A STUDY ON

THE SOURCE OF ANOMALOUS LEAD and ARSENIC CONCENTRATIONS IN SOILS FROM THE El PASO COMMUNITY--- El PASO, TEXAS.

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FOR

ENVIRONMENTAL PROTECTION AGENCY

BY

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TABLE OF CONTENTS

Sample Preparation

Point Counting

Precision and Accuracy

Tables

Figures

ABBREVIATIONS

EMPA	Electron Microprobe Analysis
EDS	Energy Dispersive Spectrometer
SOP	Standard Operating Procedure
BSPM	Backscatter photomicrograph

Galena (PbS)

Cerussite ($PbCO_3$)

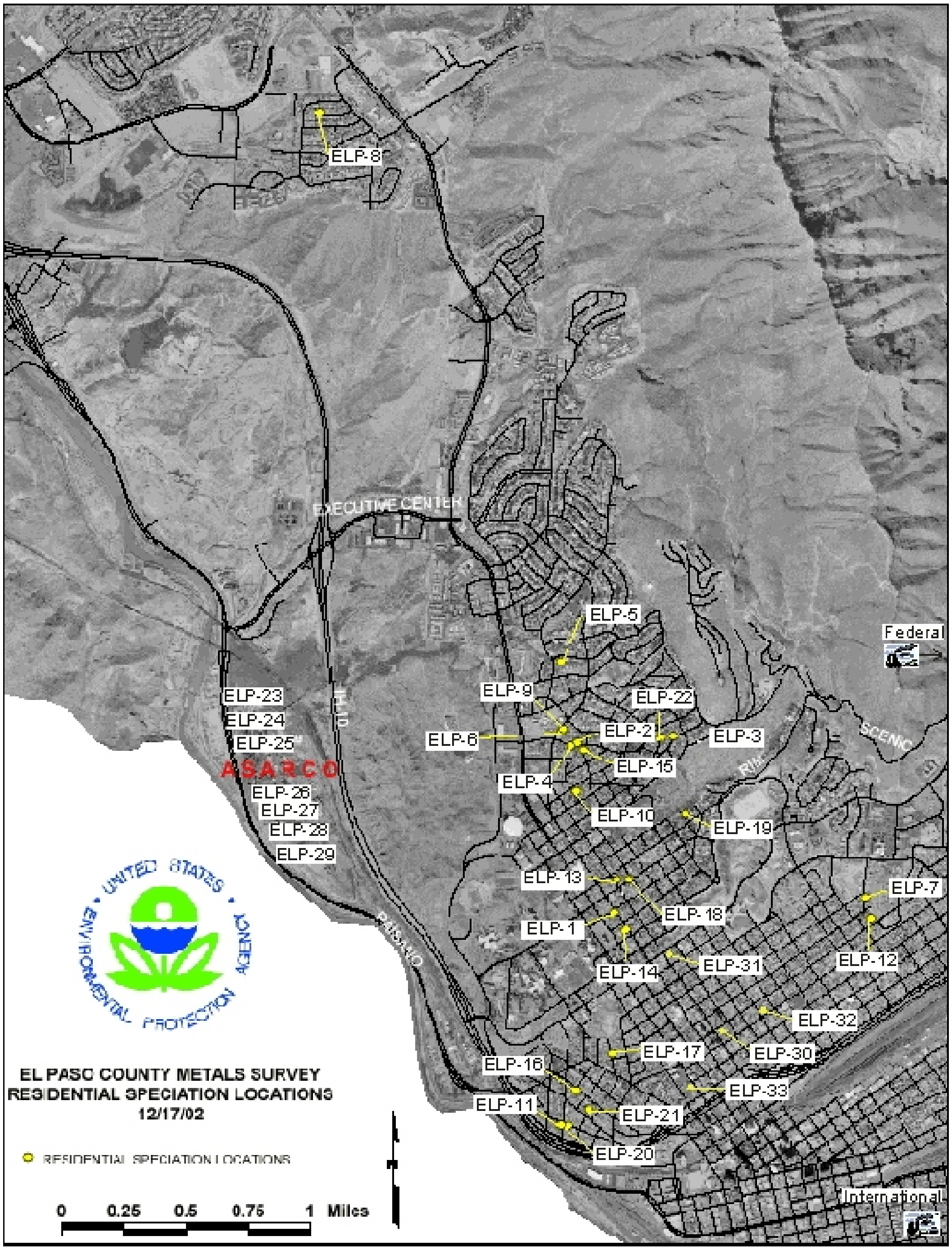
Anglesite ($PbSO_4$)

Sulfosalts (enargite- Cu_3AsS_4; tetrahedrite- $Cu_{12}Sb_4S_{13}$; tennantite- $Cu_{12}As_4S_{13}$; bournonite-$PbCuSbS_3$; and jamesonite-$Pb_4FeSb_6S_{14}$)

1.0 INTRODUCTION

The purpose of this study was to characterize the lead and arsenic mineralogy within the El Paso community soils and more specifically the source(s) of the anomalously high (121-1143 mg/kg) lead and (14-192 mg/kg) arsenic concentrations found in the community. Samples were acquired from the ASARCO (1889-present) facility in El Paso, in addition to those collected by WESTON from the surrounding community. Although the ASARCO facility was not the only smelter to operate in the El Paso community, it was the largest and had the greatest longevity. The International Smelter operated from 1888-1894 and the Federal smelter operated from 1901-1904. A site map, with sample locations and selected demographics is provided in Figure 1. Environmental concerns pertaining to plant discharges began in the early 1920's with various private and city disputes concerning damages to crops and health from excessive smoke releases. In the early 1970's more aggressive action by the city of El Paso and the state of Texas was undertaken to control air pollution from the facility. During these investigations it was concluded that the ASARCO smelter emitted approximately 1,000 tons of lead, 500 tons of zinc, 10 tons of cadmium and 1 ton of arsenic to the surrounding area over a three year period (People vs ASARCO, 1971 and Carnow et al., 1973). As a direct result of this litigation ASARCO completed a $90 million dollar renovation to the facility in 1979 to improve emission quality. However, as recently as 1990, data from the State of Texas indicate that 96 tons of lead per year (from the ore and fluid beds) and 29 tons of arsenic per year (from the copper stack) are still being emitted from the facility. These modern, measured releases could only pale in comparison to historic releases during the facilities 100+ years of operation.

Fig1


ELP-8
EXECUTIVE CENTER
I-10
ELP-5
Federal
ELP-23
ELP-24
ELP-25
ASARCO
ELP-26
ELP-27
ELP-28
ELP-29
ELP-9
ELP-22
ELP-6
ELP-2
ELP-3
SCENIC
ELP-15
ELP-4
ELP-10
ELP-19
ELP-13
ELP-18
ELP-7
ELP-1
ELP-14
ELP-31
ELP-12
ELP-32
ELP-17
ELP-30
ELP-16
ELP-33
ELP-11
ELP-21
ELP-20
PAISANO
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
EL PASO COUNTY METALS SURVEY
RESIDENTIAL SPECIATION LOCATIONS
12/17/02
RESIDENTIAL SPECIATION LOCATIONS
0 0.25 0.5 0.75 1 Miles
International

2.0 HISTORICAL and GEOLOGICAL BACKGROUND

History

The El Paso Smelter, was constructed in 1887 as the Consolidated Kansas City Smelting and Refining Company. In 1899 it became part of the newly formed American Smelting and Refining Company (**ASARCO**). It was originally built to process the rich, lead ores from the West, but was later (1910) expanded by adding a copper circuit, primarily for Arizona ores. Later in 1930's ~1950, and 1970's facilities were added for cadmium, zinc, and antimony, respectively.

The lead facility originally consisted of a 100 foot wooden stack and six blast furnaces with associated sintering (4 roasters) capacity to handle some 225,000 tons of charge per year. After the 1902 fire, seven lead furnaces were constructed along with a new 400 foot stack. The lead plant was closed in 1985. (Hydrometrics, 2001)

The copper facility consisted of four Herreshoff roasters, one reverberatory furnace, and three Peirce-Smith converters. Roaster and reverberatory gases are eliminated from a 828 foot stack and the converter gases discharge from a 100 foot stack. Baghouses and electrostatic precipitators (devices used to minimize stack emissions) were introduced to the facility in the early 1900's to limit the loss of metal from fumes. Annual production produced 110,000 tons of anode copper.

In the early 1930's a Godfrey roaster was added for cadmium production and in the 1970's an antimony plant was added.

In 1947 a zinc fuming facility, to treat slags, was added to handle the elevated concentrations of zinc (up to 10 percent Zn) which were being produced when smelting the New Mexico ores.

The furnace treated 20,000 tons of slag per month. In early 1950's a new 600 foot stack was built to handle the lead and zinc facilities.

In the mid 1980's the antimony plants closed followed by a closing of the zinc and cadmium plants in 1992. The smelter still operates its copper (CONTOP) facility which was added in 1993. The plant has been on a mandatory three-year care and maintenance since 1999.

Geology:

El Paso lies the extreme western tip of Texas, within the southern part of the Basin and Range province. The south-east flowing Rio Grande River marks the southern limits of the city and the international boundary between the United States and Mexico. The climate is arid, with annual precipitation averaging only 9 inches. The prevailing winds are westerly, with dust storms a common occurrence in the early months of the year.

The metropolitan area of El Paso lies primarily within the floodplain of the Rio Grande River, once dominated by a large lake bed (Lake Cabeza de Vaca). Millions of years of river deposition resulted in a complex sedimentary sequence of gravel, silt, clay, and sand called the Fort Hancock Formation, accumulating to a thickness of more than 9,000 feet. Recent geological activity has been dominated by Basin and Range tectonics and the emplacement of young, 40,000 year old, basalt flows and cinder cones from the Potrillo Volcanic field. There is nothing in the geological record that could account for the elevated metal (Pb, As, Cu, Cd, Zn) concentration found in the residential soils.

For decades, preceding the construction of dams on the Elephant Butte and Caballo lakes in 1916, spring flood waters would move onto the downtown area of El Paso.

3.0 LEAD and ARSENIC GEOCHEMISTRY

Arsenic is found in many minerals and is typically enriched in soils originating from shales/schists and argillaceous sediments. Lead on the other had is more commonly concentrated in silicic magmatic rocks and argillaceous sediments. Uncontaminated soils have mean concentrations of 1-6 mg/kg for arsenic and 3-19 for lead (Fergusson, 1990), worldwide. The lowest levels are typically found in soils derived from volcanic or carbonate terrain, as are those in the El Paso area (volcanics and limestones), and average 1-7 mg/kg As and 3-14 mg/kg Pb. The arid climate in the El Paso area along with the near neutral (6-8.5 pH) acidity of the local soils stimulate very low metal mobility, generally concentrating metals in the surface horizons by preventing there downward distribution over time. Mobility may be enhanced by irrigation, aeration, or by utilization of soil amendments (Logan and Chaney, 1983).

Numerous sources of lead and/or arsenic can produce elevated concentrations in surface soils. Table 1 is a compilation of the most common sources, their speciation, along with associated soil concentrations (data from Barzi et al., 1996, Kabata and Pendias, 1993; Fergusson, 1990; and Drexler, per. communication, 1998).

Table 1. Compilation of common lead and arsenic sources and associated soil-metal concentrations.

Source	**Arsenic Speciation**	**Associated Soils As mg/kg**	**Lead Speciation**	**Associated Soils Pb mg/kg**
Paint Pigments			$PbCO_3$, $PbSO_4$, PbO, $PbCrO_4$	100-900
Mining	Sulfosalts, As_2S_3, FeAsS	23-1023	Sulfosalts, PbS, $PbCO_3$, $PbSO_4$	100-96,000
Chemical Works	PbAsO, As_2O_3 ,R**AsO	10-2000	PbAsO, Pb, $PbSO_4$	100-600
Metal Processing	As_2O_3, AsM*O, PbAsO	33-2500	PbM*O, PbAsO , PbO, FePbO, $PbCO_3$, Slag, $PbCl_4$	100-12,000
Application of Pesticides	As_2O_3, PbAsO, R**AsO, Na-Ca arsenates	38-625	PbAsO,	200-2500
Gardens and orchards	PbAsO	38-892	PbAsO	200-2500
Fly Ash	Unknown	1-9		
Municipal Sludge	Unknown	1-6		80-7400
Sheep/Cattle Dip/Tannery	As_2O_3, Na-Ca arsenates	300-1000		
Wood Preservatives	Cr-Cu arsenates	10-2000		

**R = Organic compounds, *M = typically Pb, Ca, Cd, Zn, or Sb.

4.0 SPECIATION

Seven samples from the ASARCO facility and twenty-eight samples from the surrounding community (Table 2.) were speciated for lead and arsenic using electron microprobe (EMPA) techniques. Methodologies used for sample preparation, data collection, and data synthesis are described below.

Table 2.0 Speciation sample set.

Cu Lab No.	Source	Cu mg/kg	Zn mg/kg	As mg/kg	Se mg/kg	Cd mg/kg	Sb mg/kg	Pb mg/kg
ELP-1	Front Yard	518	656	74	1.0	22	1.0	1084
ELP-2	Front Yard	379	464	52	ND	14	1.0	448
ELP-3	Front Yard	189	313	66	1.0	6	1.0	236
ELP-4	Front Yard	732	712	60	8.9	22	3.7	979
ELP-5	Back Yard	396	496	40	0.5	11	1.2	400
ELP-6	Front Yard	812	782	59	2.2	27	2.4	789
ELP-7	Front Yard	108	226	17	1.2	3	ND	164
ELP-8	Front Yard	58	229	47	ND	2	1.0	109
ELP-9	Front Yard	931	1038	71	ND	24	2.0	892
ELP-10	Front Yard	802	855	57	0.7	24	2.1	1151
ELP-11	Drip Line	666	559	63	1.6	20	2.0	1046
ELP-12	Back Yard	158	317	12	ND	6	1.0	328
ELP-13	Front Yard	3797	1137	73	ND	21	7.0	939
ELP-14	Front Yard	832	685	60	1.0	18	1.8	1031
ELP-15	Back Yard	568	611	29	ND	20	1.1	754
ELP-16	Front Yard	556	610	97	ND	21	1.5	756
ELP-17	Front Yard	468	468	38	ND	17	0.6	768
ELP-18	Front Yard	536	1061	98	11.0	9	3.1	515
ELP-19	Front Yard	286	860	186	1.6	11	1.8	488
ELP-20	Back Yard	838	770	44	ND	30	2.3	1046
ELP-21	Back Yard	551	718	40	ND	17	1.3	831
ELP-22	Front Yard	321	398	33	ND	11	1.0	408
ELP-30	Front Yard	192	591	14	ND	6	ND	407
ELP-31	Front Yard	213	305	12	ND	6	ND	316
ELP-32	Front Yard	52	98	8	ND	1	ND	108
ELP-33	Front Yard	141	262	13	ND	5	ND	1785
TM	Distal Yard	27	29	4	ND	1	1.0	46
Z-1	Distal Yard	52	169	39	ND	1	1.0	53

Sample ID.	Cu Lab No.	Source	Cu mg/kg	Zn mg/kg	As mg/kg	Se mg/kg	Cd mg/kg	Sb mg/kg	Pb mg/kg
9600-55-00	ELP-23	Plant	334951	8612	4795	9031	393	773	8244
9605-55-00	ELP-24	Plant	5709	2936	602	16.0	167	15.0	6122
9606-55-00	ELP-25	Plant	183576	67918	24854	11590	6523	1210	9973
9603-55-00	ELP-26	Plant	12198	18643	400	12.0	25	16.0	3397
9602-55-00	ELP-27	Plant	15394	21418	365	11.0	22	19.0	1996
9604-55-00	ELP-28	Plant	1514	729	180	2.0	35	4.0	1312
9601-55-00	ELP-29	Plant	11053	2144	307	8.0	68	13.0	858

4.01 Methodology

Metal speciation was conducted on a JEOL 8600 electron microprobe (EMPA), operating at 15Kv (accelerating voltage) and 15-20 nanoAmps current, at the Laboratory for Geological Studies at the University of Colorado following the laboratory's SOP. For a complete description of the methodology a copy of the SOP is available at our website:

htpp://www.colorado.edu/GeolSci/legs

One exception was made in the SOP, in that the samples were not sieved to <250 μm, as is most common for bioavailability determinations, but the 2mm fraction was used in order to be consistent with previous site studies. The samples were all air dried and prepared for speciation analysis as outlined in the SOP. A combination of both an Energy Dispersive Spectrometer (EDS) and a Wavelength Dispersive Spectrometer (WDS) were used to collect x-ray spectra and determine elemental concentrations on observed mineral phases. All quantitative analyses are based on certified mineral and metal standards using a Phi Rho Z correction procedure. Representative backscatter photomicrographs (BSPM) illustrating sample characteristics were acquired.

Data from EMPA will be summarized using three methods. The first method is the determination of FREQUENCY OF OCCURRENCE (F). This is calculated by summing the longest dimension of all the lead or arsenic-bearing phases observed during the point counting and then dividing each phase by the total length for all phases.

Equation 1.0 will serve as an example of how to calculate the frequency of occurrence for an arsenic- bearing compound, lead-bearing particles are handled in a similar manner.

F_{As} - Frequency of occurrence of arsenic
in a single phase.

PLD - An individual particle's longest
dimension

$$F_{As} \text{ in phase-1} = \frac{\sum (PLD)_{\text{phase-1}}}{\sum (PLD)_{\text{phase-1}} + \sum (PLD)_{\text{phase-2}} + \sum (PLD)_{\text{phase-n}}} \qquad \text{Eq. 1.0}$$

$$\%F_{As} \text{ in phase-1} = F_{As} \text{ in phase-1} * 100$$

Thus, the frequency of occurrence of arsenic in each phase (F_{As}) is calculated by summing the longest dimension of all particles observed for that phase and then dividing each phase by the total of the longest dimensions for all phases. The data generated thus illustrate which arsenic-bearing phase(s) are the most commonly observed in the sample or relative volume percent.

The second calculation used in this report determines the RELATIVE MASS ARSENIC (RM_{As}) in a phase.

$$RM_{As} \text{ in phase-1} = \frac{\sum (M_{As}\cdot)_{\text{phase-1}}}{\qquad} \qquad \text{Eq. 2.0}$$

$$\sum (M_{As\cdot})_{phase\text{-}1} + \sum (M_{As\cdot})_{phase\text{-}2} + \sum (M_{As\cdot})_{phase\text{-}n}$$

$$\%RM_{As} \text{ in phase-1} = RM_{As} \text{ in phase-1} * 100$$

M_{As} - Mass of arsenic in a phase
SG - Specific Gravity of a phase

ppm_{As} - Concentration in ppm of arsenic in phase (see Table A1.0, Appendix I)

$$M_{As} = F_{As} * SG * ppm_{As} \qquad \text{Eq. 2.0}$$

The advantage in reviewing the RELATIVE MASS ARSENIC determinations is that it gives one information as to which metal-bearing phase(s) in a sample is likely to control the total bulk concentration for arsenic. As an example, PHASE-1 may, by relative volume, contribute 98% of the sample, however it has a low specific gravity and contains only 1000 ppm arsenic, whereas PHASE-2 contribute 2% of the sample, has a high specific gravity and contains 850000 ppm of arsenic. In this example it is PHASE-2 that is the dominant source of arsenic to the sample.

The third calculation is to determine the MINERAL MASS ARSENIC (Min_{As}). In this calculation the RM_{As} is simply multiplied by the bulk concentration of arsenic found in the sample:

$$Min_{As} = RM_{AS} * As_{Bulk} \qquad \text{Eq. 3.0}$$

Where As $_{Bulk}$ is the bulk arsenic for the sample speciated. These values are most useful for geostatistical calculations, such as kriging, or apportionment since values are not forced to 100%.

4.02 Point Counting

Point counts (weighted on longest dimension) are made by traversing each sample from left-to-right and top-to-bottom. The amount of vertical movement for each traverse would depend on magnification and CRT (cathode-ray tube) size. This movement should be minimized so that NO portion of the sample is missed when the end of a traverse is reached. Two magnification settings should be used. One ranging from 40 to 100X and a second from 300 to 600X. The last setting will allow one to find the smallest identifiable (1-2 micron) phases. The portion of the sample examined in the second pass, under the higher magnification, will depend on the time available, the number of metal-bearing particles, and the complexity of metal mineralogy. A maximum of 8 hours will be spent per sample.

The point counting procedure in petrography is a well established technique as outlined by Chayes, 1949. For our procedure we have simply substituted the electron microprobe for a simple petrographic microscope as a means of visually observing a particle and identifying its composition using the attached x-ray analyzers. The operator error (identification of phase and sizing) is generally negligible. However the particle counting error can be significant depending on the total number of particles counted and the fraction of an individual component (species) percent. Based on studies in El-Hinnawi, 1966, it was shown that the relative error of a point count based on 100 total particles versus one of 300 total particles is only 10% and 6% , respectively (for a species representing 30% of the count). It is our belief that this small decrease in error is not justified when cost and time of analysis are considered, and that it is much more beneficial to increase your total sample population and address representativeness.

4.03 Precision and Accuracy

The precision of the EMPA speciation will be evaluated based on sample duplicates analyzed at a frequency of 10% as selected by the laboratory, however the client may also submit "blind" duplicates for analyses. The precision of the data generated by the "EMPA point count" will be evaluated by calculating RPD values for all major (>20% frequency) phases, comparing the original result with the duplicate result. If the duplicate analyses are from samples that have produced at least 100 total particles it is expected that all (100%) of the dominant species (representing 60% of frequency) be found in both, and that their individual frequency of occurrence not vary by more than 30%, relative. In the evaluation of the method precision it is most important to consider the variation in results among all samples studied for a particular media, since the overall particle count is very large Data generated by the "EMPA point count" will be further evaluated statistically based on the methods of Mosimann (1965) at the 95% confidence level on the frequency data following Equation 4.

$$E_{0.95} = 2P(100-P)/N \qquad \text{(Eq. 4)}$$

Where: $E_{0.95}$ = Probable error at the 95% confidence level

P = Percentage of N of an individual metal-bearing phase based on percent length frequency

N = Total number of metal-bearing grains counted

Accuracy of quantitative metal analyses on non-stoichimetric metal phases is based on established EMPA procedures, and data reduction, Heinrich, 1981 and is generally 1-2% relative. All quantitative analyses will be performed using a series of certified mineral standards. In general, site-specific concentrations for these variable, metal-bearing forms will be determined by performing "peak counts" on the appropriate wavelength spectrometer. Average concentrations will then be used for further calculations. Data on specific gravity will be collected from referenced databases or estimated based on similar compounds.

Plant-site Samples

During the 116 year operational history of the ASARCO facility, numerous sources for heavy-metal emissions existed, including:

Roasters, blast furnaces
Storage piles
Plant road dust
Loading/unloading facilities
Baghouses/dust collectors

Few of these sources are available today for direct sampling, therefore, plant-site samples were limited. In terms of the historical speciation of lead and arsenic at the plant, these samples are most certainly incomplete. Thus these samples provide only a partial "source fingerprint".

Approximately 2100 particles containing either lead or arsenic were counted in the six soil samples from the ASARCO plant, Table 3. These samples can be generally characterized as representing three distinct media at the site; 1) a slag-rich (ELP 26,27) 2) a copper circuit (ELP 25) and 3) general plant soil (ELP 28,29). As a whole, plant samples studied to date have lead masses dominated (78% of the relative lead mass) by the following lead-bearing phases: PbS, $PbMSO_4$, $CuMSO_4$, $CrMSO_4$, PbAsO, and PbO Figure 2, Photos 1-3. The most common metals "M" are As, Sb or Cd. Arsenic masses dominated (85% of the relative arsenic mass) by the following arsenic-bearing phases: $CuMSO_4$, CuM, PbAsO, and $PbMSO_4$ Figure 2, Photos 1-3.

The most common metals “M” are Pb or Sb. These primary phases are consistent with the facilities operations.

Particle size of lead and arsenic phases are trimodal in their distribution with populations at 2,10 and 100 microns, Figure 3. The 2 micron population is dominated by PbS, the 10 micron by $CuMSO_4$, and the coarser, 100+ micron population by slag.

Each of the plant samples show unique lead and arsenic speciation and the site summary, Figure 2, is dominated by a large number of CuM and $CuMSO_4$ particles that are only found in two of the samples. If one would exclude those two samples, the dominant species of lead would be PbS, PbO, $PbMSO_4$, and PbAsO while arsenic would be primarily found in PbAsO, $PbMSO_4$, and sulfosalts species.

Table 3

TABLE 3. Summary Plant Speciation Analyses.

		F%	RM-Pb	RM-As	E-95*	Min-Pb	Min-As
ELP-23	BiMO	5.18%	1.83%	0.05%	2.56%	214	2
	Cerussite	0.46%	1.85%	0.00%	0.78%	216	0
	Cu	55.97%	0.39%	91.22%	5.74%	46	4659
	CuMO	7.95%	1.35%	1.31%	3.13%	157	67
	Galena	10.60%	53.96%	0.00%	3.56%	6309	0
	PbAsO	0.46%	1.28%	1.20%	0.78%	150	61
	PbMO	4.03%	7.05%	1.25%	2.28%	824	64
	PbMSO4	6.14%	10.10%	2.95%	2.78%	1181	151
	PbO	1.73%	11.97%	0.00%	1.51%	1399	0
	PbSiO4	3.84%	9.03%	0.06%	2.22%	1056	3
	Phosphate	0.31%	0.33%	0.03%	0.64%	39	1
	(Sb,Sn)MO	0.12%	0.03%	0.00%	0.39%	3	0
	Sulfosalts	3.53%	0.83%	1.94%	2.14%	97	99
ELP-24	Clay	0.12%	0.04%	0.03%	0.43%	3	0
	Anglesite	0.47%	5.11%	0.00%	0.84%	422	0
	AsFeO	0.18%	0.10%	1.21%	0.52%	8	10
	AsMO	0.60%	0.65%	11.94%	0.94%	54	100
	Calcite	75.64%	11.75%	0.63%	5.23%	971	5
	CuMO	0.12%	0.07%	0.17%	0.43%	5	1
	FeOOH	3.70%	1.06%	0.71%	2.30%	87	6
	MnOOH	0.52%	0.98%	0.11%	0.88%	81	1
	PbAsO	2.72%	24.18%	59.86%	1.98%	1998	502
	PbFeOOH	1.50%	3.68%	4.68%	1.48%	304	39
	PbMO	2.51%	13.99%	6.56%	1.90%	1156	55
	PbMSO4	2.03%	10.68%	8.26%	1.72%	882	69
	PbO	0.47%	10.48%	0.00%	0.84%	866	0
	PbSiO4	2.06%	15.50%	0.29%	1.73%	1280	2
	Phosphate	0.05%	0.16%	0.04%	0.26%	13	0
	Pyrite	0.37%	0.01%	0.34%	0.74%	1	3
	(Sb,Sn)MO	4.22%	0.03%	0.01%	0.26%	3	0
	Slag	0.05%	0.05%	0.02%	2.45%	4	0
	Sulfosalts	0.87%	0.67%	4.12%	1.14%	55	35
	FeSO4	1.77%	0.84%	1.02%	1.61%	69	9

ELP-25	Anglesite	0.09%	1.25%	0.00%	0.29%	655	0
	AsMSO4	0.02%	0.09%	0.21%	0.13%	47	50
	BiMO	0.01%	0.02%	0.00%	0.12%	11	0
	CrMSO4	1.61%	0.82%	0.00%	1.25%	432	0
	Cu	0.30%	0.01%	3.38%	0.54%	5	809
	CuMSO4	91.92%	61.31%	79.19%	2.71%	32193	18953
	PbAsO	0.02%	0.27%	0.40%	0.15%	142	96
	PbAsVO	0.04%	0.43%	0.01%	0.19%	225	3
	PbMSO4	5.01%	35.74%	16.63%	2.17%	18769	3981
	Slag	0.94%	0.01%	0.00%	0.96%	7	1
	Sulfosalts	0.04%	0.05%	0.17%	0.21%	24	41
ELP-26	Anglesite	1.01%	22.22%	0.00%	1.14%	506	0
	CuMO	0.13%	0.14%	2.27%	0.41%	3	8
	Galena	1.61%	53.06%	0.00%	1.43%	1209	0
	PbAsO	0.07%	1.29%	19.88%	0.30%	29	73
	PbMO	0.01%	0.16%	0.47%	0.14%	4	2
	PbMSO4	0.97%	10.36%	49.92%	1.11%	236	182
	PbO	0.22%	9.94%	0.00%	0.53%	227	0
	Slag	95.41%	2.10%	6.07%	2.38%	48	22
	Sulfosalts	0.34%	0.51%	19.74%	0.66%	12	72
	FeSO4	0.23%	0.22%	1.66%	0.54%	5	6
ELP-27	CuMO	0.03%	0.11%	1.71%	0.15%	2	6
	Galena	0.59%	72.30%	0.00%	0.69%	1445	0
	PbMO	0.07%	2.94%	8.02%	0.24%	59	28
	PbMSO4	0.02%	0.77%	3.49%	0.13%	15	12
	PbO	0.08%	13.98%	0.00%	0.26%	280	0
	Slag	98.89%	8.08%	21.82%	0.94%	162	75
	Sulfosalts	0.32%	1.80%	64.96%	0.51%	36	223

*E-95= Estimated counting error at 95% confidence level, Mosiann, 1965.

ELP-28	Clay	10.10%	1.19%	0.74%	1.59%	27	2
	Anglesite	1.18%	4.63%	0.00%	3.09%	106	0
	AsMO	3.00%	1.18%	17.56%	1.59%	27	57
	Arsenopyrite	0.77%	0.00%	9.66%	0.00%	0	31
	CuMO	0.41%	0.08%	0.17%	0.42%	2	1
	FeOOH	10.32%	1.07%	0.58%	1.51%	25	2
	Galena	3.41%	20.14%	0.00%	5.89%	462	0
	PbAsO	9.14%	29.50%	58.77%	6.70%	677	190
	PbFeOOH	2.18%	1.94%	1.99%	2.03%	45	6
	PbMO	4.05%	8.20%	3.10%	4.03%	188	10
	PbMSO4	2.73%	5.20%	3.24%	3.26%	119	10
	PbO	2.59%	20.82%	0.00%	5.96%	478	0
	PbSiO4	1.46%	3.97%	0.06%	2.87%	91	0
	Pyrite	5.18%	0.03%	1.41%	0.26%	1	5
	(Sb,Sn)MO	0.14%	0.04%	0.01%	0.28%	1	0
	Slag	32.88%	0.13%	0.05%	0.53%	3	0
	Sulfosalts	0.77%	0.21%	1.05%	0.67%	5	3
	FeSO4	9.69%	1.66%	1.62%	1.88%	38	5
ELP-29	Anglesite	1.16%	3.58%	0.00%	2.54%	48	0
	AsFeO	1.78%	0.27%	1.90%	0.71%	4	6
	AsMO	3.61%	1.12%	11.66%	1.44%	15	38
	Arsenopyrite	1.56%	0.00%	10.76%	0.00%	0	35
	BiMO	2.23%	0.72%	0.03%	1.16%	10	0
	Cerussite	0.09%	0.33%	0.00%	0.78%	4	0
	CuMO	2.77%	0.43%	0.62%	0.89%	6	2
	FeOOH	8.97%	0.73%	0.28%	1.17%	10	1
	Galena	1.61%	7.47%	0.00%	3.60%	101	0
	Native Pb	0.13%	1.08%	0.00%	1.42%	15	0
	PbAsO	16.47%	41.86%	58.36%	6.75%	566	188
	PbMO	1.38%	2.21%	0.58%	2.01%	30	2
	PbMSO4	10.66%	16.02%	6.98%	5.02%	217	22
	PbO	1.12%	7.06%	0.00%	3.51%	95	0
	PbSiO4	3.57%	7.67%	0.08%	3.64%	104	0
	Phosphate	6.07%	6.00%	0.76%	3.25%	81	2
	Pyrite	1.74%	0.01%	0.26%	0.13%	0	1
	(Sb,Sn)MO	0.13%	0.03%	0.01%	0.23%	0	0
	Slag	15.39%	0.05%	0.01%	0.30%	1	0
	Sulfosalts	9.01%	1.94%	6.75%	1.89%	26	22
	FeSO4	10.53%	1.42%	0.97%	1.62%	19	3

Fig2

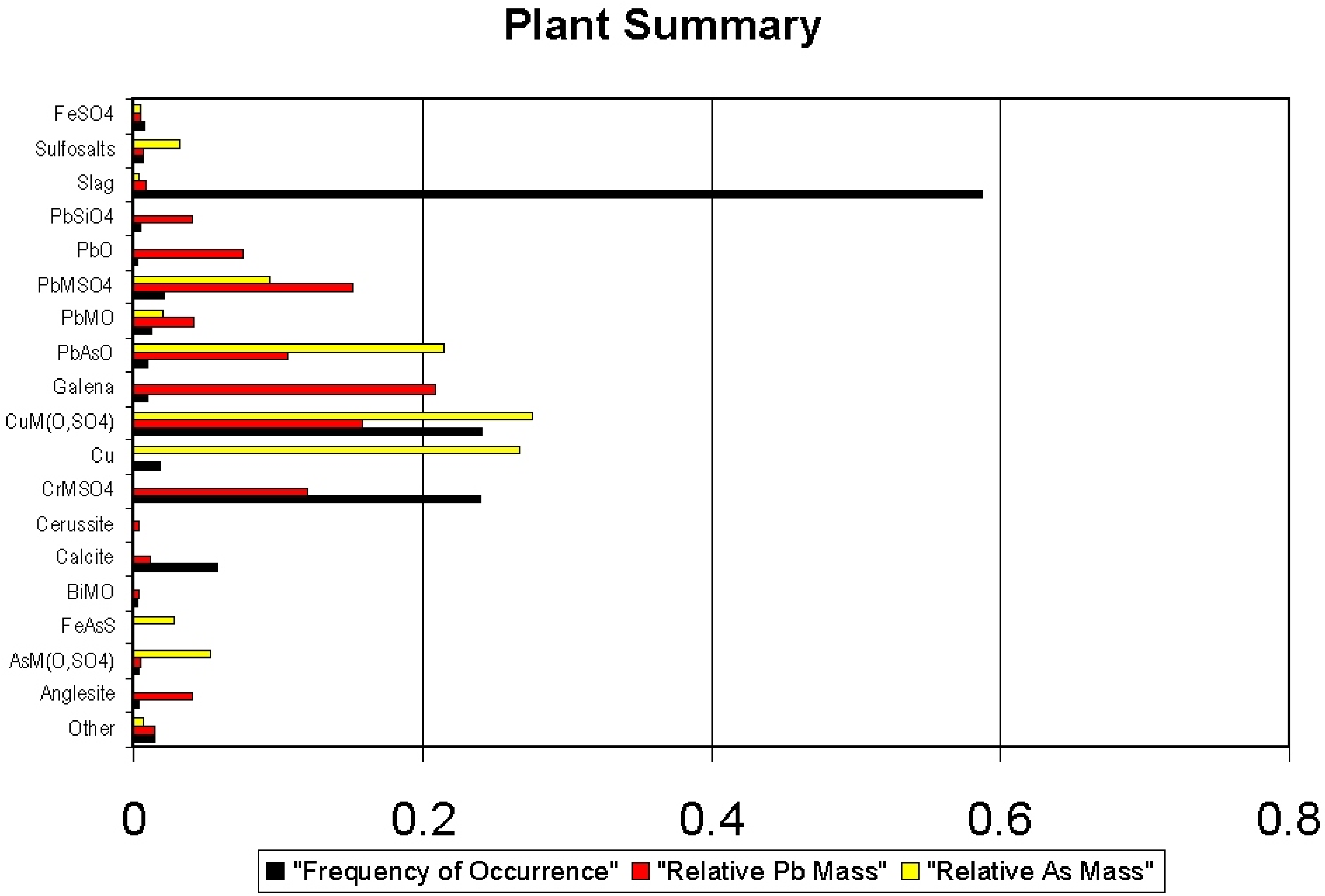
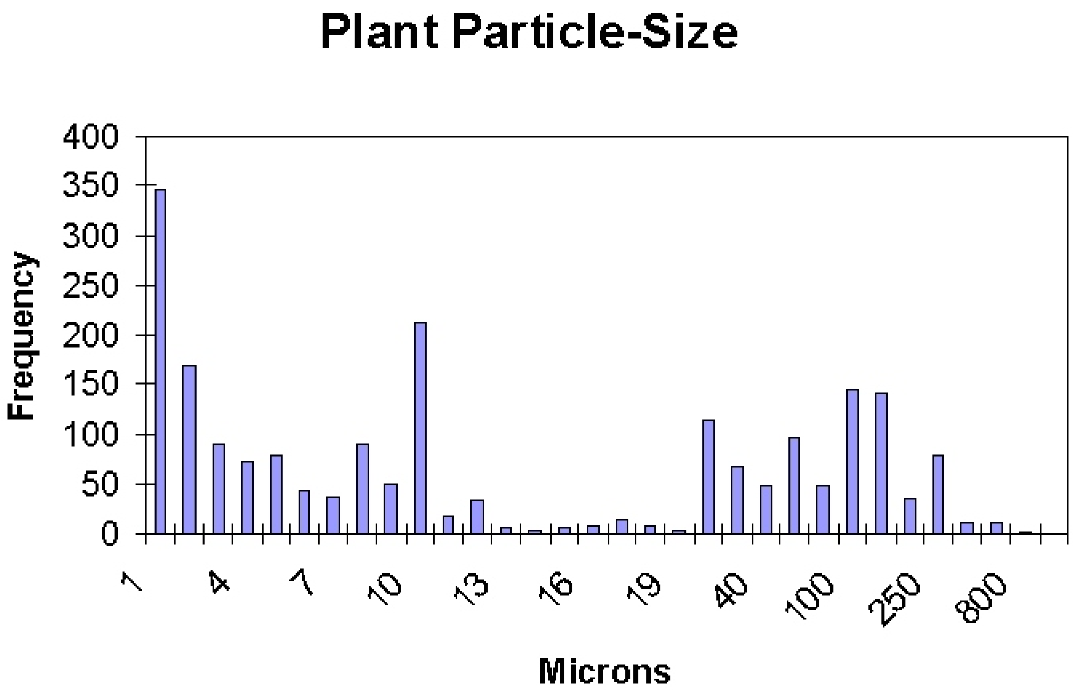

Plant Summary
FeSO4
Sulfosalts
Slag
PbSiO4
PbO
PbMSO4
PbMO
PbAsO
Galena
CuM(O,SO4)
Cu
CrMSO4
Cerussite
Calcite
BiMO
FeAsS
AsM(O,SO4)
Anglesite
Other
0
0.2
0.4
0.6
0.8
■ "Frequency of Occurrence"
■ "Relative Pb Mass"
■ "Relative As Mass"

Fig3


Plant Particle-Size
Frequency
400
350
300
250
200
150
100
50
0
1
4
7
10
13
16
19
40
100
250
800
Microns

Community Soils

Community soil sample set (Figure 1) includes soils with varied bulk lead and arsenic concentrations 46-1785 mg/kg, and 4-186 mg/kg, respectively. From these samples over 2400 lead and or arsenic bearing particles were counted, Table 4. These data indicate that slag, iron oxide and phosphate are the most commonly found lead/arsenic-bearing phases in the residential soils. However, lead masses almost exclusively (84% of the relative lead mass) are dominated by phosphate, PbS, PbAsO, PbMO, $PbCO_3$, $PbMSO_4$, and $PbSO_4$, with minor contributions from other lead forms, Figure 4. Five of these six dominant forms of lead are consistent with those found at the ASARCO facility and three of the five forms could only be associated with a pyrometalurgical facility. Arsenic masses almost exclusively (85% of the relative arsenic mass) dominated by arsenopyrite, PbAsO, AsMO, $PbMSO_4$ and phosphate, Figure 4, Photos 4-11. Again, three of the four dominant forms of arsenic in community soils are consistent with ASARCO facility speciation results and two of the three could only be associated with a pyrometalurgical facility. Approximately 62% of the residential yards had apportionable lead paint, however, only 12% of those yards had paint as a dominant lead phase. No evidence morphological, demographical, or mineralogical could be established to support lead or arsenic contributions from either pesticides or herbicides.

The particle- size distribution for all lead and arsenic species is bimodal, at approximately 2 and 40 microns, Figure 5. The 2 micron size population is not dominated by a particular phase, however, the coarser (40 micron) population is composed in general of liberated, slag grains.

Table 4

TABLE 4. Summary of Residential Speciation Analyses.

		F%	RM-Pb	RM-As	E-95*	Min-Pb	Min-As
ELP-9	Clay	2.61%	0.73%	0.97%	3.19%	6	1
	AsFeOOH	0.97%	0.44%	9.49%	1.96%	4	6
	FeOOH	27.22%	6.68%	7.76%	8.90%	57	5
	Galena	0.22%	3.13%	0.00%	0.95%	27	0
	Paint	3.36%	1.95%	0.00%	3.60%	17	0
	PbAsO	0.60%	4.56%	19.48%	1.54%	39	13
	PbM(Cl,SO,O)	5.37%	25.77%	20.87%	4.51%	219	14
	PbMSO4	2.98%	13.47%	17.99%	3.40%	114	12
	Phosphate	13.42%	39.87%	15.44%	6.82%	339	10
	SbMO	0.82%	0.53%	0.34%	1.80%	4	Tr
	Slag	36.39%	0.34%	0.27%	9.62%	3	Tr
	Sulfosalts	0.37%	0.24%	2.57%	1.22%	2	2
	FeMSO4	5.67%	2.30%	4.82%	4.63%	20	3
ELP-8	Anglesite	2.33%	8.03%	0.00%	4.67%	10	0
	AsFeOOH	3.10%	0.52%	1.70%	5.37%	1	1
	Arsenopyrite	26.74%	0.00%	95.17%	13.72%	0	54
	FeOOH	13.57%	1.24%	0.22%	10.61%	1	Tr
	Galena	16.67%	86.77%	0.00%	11.55%	105	0
	PbM(Cl,SO,O)	0.39%	0.69%	0.08%	1.93%	1	Tr
	PbMSO4	0.78%	1.30%	0.26%	2.72%	2	Tr
	Pyrite	27.91%	0.15%	2.16%	13.90%	Tr	1
	FeMSO4	8.53%	1.29%	0.41%	8.66%	2	Tr
ELP-7	Anglesite	0.90%	4.69%	0.00%	3.62%	8	0
	AsMO	2.24%	1.18%	10.90%	5.69%	2	2
	Arsenopyrite	6.28%	0.00%	65.18%	9.32%	0	10
	Galena	0.45%	3.53%	0.00%	2.57%	6	0
	PbMSO4	13.45%	34.25%	13.27%	13.12%	57	2
	Phosphate	29.60%	49.57%	5.57%	17.55%	82	1
	Pyrite	4.48%	0.04%	1.01%	7.96%	Tr	Tr
	Slag	13.45%	0.07%	0.02%	13.12%	Tr	Tr
	FeMSO4	29.15%	6.67%	4.06%	17.47%	11	1

ELP-6	Anglesite	8.82%	33.35%	0.00%	4.86%	279	0
	AsMO	0.86%	0.33%	16.36%	1.58%	3	9
	CuM(SO,O)	2.77%	0.58%	0.00%	2.81%	5	0
	FeOOH	9.17%	0.92%	1.68%	4.94%	8	1
	Galena	4.08%	23.26%	0.00%	3.39%	195	0
	Paint	16.89%	4.00%	0.00%	6.42%	34	0
	PbAsO	1.66%	5.18%	34.91%	2.19%	43	20
	PbFeOOH	1.11%	0.95%	3.30%	1.79%	8	2
	PbM(Cl,SO,O)	2.27%	4.44%	5.67%	2.55%	37	3
	PbMSO4	6.75%	12.43%	26.17%	4.30%	104	15
	Phosphate	11.04%	13.36%	8.16%	5.37%	112	5
	Slag	27.97%	0.11%	0.13%	7.69%	1	Tr
	FeMSO4	6.60%	1.09%	3.61%	4.25%	9	2
ELP-5	Anglesite	1.99%	9.98%	0.00%	3.53%	39	0
	AsFeOOH	2.99%	0.73%	6.45%	4.31%	3	3
	AsMO	2.24%	1.13%	14.69%	3.74%	4	6
	Arsenopyrite	3.48%	0.00%	48.80%	4.64%	0	20
	Cerussite	0.25%	1.48%	0.00%	1.26%	6	0
	CuM(SO,O)	1.74%	0.49%	0.00%	3.31%	2	0
	FeOOH	41.79%	5.54%	2.63%	12.48%	22	1
	Galena	3.48%	26.32%	0.00%	4.64%	102	0
	PbAsO	2.74%	11.30%	19.73%	4.13%	44	8
	PbM(Cl,SO,O)	1.49%	3.87%	1.28%	3.07%	15	1
	Phosphate	24.13%	38.75%	6.13%	10.83%	150	2
	Slag	12.19%	0.06%	0.02%	8.28%	Tr	Tr
	FeMSO4	1.49%	0.33%	0.28%	3.07%	1	Tr
ELP-4	Clay	2.88%	0.63%	0.66%	2.95%	6	Tr
	FeOOH	9.63%	1.85%	1.71%	5.21%	17	1
	MnOOH	1.66%	2.10%	0.33%	2.26%	20	Tr
	Organic	7.75%	0.34%	0.01%	4.72%	3	Tr
	PbAsO	3.65%	21.88%	74.24%	3.32%	204	38
	PbFeOOH	0.72%	1.19%	2.08%	1.49%	11	1
	PbM(Cl,SO,O)	0.17%	0.62%	0.40%	0.72%	6	Tr
	PbSiO4	1.33%	6.72%	0.17%	2.02%	63	Tr
	Phosphate	27.50%	64.04%	19.69%	7.89%	597	10
	Slag	43.77%	0.32%	0.20%	8.77%	3	Tr
	FeMSO4	0.94%	0.30%	0.50%	1.71%	3	Tr

ELP-3	AsFeOOH	0.40%	0.43%	0.44%	2.09%	1	Tr
	Arsenopyrite	13.50%	0.00%	95.30%	11.32%	0	45
	FeOOH	23.93%	13.80%	0.76%	14.14%	30	Tr
	Galena	0.67%	21.97%	0.00%	2.70%	48	0
	MnOOH	2.81%	10.65%	0.10%	5.47%	23	Tr
	PbMSO4	0.27%	2.84%	0.18%	1.71%	6	Tr
	Phosphate	6.42%	44.81%	0.82%	8.12%	97	Tr
	Pyrite	11.10%	0.38%	1.70%	10.41%	1	1
	Slag	36.63%	0.80%	0.03%	15.96%	2	Tr
	Sulfosalts	0.40%	0.61%	0.31%	2.09%	1	Tr
	FeMSO4	3.88%	3.70%	0.37%	6.40%	8	Tr
ELP-22	AsFeOOH	0.58%	0.35%	4.59%	1.97%	1	1
	Arsenopyrite	1.16%	0.00%	59.50%	2.78%	0	19
	FeOOH	27.06%	8.88%	6.23%	11.53%	34	2
	MnOOH	1.63%	3.51%	0.42%	3.28%	13	Tr
	PbAsO	0.23%	2.37%	6.12%	1.25%	9	2
	Phosphate	20.67%	82.16%	19.19%	10.51%	313	6
	Pyrite	1.28%	0.03%	1.42%	2.92%	Tr	Tr
	SbMO	0.58%	0.50%	0.19%	1.97%	2	Tr
	Slag	43.79%	0.54%	0.26%	12.88%	2	Tr
	FeMSO4	3.02%	1.64%	2.07%	4.44%	6	1
ELP-21	Anglesite	0.44%	1.76%	0.00%	1.34%	14	0
	AsFeOOH	2.81%	0.55%	5.17%	3.34%	4	2
	AsMO	0.89%	0.35%	4.96%	1.90%	3	2
	Arsenopyrite	2.81%	0.00%	33.53%	3.34%	0	14
	FeOOH	20.12%	2.11%	1.08%	8.10%	17	Tr
	Galena	3.55%	21.22%	0.00%	3.74%	174	0
	Paint	6.36%	1.58%	0.00%	4.93%	13	0
	PbAsO	5.92%	19.33%	36.31%	4.77%	158	15
	PbFeOOH	1.18%	1.07%	1.03%	2.19%	9	Tr
	PbM(Cl,SO,O)	2.81%	5.77%	2.05%	3.34%	47	1
	PbMSO4	7.69%	14.85%	8.72%	5.39%	121	4
	PbSiO4	1.18%	3.27%	0.05%	2.19%	27	Tr
	Phosphate	19.38%	24.61%	4.19%	7.99%	201	2
	Pyrite	0.44%	0.00%	0.12%	1.34%	0	Tr
	SbMO	2.51%	0.69%	0.20%	3.17%	6	Tr
	Slag	5.62%	0.02%	0.01%	4.66%	Tr	Tr
	FeMSO4	16.27%	2.83%	2.60%	7.46%	23	1

ELP-20	Anglesite	0.82%	4.94%	0.00%	1.51%	57	0
	AsMO	5.60%	3.41%	59.09%	3.85%	40	26
	CuM(SO,O)	9.63%	3.24%	0.00%	4.94%	38	0
	FeOOH	32.05%	5.13%	3.24%	7.81%	60	1
	Galena	1.40%	12.77%	0.00%	1.97%	148	0
	Paint	11.97%	4.53%	0.00%	5.44%	53	0
	PbAsO	1.75%	8.72%	20.29%	2.20%	101	9
	PbM(Cl,SO,O)	4.32%	13.51%	5.96%	3.40%	157	3
	PbMSO4	0.58%	1.72%	1.25%	1.28%	20	1
	Phosphate	20.61%	39.90%	8.41%	6.77%	464	4
	SbMO	1.93%	0.81%	0.28%	2.30%	9	Tr
	Slag	4.50%	0.03%	0.01%	3.47%	Tr	Tr
	FeMSO4	4.85%	1.28%	1.46%	3.60%	15	1
ELP-19	Arsenopyrite	12.30%	0.00%	85.12%	9.60%	0	163
	FeOOH	12.94%	2.30%	0.40%	9.81%	12	1
	Galena	3.24%	32.78%	0.00%	5.17%	173	0
	PbFeOOH	6.47%	9.90%	3.27%	7.19%	52	6
	PbM(Cl,SO,O)	2.27%	7.88%	0.96%	4.35%	42	2
	PbMSO4	3.88%	12.71%	2.55%	5.64%	67	5
	Phosphate	12.30%	26.47%	1.54%	9.60%	140	3
	Pyrite	21.68%	0.23%	3.26%	12.04%	1	6
	SbMO	1.29%	0.61%	0.06%	3.30%	3	Tr
	Sulfosalts	0.97%	0.45%	0.73%	2.86%	2	1
	FeMSO4	22.65%	6.67%	2.10%	12.23%	35	4
ELP-18	Arsenopyrite	3.75%	0.00%	70.06%	4.45%	0	46
	CuM(SO,O)	0.26%	0.25%	0.00%	1.20%	2	0
	FeOOH	12.48%	5.75%	1.05%	7.74%	35	1
	Galena	0.07%	1.73%	0.00%	0.60%	10	0
	Paint	1.84%	2.01%	0.00%	3.15%	12	0
	PbAsO	1.45%	20.75%	13.91%	2.80%	125	9
	PbFeOOH	1.31%	5.21%	1.80%	2.67%	31	1
	PbM(Cl,SO,O)	0.85%	7.70%	0.98%	2.16%	46	1
	PbMSO4	5.58%	47.36%	9.93%	5.38%	286	7
	PbO	0.20%	7.04%	0.00%	1.04%	43	0
	Phosphate	0.07%	0.37%	0.02%	0.60%	2	Tr
	Pyrite	4.73%	0.13%	1.92%	4.97%	1	1
	Slag	66.16%	1.16%	0.15%	11.08%	7	Tr
	FeMSO4	0.72%	0.55%	0.18%	1.98%	3	Tr

ELP-17	AsFeOOH	0.09%	0.03%	0.71%	0.56%	Tr	Tr
	AsMO	0.27%	0.17%	6.44%	0.97%	2	3
	Barite	0.27%	0.08%	0.00%	0.97%	1	0
	Cerussite	0.18%	1.37%	0.00%	0.79%	13	0
	Cr	28.60%	6.24%	0.00%	8.33%	59	0
	CuM(SO,O)	0.09%	0.03%	0.00%	0.56%	0	0
	FeOOH	33.73%	5.59%	7.58%	8.72%	53	3
	Galena	0.09%	0.87%	0.00%	0.56%	8	0
	PbAsO	1.56%	8.04%	40.10%	2.28%	76	18
	PbAsVO	2.66%	13.61%	1.54%	2.97%	129	1
	PbFeOOH	1.19%	1.70%	4.35%	2.00%	16	2
	PbM(Cl,SO,O)	4.31%	13.97%	13.19%	3.74%	132	6
	PbMSO4	0.73%	2.24%	3.48%	1.57%	21	2
	Solder	0.18%	0.12%	0.00%	0.79%	1	Tr
	Phosphate	22.36%	44.88%	20.27%	7.68%	425	9
	SbMO	0.37%	0.16%	0.12%	1.11%	2	Tr
	FeMSO4	3.30%	0.91%	2.21%	3.29%	9	1
ELP-16	Anglesite	0.86%	4.05%	0.00%	1.61%	37	0
	AsFeOOH	7.26%	1.67%	12.99%	4.51%	15	14
	AsMO	2.34%	1.11%	12.70%	2.63%	10	14
	Arsenopyrite	1.48%	0.00%	17.13%	2.10%	0	19
	CuM(SO,O)	0.62%	0.16%	0.00%	1.36%	1	0
	FeOOH	23.74%	2.95%	1.24%	7.40%	27	1
	Galena	1.72%	12.20%	0.00%	2.26%	111	0
	MnOOH	0.62%	0.50%	0.04%	1.36%	5	Tr
	PbAsO	6.03%	23.34%	35.98%	4.14%	213	40
	PbAsVO	0.86%	3.31%	0.12%	1.61%	30	Tr
	PbFeOOH	4.31%	4.61%	3.65%	3.53%	42	4
	PbM(Cl,SO,O)	9.84%	23.94%	6.99%	5.18%	218	8
	PbMSO4	5.29%	12.10%	5.83%	3.89%	110	6
	Phosphate	4.80%	7.22%	1.01%	3.72%	66	1
	Pyrite	1.72%	0.01%	0.43%	2.26%	Tr	Tr
	SbMO	1.11%	0.36%	0.08%	1.82%	3	Tr
	Slag	15.87%	0.07%	0.02%	6.35%	1	Tr
	FeMSO4	11.56%	2.38%	1.80%	5.56%	22	2
ELP-15	AsFeOOH	1.75%	0.28%	6.50%	2.60%	2	2

	FeOOH	20.26%	1.73%	2.18%	7.96%	14	1
	Galena	8.61%	41.97%	0.00%	5.55%	337	0
	PbAsO	4.63%	12.32%	57.12%	4.16%	99	18
	PbFeOOH	4.15%	3.05%	7.27%	3.95%	25	2
	PbM(Cl,SO,O)	3.67%	6.14%	5.39%	3.72%	49	2
	PbMSO4	2.23%	3.51%	5.09%	2.93%	28	2
	PbO	0.32%	2.11%	0.00%	1.12%	17	0
	Phosphate	25.52%	26.42%	11.10%	8.63%	212	3
	SbMO	12.12%	0.11%	0.07%	1.37%	1	Tr
	Slag	0.48%	0.04%	0.03%	6.46%	Tr	Tr
	FeMSO4	16.27%	2.30%	5.24%	7.31%	18	2
ELP-14	Clay	2.43%	0.39%	0.30%	2.54%	4	Tr
	AsFeOOH	0.47%	0.12%	1.52%	1.13%	1	1
	AsMO	1.31%	0.69%	12.90%	1.88%	8	9
	CuM(SO,O)	0.28%	0.08%	0.00%	0.87%	1	0
	FeOOH	26.07%	3.63%	2.47%	7.25%	40	2
	MnOOH	16.45%	15.05%	1.76%	6.12%	168	1
	PbAsO	4.58%	19.84%	49.63%	3.45%	221	34
	PbFeOOH	0.93%	1.11%	1.43%	1.58%	12	1
	PbM(Cl,SO,O)	9.44%	25.68%	12.18%	4.83%	287	8
	PbMSO4	2.06%	5.26%	4.11%	2.34%	59	3
	Phosphate	14.39%	24.24%	5.49%	5.79%	270	4
	Slag	5.89%	0.03%	0.01%	3.89%	Tr	Tr
	Sulfosalts	1.87%	0.68%	4.28%	2.24%	8	3
	FeMSO4	13.83%	3.19%	3.91%	5.70%	36	3
ELP-13	Clay	0.09%	0.11%	0.14%	0.47%	1	Tr
	Anglesite	0.11%	4.58%	0.00%	0.52%	42	0
	AsMO	0.02%	0.07%	2.02%	0.20%	1	1
	CuM(SO,O)	0.30%	0.67%	0.00%	0.85%	6	0
	FeOOH	0.72%	0.78%	0.87%	1.33%	7	1
	Galena	0.21%	12.83%	0.00%	0.72%	117	0
	MnOOH	0.07%	0.51%	0.10%	0.42%	5	Tr
	PbAsO	0.02%	0.54%	2.22%	0.20%	5	1
	PbFeOOH	0.50%	4.62%	9.77%	1.10%	42	6
	PbM(Cl,SO,O)	0.17%	3.56%	2.77%	0.64%	32	2
	PbMSO4	2.74%	54.66%	70.31%	2.56%	498	46
	Phosphate	0.89%	11.64%	4.34%	1.47%	106	3
	Pyrite	0.06%	0.00%	0.33%	0.37%	Tr	Tr
	Slag	93.25%	3.82%	2.95%	3.94%	35	2
	Sulfosalts	0.04%	0.11%	1.17%	0.31%	1	1
	FeMSO4	0.83%	1.49%	3.01%	1.43%	14	2
ELP-12	Anglesite	0.93%	3.43%	0.00%	2.68%	13	0

	AsFeOOH	0.79%	0.14%	15.46%	2.49%	1	2
	AsMO	0.40%	0.15%	23.46%	1.76%	1	3
	FeOOH	8.21%	0.80%	4.65%	3.78%	3	1
	Galena	1.46%	8.13%	0.00%	7.69%	31	0
	MnOOH	2.78%	1.79%	1.78%	3.36%	7	Tr
	Paint	67.55%	37.24%	0.00%	4.60%	140	0
	PbAsO	0.26%	0.81%	17.19%	13.11%	3	2
	PbM(Cl,SO,O)	0.26%	0.51%	2.05%	1.44%	2	Tr
	PbMSO4	0.93%	1.67%	11.11%	1.44%	6	2
	Phosphate	7.42%	8.79%	16.95%	2.68%	33	2
	Slag	6.62%	0.02%	0.10%	7.34%	Tr	Tr
	Sulfosalts	0.53%	0.14%	7.26%	6.96%	1	1
	Brass	1.85%	0.00%	0.02%	2.03%	Tr	Tr
ELP-11	Clay	1.81%	0.31%	0.31%	2.25%	4	Tr
	Anglesite	0.50%	2.82%	0.00%	1.19%	32	0
	AsMO	1.71%	0.97%	23.41%	2.18%	11	15
	CuM(SO,O)	0.20%	0.06%	0.00%	0.76%	1	0
	FeOOH	40.96%	6.09%	5.39%	8.30%	70	3
	MnOOH	4.12%	4.03%	0.61%	3.35%	46	Tr
	Paint	6.22%	2.19%	0.00%	4.08%	25	0
	PbAsO	2.91%	13.49%	43.88%	2.84%	154	27
	PbFeOOH	1.31%	1.67%	2.79%	1.91%	19	2
	PbM(Cl,SO,O)	3.11%	9.06%	5.58%	2.93%	104	3
	Solder	1.41%	0.84%	0.02%	1.99%	10	Tr
	Phosphate	32.13%	57.86%	17.05%	7.88%	661	11
	Slag	1.20%	0.01%	0.00%	1.84%	Tr	Tr
	FeMSO4	2.41%	0.59%	0.95%	2.59%	7	1
ELP-10	AsFeOOH	0.41%	0.15%	1.92%	1.52%	1	1
	AsMO	1.22%	0.90%	17.50%	2.63%	8	10
	Arsenopyrite	0.20%	0.00%	6.23%	1.08%	0	3
	CuM(SO,O)	0.51%	0.21%	0.00%	1.70%	2	0
	FeOOH	27.26%	5.30%	3.75%	10.66%	45	2
	Galena	0.31%	3.38%	0.00%	1.32%	29	0
	Paint	23.60%	10.86%	0.00%	10.17%	93	0
	PbAsO	2.03%	12.31%	32.04%	3.38%	105	18
	PbFeOOH	5.19%	8.68%	11.60%	5.31%	74	6
	PbM(Cl,SO,O)	7.02%	26.67%	13.16%	6.12%	228	7
	PbMSO4	0.81%	2.91%	2.37%	2.15%	25	1
	InMS	0.20%	0.01%	0.00%	1.08%	Tr	Tr
	Phosphate	10.68%	25.12%	5.92%	7.40%	215	3
	Pyrite	0.81%	0.01%	0.54%	2.15%	Tr	Tr
	Slag	9.16%	0.07%	0.03%	6.91%	1	Tr
	Sulfosalts	0.20%	0.10%	0.68%	1.08%	1	Tr

	FeMSO4	10.38%	3.34%	4.26%	7.30%	28	2
ELP-1	AsCaO	7.09%	0.52%	41.35%	4.39%	5	27
	AsMO	3.72%	1.96%	23.37%	3.24%	20	15
	FeOOH	27.37%	3.79%	1.65%	2.26%	38	1
	Galena	1.77%	13.98%	0.00%	7.64%	141	0
	MnOOH	1.42%	1.29%	0.10%	2.26%	13	Tr
	Paint	4.43%	1.45%	0.00%	2.02%	15	0
	PbAsO	3.10%	13.37%	21.41%	3.52%	135	14
	PbM(Cl,SO,O)	1.77%	4.80%	1.46%	2.97%	48	1
	PbMSO4	1.77%	4.52%	2.26%	2.26%	45	1
	PbSiO4	0.18%	0.65%	0.01%	2.26%	7	Tr
	Phosphate	31.09%	52.14%	7.56%	0.72%	525	5
	SbMO	1.68%	0.61%	0.15%	7.93%	6	Tr
	Slag	9.03%	0.05%	0.01%	2.20%	Tr	Tr
	FeMSO4	3.81%	0.87%	0.69%	4.91%	9	Tr
	Cerussite	1.77%	9.93%	0.00%	3.28%	100	0
ELP-2	Anglesite	1.57%	10.12%	0.00%	2.30%	39	0
	AsFeOOH	1.12%	0.35%	2.43%	1.95%	1	1
	AsMO	1.57%	1.02%	10.33%	2.30%	4	5
	Arsenopyrite	4.26%	0.00%	59.91%	3.74%	0	29
	Cerussite	0.22%	1.72%	0.00%	0.88%	7	0
	FeOOH	12.91%	2.20%	0.81%	6.21%	9	Tr
	Galena	3.14%	30.50%	0.00%	3.23%	118	0
	PbAsO	2.24%	11.91%	16.22%	2.74%	46	8
	PbFeOOH	0.11%	0.16%	0.12%	0.62%	1	Tr
	PbM(Cl,SO,O)	2.58%	8.60%	2.22%	2.94%	33	1
	PbMSO4	2.81%	8.79%	3.74%	3.06%	34	2
	Phosphate	11.00%	22.68%	2.80%	5.79%	88	1
	Pyrite	0.79%	0.01%	0.24%	1.64%	Tr	Tr
	Slag	49.94%	0.32%	0.08%	9.26%	1	Tr
	FeMSO4	5.72%	1.61%	1.08%	4.30%	6	1
ELP-30	Arsenopyrite	1.10%	0.00%	61.62%	1.93%	0	9
	Cerussite	4.69%	39.67%	0.00%	3.92%	44	0
	CuM(SO,O)	0.10%	0.04%	0.00%	0.57%	Tr	0
	FeOOH	25.48%	4.79%	6.40%	8.07%	5	1
	Galena	0.57%	6.16%	0.00%	1.40%	7	0
	Paint	30.41%	13.55%	0.00%	8.52%	15	0
	PbAsO	0.24%	1.40%	6.89%	0.91%	2	1
	Pyrite/Chalcopyrite	0.67%	0.00%	0.82%	1.51%	Tr	Tr
	PbFeOOH	0.48%	0.78%	1.96%	1.28%	1	Tr
	PbM(Cl,SO,O)	3.21%	11.81%	10.99%	3.26%	13	2

	PbMSO4	0.14%	0.50%	0.76%	0.70%	1	Tr
	Pb	0.14%	2.70%	0.00%	0.70%	3	0
	PbSiO4	0.05%	0.24%	0.01%	0.41%	0	Tr
	Solder	0.91%	0.69%	0.02%	1.76%	1	Tr
	Phosphate	7.09%	16.14%	7.18%	4.75%	18	1
	SbMO	0.14%	0.07%	0.05%	0.70%	Tr	Tr
	Slag	20.35%	0.15%	0.13%	7.46%	Tr	Tr
	FeMSO4	4.21%	1.31%	3.16%	3.72%	1	Tr
ELP-31	AsMO	6.95%	5.74%	55.74%	6.38%	18	6
	Barite	1.74%	0.66%	0.00%	3.28%	2	0
	Cerussite	0.77%	7.53%	0.00%	2.20%	24	0
	FeOOH	41.12%	8.93%	3.16%	12.35%	29	Tr
	Galena	0.58%	7.16%	0.00%	1.90%	23	0
	MnOOH	1.93%	2.76%	0.17%	3.45%	9	Tr
	Paint	2.70%	1.39%	0.00%	4.07%	4	0
	PbAsO	3.47%	23.49%	30.62%	4.60%	75	3
	PbM(Cl,SO,O)	6.56%	27.86%	6.88%	6.21%	89	1
	Solder	2.32%	2.03%	0.02%	3.78%	6	Tr
	Phosphate	3.28%	8.62%	1.02%	4.47%	28	Tr
	Slag	18.34%	0.15%	0.04%	9.71%	Tr	Tr
	FeMSO4	10.23%	3.68%	2.35%	7.61%	12	Tr
ELP-32	Anglesite	1.85%	11.69%	0.00%	4.13%	13	0
	AsFeOOH	2.96%	0.92%	2.47%	5.19%	1	Tr
	AsMO	10.00%	6.36%	25.35%	9.18%	7	2
	Arsenopyrite	11.48%	0.00%	62.18%	9.76%	0	5
	Cerussite	5.93%	44.48%	0.00%	7.23%	48	0
	FeOOH	13.70%	2.29%	0.33%	10.53%	2	Tr
	PbAsO	2.96%	15.42%	8.26%	5.19%	16	1
	PbM(Cl,SO,O)	1.48%	4.84%	0.49%	3.70%	5	Tr
	Brass	2.96%	0.01%	0.00%	5.19%	Tr	Tr
	Phosphate	6.30%	12.73%	0.62%	7.44%	14	Tr
	Slag	36.67%	0.23%	0.02%	14.75%	Tr	Tr
	FeMSO4	3.70%	1.02%	0.27%	5.78%	1	Tr
ELP-33	AsMO	0.37%	0.23%	22.74%	1.21%	4	3
	Barite	1.10%	0.32%	0.00%	2.09%	6	0
	Cerussite	7.08%	53.15%	0.00%	5.13%	949	0
	FeOOH	42.59%	7.11%	25.25%	9.89%	127	3
	MnOOH	4.23%	4.65%	2.83%	4.03%	83	Tr
	PbM(Cl,SO,O)	0.46%	1.50%	3.72%	1.35%	27	Tr
	Solder	1.66%	1.12%	0.10%	2.55%	20	Tr
	Phosphate	14.72%	29.76%	35.19%	7.09%	531	5

	Pyrite/Chalcopyrite	1.10%	0.00%	3.17%	2.09%	Tr	Tr
	SbMO	3.22%	1.42%	2.77%	3.53%	25	Tr
	Slag	21.25%	0.13%	0.33%	8.18%	2	Tr
	FeMSO4	2.21%	0.61%	3.91%	2.94%	11	1
TM	Brass	7.14%	0.02%	0.00%	5.15%	Tr	Tr
	PbAsO	21.43%	55.45%	85.98%	8.21%	26	3
	PbM(Cl,SO,O)	21.43%	34.83%	10.23%	8.21%	16	Tr
	Solder	14.29%	4.79%	0.05%	7.00%	2	Tr
	FeMSO4	35.71%	4.91%	3.73%	9.59%	2	Tr
Z-1	Arsenopyrite	9.72%	0.00%	97.75%	8.05%	0	38
	Brass	1.54%	0.07%	0.00%	3.35%	Tr	Tr
	CuM(SO,O)	0.62%	2.32%	0.00%	2.13%	1	0
	Galena	0.62%	62.91%	0.00%	2.13%	33	0
	MnOOH	1.23%	14.53%	0.06%	3.00%	8	Tr
	Pyrite/Chalcopyrite	6.48%	0.02%	1.42%	6.69%	Tr	1
	Slag	74.69%	5.06%	0.09%	11.82%	3	Tr
	FeMSO4	5.09%	15.08%	0.69%	5.98%	8	Tr
ELP-16-Dup	Anglesite	0.49%	2.50%	0.00%	1.25%	23	0
	AsFeOOH	6.27%	1.56%	12.29%	4.34%	14	14
	AsMO	1.35%	0.69%	8.05%	2.07%	6	9
	Arsenopyrite	1.47%	0.00%	18.75%	2.16%	0	21
	FeOOH	27.27%	3.68%	1.56%	7.97%	34	2
	Galena	1.47%	11.32%	0.00%	2.16%	103	0
	MnOOH	0.61%	0.54%	0.04%	1.40%	5	0
	PbAsO	6.02%	25.27%	39.40%	4.26%	230	43
	PbFeOOH	2.33%	2.71%	2.17%	2.70%	25	2
	PbM(Cl,SO,O)	9.09%	23.96%	7.08%	5.14%	219	8
	PbMSO4	5.90%	14.62%	7.13%	4.21%	133	8
	Solder	0.61%	0.33%	0.00%	1.40%	3	0
	Phosphate	6.02%	9.82%	1.39%	4.26%	90	2
	SbMO	0.49%	0.17%	0.04%	1.25%	2	0
	Slag	18.43%	0.09%	0.03%	6.94%	1	0
	FeMSO4	12.16%	2.71%	2.07%	5.85%	25	2
ELP-30-Dup	Arsenopyrite	0.73%	0.00%	44.22%	1.66%	0	6
	Cerussite	4.67%	40.69%	0.00%	4.11%	166	0
	FeOOH	29.73%	5.77%	8.06%	8.91%	23	1
	Paint	16.67%	7.66%	0.00%	7.27%	31	0
	PbAsO	0.33%	2.01%	10.34%	1.12%	8	1
	Pyrite/Chalcopyrite	0.87%	0.00%	1.14%	1.81%	0	0
	PbFeOOH	1.13%	1.89%	4.99%	2.06%	8	1
	PbM(Cl,SO,O)	4.47%	16.95%	16.49%	4.03%	69	2
	PbSiO4	0.33%	1.70%	0.07%	1.12%	7	0

Solder	0.33%	0.26%	0.01%	1.12%	1	0
Phosphate	8.93%	20.99%	9.76%	5.56%	85	1
Slag	25.93%	0.19%	0.18%	8.55%	1	0
FeMSO4	5.87%	1.88%	4.74%	4.58%	8	1

*E-95%= Estamated counting error at 95% confidence, Mossiman, 1965.

Fig 4

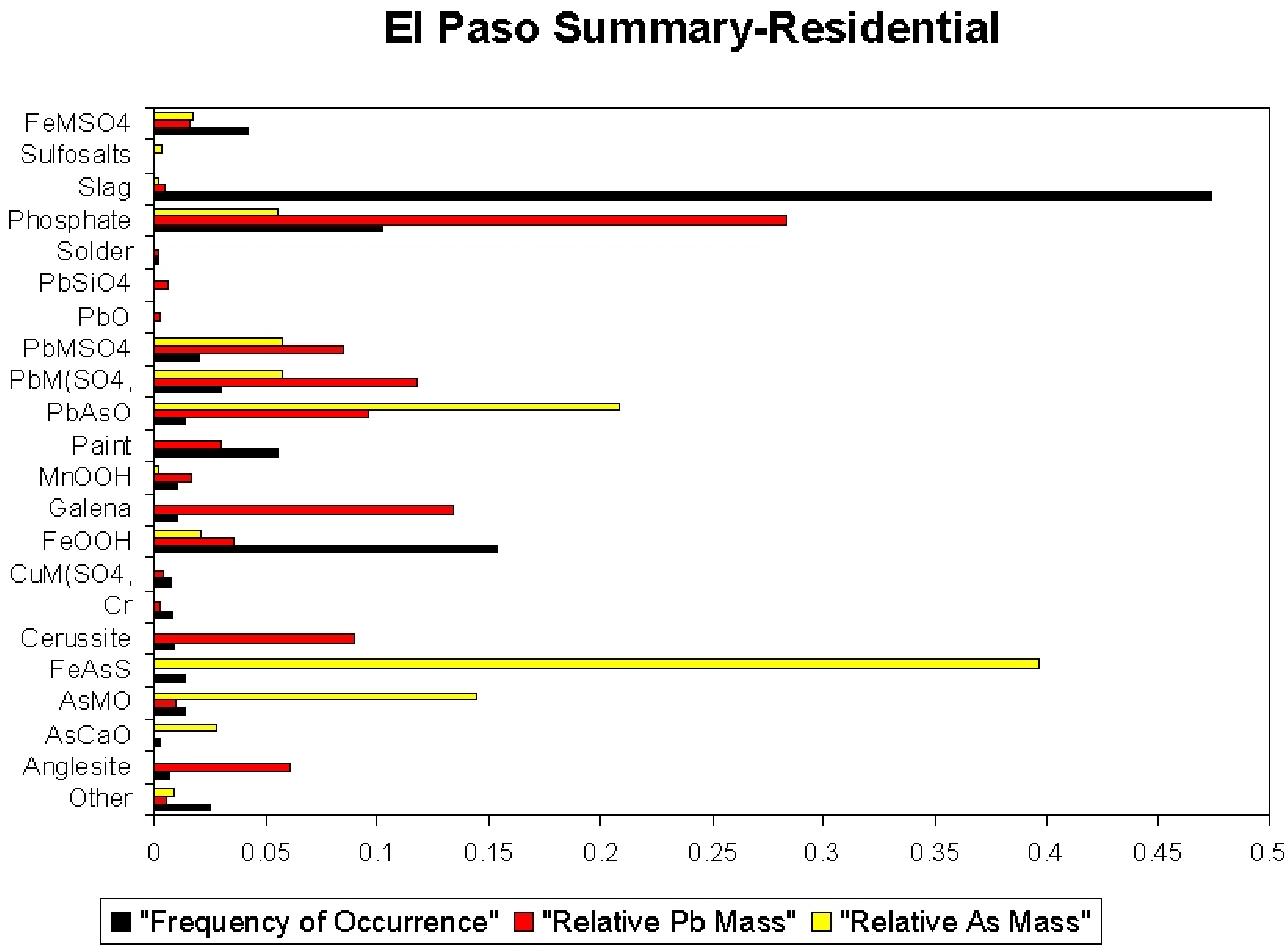
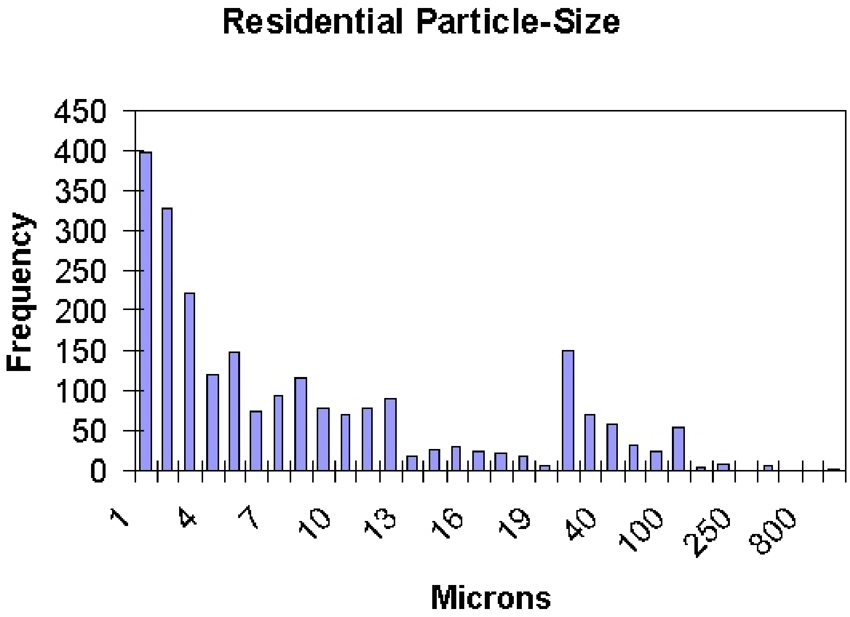

El Paso Summary-Residential
FeMSO4
Sulfosalts
Slag
Phosphate
Solder
PbSiO4
PbO
PbMSO4
PbM(SO4,
PbAsO
Paint
MnOOH
Galena
FeOOH
CuM(SO4,
Cr
Cerussite
FeAsS
AsMO
AsCaO
Anglesite
Other
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
"Frequency of Occurrence"
"Relative Pb Mass"
"Relative As Mass"

Fig5



Residential Particle-Size

Statistical Study–Correlation Analysis

A matrix was constructed using twenty-six variables and 26 cases (soil samples) and twenty-six variables and 6 cases (plant samples) to conduct a correlation analysis using *STATISTICA*. The variables included data from the El Paso speciation study (Min_{Pb}), and bulk metals concentrations. Based on these data a correlation matrix was computed for each group.

Correlations within the residential samples can be used for apportionment calculations. These correlations are often valuable in assigning source(s) to "non-specific" phases and phases that can be common to multiple sources. However, one must remember that a correlation does not necessarily indicate an association! Other statistical techniques can be applied to the data and may offer further insight. The most significant correlations between variable pairs have been marked in **bold** in Tables 5- 6. Many of these correlations support the categories established later in Chapter 6.

For plant soils, correlation coefficients suggest; 1) bulk lead and arsenic concentrations at the plant are dominated by emission products and 2) all of the pyrometalurgical phases (except slag) proposed in Chapter 6 show a strong correlation and 3) all concentrate phases (except anglesite) proposed in Chapter 6 show a strong correlation.

For community soils a number of observations that one can make from the data, which may be important to this study, are; 1) that bulk lead and arsenic do not correlate highly ($r > 0.80$, $p < 0.05$) with any particular phase 2) bulk cadmium however does correlate well with all emission products 3) concentrate phases, other than pyrite and sulfosalts are poorly correlated to other factors 4) the total lack of a correlation between paint and any other phase, particularly anglesite, cerussite or lead oxide, or bulk metal concentration 5) “solder” may be miss-identified as an anthropogenic phase, and may be a by product from the facility and 6) most (9 out of 12) of the proposed pyrometalurgical phases show good inter-phase correlation.

Table 5. Correlation matrix of Factor Analysis

TABLE 5. Plant speciation correlations.

Marked correlations are significant at $p < .05000$

	Anglesite	AsFeOOH	AsMO	AsMSO4	BiMO	Cerussite	CrMO	Cu	CuMO	CuMSO4	FeOOH	Galena	MnOOH	PbAsO	PbVAsO	PbFeOOH	PbMO	PbMSO4	PbO	PbSiO4	Phos	Slag	SS	FeMSO4	Bulk Pb	Bulk As
Anglesite	1.00	0.10	0.04	0.67	-0.39	-0.41	0.67	-0.33	-0.41	0.67	0.16	-0.46	0.26	0.12	0.67	0.23	-0.10	0.67	-0.38	-0.11	-0.47	-0.25	-0.34	0.23	0.65	0.60
AsFeOOH	0.10	1.00	**0.84**	-0.24	-0.24	-0.23	-0.24	-0.27	-0.21	-0.24	**0.88**	-0.37	**0.89**	**0.91**	-0.24	**0.87**	0.61	-0.22	0.15	0.59	0.32	-0.31	0.16	**0.90**	-0.19	-0.27
AsMO	0.04	**0.84**	1.00	-0.30	-0.32	-0.30	-0.30	-0.33	-0.28	-0.30	**0.96**	-0.42	**0.85**	**0.98**	-0.30	**0.90**	0.61	-0.29	0.22	0.53	0.03	-0.38	-0.04	**0.89**	-0.26	-0.35
AsMSO4	0.67	-0.24	-0.30	1.00	-0.13	-0.17	**1.00**	-0.06	-0.19	**1.00**	-0.24	-0.27	-0.17	-0.23	**1.00**	-0.19	-0.31	**1.00**	-0.42	-0.29	-0.27	-0.18	-0.17	-0.20	**0.98**	**0.98**
BiMO	-0.39	-0.24	-0.32	-0.13	1.00	**1.00**	-0.13	**1.00**	**1.00**	-0.13	-0.26	**0.95**	-0.19	-0.24	-0.13	-0.22	0.47	-0.08	**0.81**	0.55	0.32	-0.26	**0.86**	-0.22	0.04	0.07
Cerussite	-0.41	-0.23	-0.30	-0.17	**1.00**	1.00	-0.17	**0.99**	**1.00**	-0.17	-0.24	**0.96**	-0.17	-0.23	-0.17	-0.20	0.49	-0.12	**0.83**	0.57	0.30	-0.24	**0.86**	-0.20	0.00	0.03
CrMO	0.67	-0.24	-0.30	**1.00**	-0.13	-0.17	1.00	-0.06	-0.19	**1.00**	-0.24	-0.27	-0.17	-0.23	**1.00**	-0.19	-0.31	**1.00**	-0.42	-0.29	-0.27	-0.18	-0.17	-0.20	**0.98**	**0.98**
Cu	-0.33	-0.27	-0.33	-0.06	**1.00**	**0.99**	-0.06	1.00	**0.99**	-0.06	-0.27	**0.95**	-0.19	-0.25	-0.06	-0.22	0.46	-0.01	**0.80**	0.55	0.26	-0.26	**0.86**	-0.22	0.11	0.14
CuMO	-0.41	-0.21	-0.28	-0.19	**1.00**	**1.00**	-0.19	**0.99**	1.00	-0.19	-0.22	**0.96**	-0.15	-0.21	-0.19	-0.18	0.50	-0.14	**0.84**	0.59	0.31	-0.24	**0.87**	-0.18	-0.02	0.01
CuMSO4	0.67	-0.24	-0.30	**1.00**	-0.13	-0.17	**1.00**	-0.06	-0.19	1.00	-0.24	-0.27	-0.17	-0.23	**1.00**	-0.19	-0.31	**1.00**	-0.42	-0.29	-0.27	-0.18	-0.17	-0.20	**0.98**	**0.98**
FeOOH	0.16	**0.88**	**0.96**	-0.24	-0.26	-0.24	-0.24	-0.27	-0.22	-0.24	1.00	-0.36	**0.95**	**0.99**	-0.24	**0.99**	0.71	-0.22	0.29	0.64	-0.07	-0.31	0.09	**0.98**	-0.17	-0.27
Galena	-0.46	-0.37	-0.42	-0.27	**0.95**	**0.96**	-0.27	**0.95**	**0.96**	-0.27	-0.36	1.00	-0.27	-0.37	-0.27	-0.30	0.38	-0.23	0.79	0.45	0.17	-0.01	**0.81**	-0.30	-0.11	-0.08
MnOOH	0.26	**0.89**	**0.85**	-0.17	-0.19	-0.17	-0.17	-0.19	-0.15	-0.17	**0.95**	-0.27	1.00	**0.92**	-0.17	**0.99**	0.77	-0.14	0.32	0.71	-0.09	-0.21	0.23	**1.00**	-0.08	-0.18
PbAsO	0.12	**0.91**	**0.98**	-0.23	-0.24	-0.23	-0.23	-0.25	-0.21	-0.23	**0.99**	-0.37	**0.92**	1.00	-0.23	**0.95**	0.70	-0.21	0.27	0.63	0.08	-0.41	0.09	**0.95**	-0.17	-0.26
PbVAsO	0.67	-0.24	-0.30	**1.00**	-0.13	-0.17	**1.00**	-0.06	-0.19	**1.00**	-0.24	-0.27	-0.17	-0.23	1.00	-0.19	-0.31	**1.00**	-0.42	-0.29	-0.27	-0.18	-0.17	-0.20	**0.98**	**0.98**
PbFeOOH	0.23	**0.87**	**0.90**	-0.19	-0.22	-0.20	-0.19	-0.22	-0.18	-0.19	**0.99**	-0.30	**0.99**	**0.95**	-0.19	1.00	0.76	-0.17	0.33	0.69	-0.13	-0.25	0.17	**1.00**	-0.11	-0.22
PbMO	-0.10	0.61	0.61	-0.31	0.47	0.49	-0.31	0.46	0.50	-0.31	0.71	0.38	0.77	0.70	-0.31	0.76	1.00	-0.25	**0.85**	**0.99**	0.08	-0.35	0.73	0.75	-0.12	-0.19
PbMSO4	0.67	-0.22	-0.29	**1.00**	-0.08	-0.12	**1.00**	-0.01	-0.14	**1.00**	-0.22	-0.23	-0.14	-0.21	**1.00**	-0.17	-0.25	1.00	-0.37	-0.23	-0.26	-0.21	-0.12	-0.17	**0.99**	**0.99**
PbO	-0.38	0.15	0.22	-0.42	**0.81**	**0.83**	-0.42	**0.80**	**0.84**	-0.42	0.29	0.79	0.32	0.27	-0.42	0.33	**0.85**	-0.37	1.00	**0.86**	0.11	-0.26	**0.85**	0.31	-0.23	-0.25
PbSiO4	-0.11	0.59	0.53	-0.29	0.55	0.57	-0.29	0.55	0.59	-0.29	0.64	0.45	0.71	0.63	-0.29	0.69	**0.99**	-0.23	**0.86**	1.00	0.18	-0.38	**0.80**	0.69	-0.09	-0.16
Phos	-0.47	0.32	0.03	-0.27	0.32	0.30	-0.27	0.26	0.31	-0.27	-0.07	0.17	-0.09	0.08	-0.27	-0.13	0.08	-0.26	0.11	0.18	1.00	-0.37	0.31	-0.08	-0.25	-0.22
Slag	-0.25	-0.31	-0.38	-0.18	-0.26	-0.24	-0.18	-0.26	-0.24	-0.18	-0.31	-0.01	-0.21	-0.41	-0.18	-0.25	-0.35	-0.21	-0.26	-0.38	-0.37	1.00	-0.12	-0.24	-0.26	-0.24
SS	-0.34	0.16	-0.04	-0.17	**0.86**	**0.86**	-0.17	**0.86**	**0.87**	-0.17	0.09	**0.81**	0.23	0.09	-0.17	0.17	0.73	-0.12	**0.85**	**0.80**	0.31	-0.12	1.00	0.19	0.02	0.01
FeMSO4	0.23	**0.90**	**0.89**	-0.20	-0.22	-0.20	-0.20	-0.22	-0.18	-0.20	**0.98**	-0.30	**1.00**	**0.95**	-0.20	**1.00**	0.75	-0.17	0.31	0.69	-0.08	-0.24	0.19	1.00	-0.11	-0.22
Bulk Pb	0.65	-0.19	-0.26	**0.98**	0.04	0.00	**0.98**	0.11	-0.02	**0.98**	-0.17	-0.11	-0.08	-0.17	**0.98**	-0.11	-0.12	**0.99**	-0.23	-0.09	-0.25	-0.26	0.02	-0.11	1.00	**0.99**
Bulk As	0.60	-0.27	-0.35	**0.98**	0.07	0.03	**0.98**	0.14	0.01	**0.98**	-0.27	-0.08	-0.18	-0.26	**0.98**	-0.22	-0.19	**0.99**	-0.25	-0.16	-0.22	-0.24	0.01	-0.22	**0.99**	1.00

Table 6

TABLE 6. Correlation matrix for Residential Soils

Marked correlations are significant at p < .05000

	Anglesite	AsFeOOH	AsMO	Arsenopyrite	Cerussite	CuMO	FeOOH	Galena	MnOOH	Paint	PbAsO	PbFeOOH	PbMO	PbMSO4	PbO	PbSiO4	Solder	Phosphate	Pyrite	SbMO	Slag	Sulfosalt	FeMSO4	Bulk Pb	Bulk As	Bulk Cd
Anglesite	1.00	0.26	0.29	-0.01	0.12	0.32	0.04	0.31	0.02	0.23	-0.05	0.07	-0.05	0.01	0.19	0.16	0.27	-0.15	0.26	0.25	0.21	0.25	0.17	-0.03	0.02	0.37
AsFeOOH	0.26	1.00	**0.90**	0.42	0.67	**0.92**	0.60	0.06	0.44	0.42	0.12	0.67	0.12	0.06	**0.89**	**0.81**	**0.98**	-0.17	**0.99**	**0.99**	**0.92**	**0.98**	**0.88**	-0.35	0.25	**0.91**
AsMO	0.29	**0.90**	1.00	0.30	0.73	**0.97**	0.72	0.09	0.45	0.49	0.19	0.57	0.20	-0.02	**0.80**	0.72	**0.94**	0.05	**0.91**	**0.91**	**0.84**	**0.91**	**0.82**	-0.14	0.20	**0.93**
Arsenopyrite	-0.01	0.42	0.30	1.00	0.21	0.35	0.07	0.16	0.07	-0.01	-0.28	0.48	-0.20	0.01	0.44	0.29	0.41	-0.38	0.44	0.44	0.37	0.44	0.49	-0.53	0.77	0.24
Cerussite	0.12	0.67	0.73	0.21	1.00	0.62	0.50	0.12	0.30	0.28	0.14	0.35	-0.01	-0.02	0.60	0.58	0.68	0.15	0.69	0.72	0.63	0.68	0.56	-0.08	0.20	0.69
CuMO	0.32	**0.92**	**0.97**	0.35	0.62	1.00	0.66	0.10	0.40	0.49	0.07	0.59	0.13	0.06	**0.84**	0.75	**0.96**	-0.06	**0.93**	**0.92**	**0.89**	**0.93**	**0.82**	-0.24	0.19	**0.92**
FeOOH	0.04	0.60	0.72	0.07	0.50	0.66	1.00	-0.26	0.46	0.32	0.36	0.44	0.53	-0.11	0.56	0.44	0.67	0.45	0.61	0.62	0.52	0.62	0.60	0.22	0.19	0.72
Galena	0.31	0.06	0.09	0.16	0.12	0.10	-0.26	1.00	-0.27	-0.09	-0.06	0.09	-0.17	0.08	0.06	-0.03	0.03	-0.20	0.04	0.06	0.04	0.02	0.14	0.05	0.13	0.14
MnOOH	0.02	0.44	0.45	0.07	0.30	0.40	0.46	-0.27	1.00	0.11	0.44	0.26	0.44	-0.06	0.37	0.38	0.46	0.13	0.46	0.44	0.41	0.52	0.56	0.07	0.11	0.44
Paint	0.23	0.42	0.49	-0.01	0.28	0.49	0.32	-0.09	0.11	1.00	-0.06	0.38	0.13	-0.12	0.38	0.30	0.46	-0.11	0.44	0.43	0.38	0.44	0.36	-0.05	-0.13	0.45
PbAsO	-0.05	0.12	0.19	-0.28	0.14	0.07	0.36	-0.06	0.44	-0.06	1.00	0.19	0.55	-0.05	0.11	0.30	0.08	0.45	0.05	0.07	-0.01	0.07	0.20	0.60	0.09	0.25
PbFeOOH	0.07	0.67	0.57	0.48	0.35	0.59	0.44	0.09	0.26	0.38	0.19	1.00	0.31	0.31	0.66	0.50	0.65	-0.19	0.66	0.66	0.69	0.66	0.78	0.01	0.55	0.68
PbMO	-0.05	0.12	0.20	-0.20	-0.01	0.13	0.53	-0.17	0.44	0.13	0.55	0.31	1.00	0.00	0.01	-0.07	0.08	0.22	0.05	0.07	0.01	0.10	0.37	0.56	0.16	0.28
PbMSO4	0.01	0.06	-0.02	0.01	-0.02	0.06	-0.11	0.08	-0.06	-0.12	-0.05	0.31	0.00	1.00	0.20	-0.01	0.03	-0.32	0.05	0.06	0.35	0.06	0.10	0.14	0.29	0.10
PbO	0.19	**0.89**	**0.80**	0.44	0.60	**0.84**	0.56	0.06	0.37	0.38	0.11	0.66	0.01	0.20	1.00	0.73	**0.90**	-0.23	**0.91**	**0.90**	**0.87**	**0.90**	0.76	-0.36	0.27	**0.81**
PbSiO4	0.16	**0.81**	0.72	0.29	0.58	0.75	0.44	-0.03	0.38	0.30	0.30	0.50	-0.07	-0.01	0.73	1.00	**0.81**	0.12	**0.82**	**0.83**	0.77	**0.81**	0.68	-0.16	0.17	0.79
Solder	0.27	**0.98**	**0.94**	0.41	0.68	**0.96**	0.67	0.03	0.46	0.46	0.08	0.65	0.08	0.03	**0.90**	**0.81**	1.00	-0.07	**0.99**	**0.99**	**0.93**	**0.99**	**0.86**	-0.31	0.22	**0.93**
Phosphate	-0.15	-0.17	0.05	-0.38	0.15	-0.06	0.45	-0.20	0.13	-0.11	0.45	-0.19	0.22	-0.32	-0.23	0.12	-0.07	1.00	-0.15	-0.12	-0.19	-0.14	-0.13	0.66	-0.09	0.09
Pyrite	0.26	**0.99**	**0.91**	0.44	0.69	**0.93**	0.61	0.04	0.46	0.44	0.05	0.66	0.05	0.05	**0.91**	**0.82**	**0.99**	-0.15	**1.00**	**1.00**	**0.94**	**1.00**	**0.87**	-0.36	0.24	**0.91**
SbMO	0.25	**0.99**	**0.91**	0.44	0.72	**0.92**	0.62	0.06	0.44	0.43	0.07	0.66	0.07	0.06	**0.90**	**0.83**	**0.99**	-0.12	1.00	1.00	**0.93**	**0.99**	**0.88**	-0.34	0.26	**0.92**
Slag	0.21	**0.92**	**0.84**	0.37	0.63	**0.89**	0.52	0.04	0.41	0.38	-0.01	0.69	0.01	0.35	**0.87**	0.77	**0.93**	-0.19	**0.94**	**0.93**	1.00	**0.94**	**0.81**	-0.29	0.26	**0.88**
Sulfo	0.25	**0.98**	**0.91**	0.44	0.68	**0.93**	0.62	0.02	0.52	0.44	0.07	0.66	0.10	0.06	**0.90**	**0.81**	**0.99**	-0.14	**1.00**	**0.99**	**0.94**	1.00	**0.89**	-0.34	0.25	**0.92**

salt																										
FeM SO4	0.17	**0.88**	**0.82**	0.49	0.56	**0.82**	0.60	0.14	0.56	0.36	0.20	0.78	0.37	0.10	0.76	0.68	**0.86**	-0.13	**0.87**	**0.88**	**0.81**	**0.89**	1.00	-0.12	0.43	**0.87**
Bulk Pb	-0.03	-0.35	-0.14	-0.53	-0.08	-0.24	0.22	0.05	0.07	-0.05	0.60	0.01	0.56	0.14	-0.36	-0.16	-0.31	0.66	-0.36	-0.34	-0.29	-0.34	-0.12	1.00	0.03	0.01
Bulk As	0.02	0.25	0.20	0.77	0.20	0.19	0.19	0.13	0.11	-0.13	0.09	0.55	0.16	0.29	0.27	0.17	0.22	-0.09	0.24	0.26	0.26	0.25	0.43	0.03	1.00	0.25
Bulk Cd	0.37	**0.91**	**0.93**	0.24	0.69	**0.92**	0.72	0.14	0.44	0.45	0.25	0.68	0.28	0.10	**0.81**	0.79	**0.93**	0.09	**0.91**	**0.92**	**0.88**	**0.92**	**0.87**	0.01	0.25	1.00

5.0 LEAD ISOTOPIC CHARACTERIZATION

As anticipated, the community soils in the El Paso area have a considerable fraction of their bulk lead associated with the soil forming phases (phosphates, MnOOH and FeOOH). These phase are “non-source specific” in there lead concentration, and represent a mixture of all soluble lead forms historically associated with the soil. Therefore, a new methodology, using ICP/MS/LA to determine lead isotopic values for a single soil particle was conducted in order to provide insight into lead sources for these important and often abundant lead forms.

Both bulk and single particle isotopic lead values were determined on a VARIAN Ultramass inductive coupled plasma mass spectrometer (ICPMS) equipped with a CETAC LS200 laser ablation unit. Bulk samples were prepared following USEPA 3050/6010 while single particles were analyzed from identified lead particles in EMPA pucks. A complete SOP for ICP/MS/LA is provided in the Appendix. Both sample sets were standardized using NIST 982 and/or 3128.

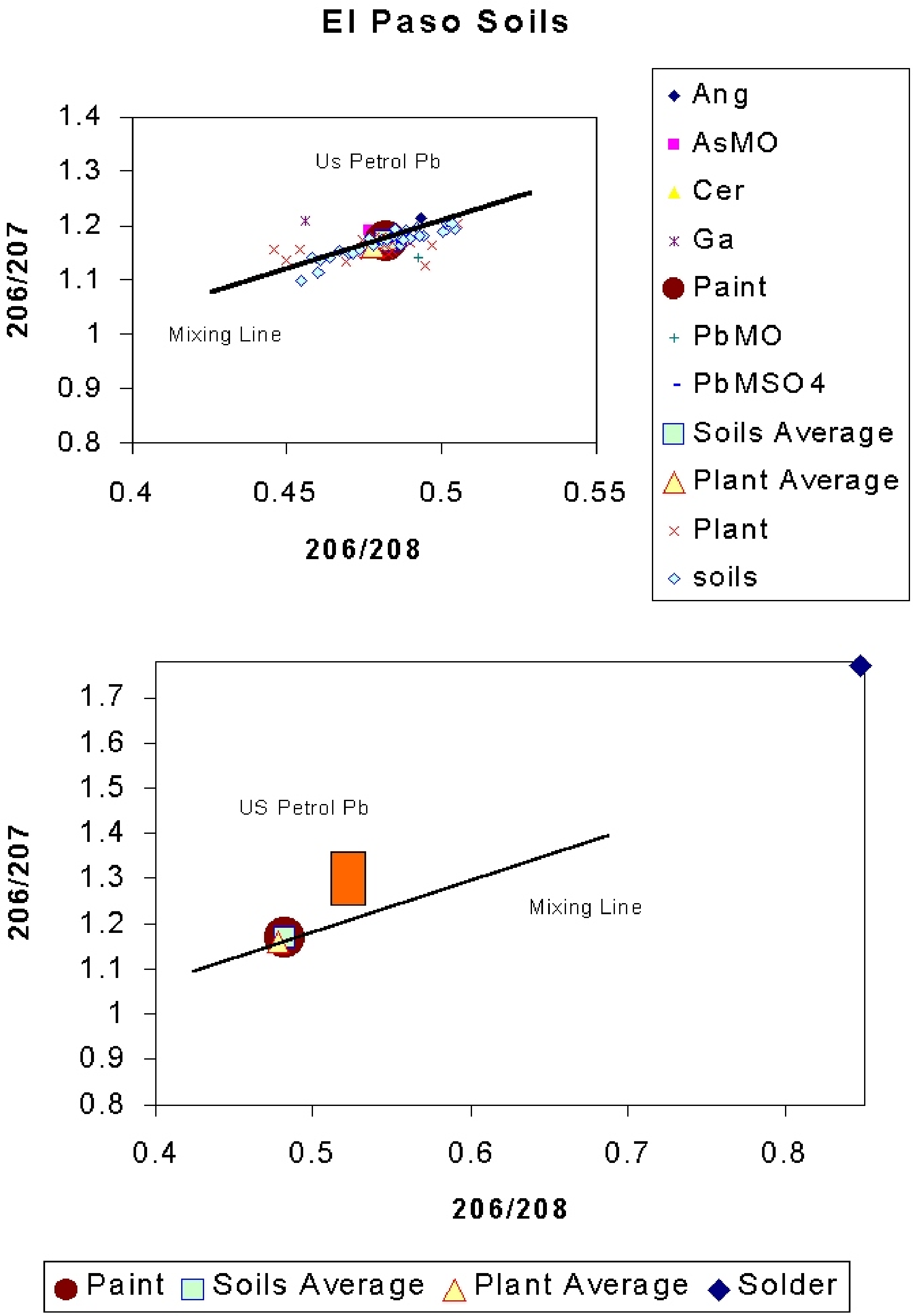
The isotopes of lead Pb ^{207}, Pb ^{206}, and Pb ^{208} are produced by the radioactive decay of U^{235}, U^{238} and Th ^{232} respectively, while Pb ^{204} has no radiogenic source. Variations are a function of the initial uranium and thorium concentrations and age of the ore.

Lead isotopic compositions have been previously used in apportionment studies with some limited success (Hurst et.al., 1996, Gulson et al., 1995, 1996, Robinowitz and Wetherill, 1972, and Sturges and Barrie, 1987, 1989). The major difficulty with these studies was in the sole use of bulk sample analyses. This isotopic signature represents a mixture of all lead sources, therefore apportionment is complicated when more than two sources are involved. With the improvements made in quadrupole ICP/MS systems and the advancements in laser technology, we can now combine EMPA studies (identification of lead-bearing phases) with single particle isotopic lead analysis.

Isotopic results on site samples along with those from the NIST 928 standard are presented in Figure 8. The absolute value and variations about the NIST standard, although not equivalent to a magnetic sector mass spectrometer, provides a good estimate of the precision (2%) and accuracy (3%) at a 95% confidence level for quadrupole ICP/MS/LA.

The three most abundant isotopes of lead Pb^{208}, Pb^{206} and Pb^{207} (54%, 24%, and 22%, respectively) are the most useful for source characterization. Figure 8, a plot of $Pb^{206/207}$ vs $Pb^{206/208}$, illustrates some of the most important characteristics of the data set. It is clear that the ASARCO plant soils have a very wide range in isotopic composition that is likely the result of its more extensive operational history and numerous lead-ore sources (Mexico, New Mexico, Arizonia, and Colorado). Preliminary review of the data would support multiple primary lead sources for the plant. Data from the community soils was much more difficult to obtain. Single-phase laser analyses were limited to a few phases, paint, and solder primarily do to the size limitations in finding a single particle of lead using the low power microscope on the laser. Therefore, bulk isotopic lead analyses were included for characterization. The bulk isotopic lead samples however are represented by a rather broad distribution, overlapping the ASARCO population . Figure 8B is a simplified $Pb^{206/208}$ vs $Pb^{206/207}$ plot, using only average values for all potential sources and soil. In this plot it becomes more apparent that the community soils are isotopically similar to the ASARCO facility soils and that a contribution from lead paint can not be ruled out isotopically, however, gasoline and solder are not significant contributors to their isotopic character.

Figure 8


El Paso Soils
1.4
1.3
1.2
1.1
1
0.9
0.8
206/207
Us Petrol Pb
Mixing Line
0.4
0.45
0.5
0.55
206/208
Ang
AsMO
Cer
Ga
Paint
PbMO
PbMSO4
Soils Average
Plant Average
Plant
soils
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
206/207
US Petrol Pb
Mixing Line
0.4
0.5
0.6
0.7
0.8
206/208
Paint
Soils Average
Plant Average
Solder

6.0 APPORTIONMENT

Based on the results from the arsenic speciation study an attempt to apportion the total soil lead and arsenic to most probable sources was made using the Min_{Pb-As} values (Tables 7 and 8). Thus four specific categories for the apportionment were made: pyrometallurgical , concentrate, non-specific soil-forming, and anthropogenic. Criteria for each of these categories were as follows:

Pyrometallurgical : PbAsO, AsFeOOH, PbMO, AsMO, PbFeOOH, $PbMSO_4$

Concentrate: Galena, anglesite, sulfosalts, arsenopyrite, and pyrite

Soil-Forming : Fe oxide, Mn oxide, phosphate, and clays

Anthropogenic: Paint, brass, AsCaO, and solder

Pyrometallurgical and concentrate species were chosen based on data from site-specific, ASARCO plant samples, metallurgical literature (Fergusson, 1990), and previous studies (Drexler, 1995,1997; Thorton 1995). The soil-forming phases are most likely the result of solublized lead and/or arsenic, released from the other two populations that are now sequestered (by sorption) in common, soil-forming mineral phases. Since at least some of the bulk metal found in this category may have come from pyrometallurgical processes or concentrate alterations, a percentage of the “non-source specific” category could be assigned to these sources. Site specific examples, Photos 12-15, clearly illustrate that this argument is valid, showing primary smelter and concentrate phases altering to phosphates, clays, and manganese oxides that contain arsenic and lead.

Possible residential anthropogenic forms of lead/arsenic include: brass, solder, gasoline, pesticides, glass, and paint. Anthropogenic species were chosen based on data from literature (Fergusson, 1990), and previous studies (Drexler, 1995,1997; Thorton 1995). Lead paint is characteristically associated with following forms of lead: lead carbonate, lead sulfate, lead oxide, and lead chromate. The presence of lead paint in approximately 30% of the residential homes near the ASARCO facility was noted by Landrigan et al., 1975. Since both $PbSO_4$ and $PbCO_3$ are both common lead ores (concentrates) and paint pigments one must define a rational for its apportionment. The author apportioned all of the $PbSO_4$ to “concentrate”, since the ASARCO facility contained a significant quantity of anglesite and it is the least common white-lead pigment, while all of the $PbCO_3$ was apportioned to “anthropogenic”, since little cerussite was found at the facility and it is the most common white-lead pigment. In general, this rational would only have had a significant impact on two residential samples (ELP-6 and ELP-33). One under estimating facility apportionment and the other paint apportionment, thus not impacting the overall apportionment. Pigments of arsenic are rare and not considered a likely source. Pesticides would typically contain lead, calcium, or sodium arsenate. Gasoline as a significant source is unlikely because of the historical rural location of the plant and even though today, major roadways are within the area, lead contamination from automobile emissions or spills is generally limited to a few hundred feet of a roadway. This conclusion is also supported by both the isotopic data (Chapter 5) and the study of Landrigan et al., 1975.

Results of the apportionment are summarized in Tables 7 and 8. The apportionment calculation indicates that on average a minimum of 53% of the bulk lead in residential soils can be attributed to the ASARCO facility either as a result of stack emissions or fugitive dust from concentrate piles. This value would increase to 64% if only a third of the non-specific lead was apportioned to ASARCO as justified previously. Virtually all, 85%, of the arsenic is most likely from the ASARCO facility.

Table 7

TABLE 7. Lead Apportionment Distribution for Residential Soils

		ELP-9	ELP-8	ELP-7	ELP-6	ELP-5	ELP-4	ELP-3	ELP-22	ELP-21	ELP-20	ELP-19	ELP-18	ELP-17	ELP-16	ELP-15	ELP-14	ELP-13	ELP-12	ELP-11	ELP-10	ELP-1	ELP-2	ELP-30	ELP-31	ELP-32	ELP-33
		849	121	165	838	388	932	217	381	818	1162	528	604	948	912	803	1116	912	376	1143	854	1007	388	407	316	108	1785
Pyrometalurgical																											
	PbAsO	39	0	0	43	44	204	0	9	158	101	0	125	76	213	99	221	6	3	154	105	135	46	2	75	16	0
	Cr	0	0	0	0	0	0	0	0	0	0	0	0	59	0	0	0	0	0	0	0	0	0	0	0	0	0
	CuM(SO,O)	0	0	0	5	2	0	0	0	0	38	0	2	0	1	0	1	8	0	1	2	0	0	0	0	0	0
	AsFeOOH	4	1	0	0	3	0	1	1	4	0	0	0	0	15	2	1	0	1	0	1	0	1	0	0	1	0
	AsMO	0	0	2	3	4	0	0	0	3	40	0	0	2	10	0	8	1	1	11	8	20	4	0	18	7	4
	PbAsVO	0	0	0	0	0	0	0	0	0	0	0	0	129	30	0	0	0	0	0	0	0	0	0	0	0	0
	PbM(Cl,SO,O)	219	1	0	37	15	6	0	0	47	157	42	46	132	218	49	287	42	2	104	228	48	33	13	89	5	27
	PbMSO4	114	2	57	104	0	0	6	0	121	20	67	286	21	110	28	59	430	6	0	25	45	34	1	0	0	0
	PbO	0	0	0	0	0	0	0	0	0	0	0	43	0	0	17	0	0	0	0	0	0	0	0	0	0	0
	PbSiO4	0	0	0	0	0	63	0	0	27	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0
	SbMO	4	0	0	0	0	0	0	2	6	0	3	0	2	3	1	0	0	0	0	0	6	0	0	0	0	25
	Slag	3	0	0	1	0	3	2	2	0	0	0	7	0	1	0	0	45	0	0	1	0	1	0	0	0	2
	FeMSO4	20	2	11	9	1	3	8	6	23	15	35	3	9	22	18	36	18	0	7	28	9	6	1	12	1	11
	PbFeOOH	0	0	0	8	0	11	0	0	9	0	52	31	16	42	25	12	55	0	19	74	0	1	0	0	0	0
Total Pyrometalurgical		402	5	70	210	70	289	17	21	399	371	199	544	446	666	239	625	605	12	295	472	270	127	17	194	30	69
	% of total Pb	47%	4%	42%	25%	18%	31%	8%	5%	49%	32%	38%	90%	47%	73%	30%	56%	66%	3%	26%	55%	27%	33%	4%	61%	28%	4%
Concentrate	Arsenopyrite	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Barite	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	6
	Galena	27	105	6	195	102	0	48	0	174	148	173	10	8	111	337	0	152	31	0	29	141	118	7	23	0	0
	Anglesite	0	10	8	279	39	0	0	0	14	57	0	0	0	37	0	0	0	13	32	0	0	39	0	0	13	0
	Pyrite	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sulfosalts	2	0	0	0	0	0	1	0	0	0	2	0	0	0	0	8	1	1	0	1	0	0	0	0	0	0
Total Concentrate		29	115	14	474	141	0	50	0	188	205	177	11	9	148	337	8	153	44	32	30	141	158	7	25	13	6
	% of total Pb	3%	95%	8%	57%	36%	0%	23%	0%	23%	18%	33%	2%	1%	16%	42%	1%	17%	12%	3%	3%	14%	41%	2%	8%	12%	0%
	AsCaO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Anthropogenic	Cerussite	0	0	0	0	6	0	0	0	0	0	0	0	13	0	0	0	0	230	0	0	100	7	44	24	48	949
	Paint	17	0	0	34	0	0	0	0	13	53	0	12	0	0	0	0	0	47	25	93	15	0	15	4	0	0
	Solder	0	0	0	0	0	0	0	0	0	9	0	0	1	0	0	0	0	0	10	0	0	0	1	6	0	20
Total Anthropogenic		17	0	0	34	6	0	0	0	13	62	0	12	14	0	0	0	0	277	35	93	120	7	60	34	48	969
	% of total Pb	2%	0%	0%	4%	1%	0%	0%	0%	2%	5%	0%	2%	1%	0%	0%	0%	0%	74%	3%	11%	12%	2%	15%	11%	44%	54%
Non-Specific	Clay	6	0	0	0	0	6	0	0	0	0	0	0	0	0	0	4	0	0	4	0	0	0	0	0	0	0
	FeOOH	57	1	0	8	22	17	30	34	17	60	12	35	53	27	14	40	9	3	70	45	38	9	5	29	2	127

MnOOH	0	0	0	0	0	20	23	13	0	0	0	0	0	5	0	168	6	7	46	0	13	0	0	9	0	83	
Organic	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Phosphate	339	0	82	112	150	597	97	313	201	464	140	2	425	66	212	270	138	33	661	215	525	88	18	28	14	535	
Total Non-Specific	401	1	82	120	172	643	150	360	219	524	152	37	478	97	226	483	153	43	781	260	576	97	23	66	16	745	
% of total Pb	47%	1%	50%	14%	44%	69%	69%	95%	27%	45%	29%	6%	50%	11%	28%	43%	17%	11%	68%	30%	57%	25%	6%	21%	15%	42%	
Total ASARCO Contribution	51%	99%	50%	82%	54%	31%	31%	5%	72%	50%	71%	92%	48%	89%	72%	57%	83%	15%	29%	59%	41%	73%	6%	69%	40%	4%	53%
Asarco + 33% of non-specific	66%	99%	67%	86%	69%	54%	54%	37%	81%	64%	81%	94%	65%	93%	81%	71%	89%	19%	51%	69%	60%	82%	8%	76%	45%	18%	64%

table 8

TABLE 8. Arsenic Apportionment Distribution for Residential Soils

		ELP-9	ELP-8	ELP-7	ELP-6	ELP-5	ELP-4	ELP-3	ELP-22	ELP-21	ELP-20	ELP-19	ELP-18	ELP-17	ELP-16	ELP-15	ELP-14	ELP-13	ELP-12	ELP-11	ELP-10	ELP-1	ELP-2	ELP-30	ELP-31	ELP-32	ELP-33	
		67	57	16	58	40	51	47	32	41	44	192	66	45	110	31	69	65	14	62	56	65	48	14	12	8	13	
Pyrometalurgical																												
	AsFeOOH	6	1	0	0	3	0	0	1	2	0	0	0	0	14	2	1	0	2	0	1	0	1	0	0	0	0	
	AsMO	0	0	2	9	6	0	0	0	2	26	0	0	3	14	0	9	2	3	15	10	15	5	0	6	2	3	
	SbMO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	PbAsO	13	0	0	20	8	38	0	2	15	9	0	9	18	40	18	34	2	2	27	18	14	8	1	3	1	0	
	PbAsVO	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
	PbFeOOH	0	0	0	2	0	1	0	0	0	0	6	1	2	4	2	1	8	0	2	6	0	0	0	0	0	0	
	PbM(Cl,SO,O)	14	0	0	3	1	0	0	0	1	3	2	1	6	8	2	8	2	0	3	7	1	1	2	1	0	0	
	Slag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	
	FeMSO4	3	0	1	2	0	0	0	1	1	1	4	0	1	2	2	3	3	0	1	2	0	1	0	0	0	1	
Total Pyrometalurgical		37	1	2	37	17	39	0	4	21	39	12	11	31	82	25	56	19	8	48	45	31	16	3	10	3	4	
% of total As		55%	2%	15%	64%	42%	77%	1%	13%	52%	89%	6%	17%	69%	74%	82%	82%	30%	58%	77%	81%	47%	32%	21%	83%	38%	31%	
Concentrate	PbMSO4	12	0	2	15	0	0	0	0	4	1	5	7	2	6	2	3	40	2	0	1	1	2	0	0	0	0	
	Arsenopyrite	0	54	10	0	20	0	45	19	14	0	163	46	0	19	0	0	0	0	0	3	0	29	9	0	5	0	
	Pyrite	0	1	0	0	0	0	1	0	0	0	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Sulfosalts	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	1	1	0	0	0	0	0	0	0	0	
Total Concentrate		14	56	13	15	20	0	46	19	17	1	176	54	2	26	2	6	41	3	0	5	1	31	9	0	5	0	
% of total As		21%	98%	79%	26%	49%	0%	97%	61%	42%	3%	92%	82%	3%	23%	6%	8%	63%	18%	0%	10%	2%	64%	64%	0%	63%	0%	
Anthropogenic																												
	AsCaO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	0	0	0	0	0	
Total Anthropogenic		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	0	0	0	0	0	
% of total As		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	41%	0%	0%	0%	0%	0%	
Non-Specific																												
	FeOOH	5	0	0	1	1	1	0	2	0	1	1	1	3	1	1	2	1	1	3	2	1	0	1	0	0	3	
	MnOOH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	
	Phosphate	10	0	1	5	2	10	0	6	2	4	3	0	9	1	3	4	4	2	11	3	5	1	1	0	0	5	
	Clay	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total Non-Specific		16	0	1	6	4	11	1	8	2	5	4	1	13	3	4	7	5	3	14	5	6	2	2	0	0	8	
% of total As		24%	0%	6%	10%	9%	22%	2%	26%	5%	11%	2%	1%	28%	2%	11%	10%	7%	23%	23%	10%	9%	4%	14%	0%	0%	62%	
Total ASARCO Contribution		76%	100%	94%	90%	91%	77%	98%	74%	95%	92%	98%	99%	72%	98%	88%	90%	93%	77%	77%	90%	49%	96%	86%	83%	100%	31%	85%

7.0 FURTHER STUDIES

The conclusions reached in this report are based on review of available data, which was primarily collected to protect the public health and not to determine the specific source(s) of a particular metal. Therefore, additional data should be collected that could aid in the final identification of the source(s) of lead and arsenic within the El Paso area soils. These data include: 1) more samples should be collected in the community, including sediment and interior dust samples. In particular, from the speciation results it is apparent that the areal limit of influence from the ASARCO facility is likely greater than the sample coverage.
2) speciation of sample sets for copper could also strengthen conclusions on source(s) and 3) a better effort to collect samples from the ASARCO facility which could give more specific information on the speciation characteristics of each of the metal circuits.

8.0 CONCLUSIONS

Based on the data presented in this report the following observations...conclusions can be reached with respect to the occurrences of lead and arsenic found in residential soils from the El Paso area.

- Arsenopyrite, PbAsO, and AsMO are the dominant arsenic contaminants in the soils
- Galena, anglesite, cerussite, phosphate, PbAsO, PbMO, and $PbMSO_4$ are the dominant lead contaminants in soils
- NO correlation between bulk lead and paint was found
- Greater than 53% of the bulk lead and 85% of the bulk arsenic can be apportioned to pyrometallurgical or concentrate sources

Based on the data reviewed in this report it is my opinion that the lead and arsenic in the El Paso area of study are the result of both smelter-stack emissions and fugitive dust from plant raw materials.

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APPENDIX I

Table 1A. Site -Specific parameters for relative mass calculations.

	Specific Gravity	**Pb mg/kg**	**As mg/kg**
Clay	3.1	41900	5200
Anglesite	6.3	68400	0
AsCaO	6	10000	200000
AsFeOOH	4.5	46900	94600
AsMO	7	62000	184600
Arsenopyrite	6	0	460000
Barite	4	50000	0
Cerussite	6.6	776000	0
Cr	5	30000	0
CuM(SO,O)	6	40000	0
FeOOH	4	28500	3100
Galena	7.5	866000	0
MnOOH	5	150000	2800
Organic	1.3	20000	100
Paint	6	45000	0
PbAsO	7.1	500000	200000
PbAsVO	6.4	550000	5000
PbFeOOH	4.5	218000	44800
PbM(Cl,SO,O)	6.5	343000	26000
PbMSO4	5.7	368000	46000
PbO	9.5	930000	0
PbSiO4	6	500000	1500
Solder	6.3	73000	200
Phosphate	5	276000	10000
Pyrite	4	1700	15000
SbMO	6	50000	3000
Slag	3.6	1200	90
Sulfosalts	6	50000	50000
FeMSO4	3.7	51000	10000
BiMO	9	50000	500
Calcite	2.7	23000	200
Cu	8.9	1000	100000
CuMO	6	36000	15000
Native Pb	11.3	1000000	0