	cpy	bar	min.	$\delta^{34}S$
TC-17-74	6						gyp	15.3
TC-18-74	6						anh	16.7
TC-19-74	6					15.4		
TC-20-74	6					22.9		
TC-21-74	6						gyp	17.3
TC-22-74	?		2.2					
TC-26-73	6						gyp	18.4

Data from Casadevall and Ohmoto, 1977.

GOLDFIELD, NEVADA

Sample	Stage	$\delta^{34}S$					
		py	sph	gal	cpy	bar	alunite
X8-9.3	P	2.4					
S2-6.8	P	1.8					
S7-5.8	P	-1.8					
T6-10.1A	P	-0.5					
T3-12.7B	P	-1.1					
P4-8.6	P	-2.8					
F-350-6	P	-2.4					
F-250-7	P	-2.0					
R9-25	P						17.7
4VV-92	P						17.5
C-1-1191	P						13.3
3VV-49	P						11.6
4VV-289	P						23.3
97VV-31	P						21.4
P3-15	S						1.5
I3-43	S						-1.8
Q-20	S						0.8
H4-30	S						-0.8
G7-38.2	S						1.7
N4-26	S						1.0
T8-19.7	S						0.3
N7-29.6	S						-0.2
N-46	S						-2.5
07-15	S						0.0

Data from Jensen et al., 1971.
Abbreviations: P, primary; S, secondary.

COLQUI, PERU

Sample	Stage	$\delta^{34}S$ py	sph	gal	cpy	bar
4284	1		-1.4	-3.3		
45	2	-2.1	-1.1	-3.5		
4217	2	-0.4				
4224	2	-0.1				
4263	2	-2.9	-1.4	-4.0		
4263	2		-1.4	-3.6		
4284	2	-3.5				
4295	2	-2.1				
0901	4		0.6	-2.1		
0909-B	4		-0.5	-3.0		
4217	4	-0.4	-0.4	-2.3		
4284	4		-0.5	-2.5		
4295	4	-1.7				
19	4		0.7	-2.0		
4203	4		0.1	-2.0		
8720	4		1.0			
4208	4		0.5			
4257	4		0.7	-2.1		
4263	5				-0.5	
4269	5				-0.6	
4263	6		0.5	-2.4		
8715	6		1.3	-1.3		
8715	6		1.5	-1.3		
4212	7		-1.0	-3.8		14.1
4212	7					14.0
4288	7		0.9	-1.6		
8715	7		-0.5	-3.2		
8715	7		-0.3	-3.2		

Data from Kamilli and Ohmoto, 1977.

LAKE CITY, COLORADO

Sample	Stage	$\delta^{34}S$ py	sph	gal	cpy	bar
UU1	IIA		-5.16	1.22		11.17
UU1	IIA			1.01		
UU2	IIA		-3.6	-6.37		10.47

Data from Pisutha-Arnond, 1978