Chemical Composition of Potential Fugitive Dust Sources

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OBJECTIVES

1) To characterize the PM emitted from various unprotected surfaces

2) To attribute chemicals of anthropogenic origins detected in the soil to the potential sources in the region

PM in the PdN Region

- PM is the major air pollutant
- Li et al. (2001) examined its spatial and temporal variations reporting that $PM_{2.5\text{-}10}$ ~ 75 % PM_{10}
- Jeon et al. (2001) identified sources of PM
- PM appears to be inorganic with major sources:
  1. Fugitive dust from unprotected surfaces
  2. Trace elements from re-suspension of deposited metals

Fugitive Dust

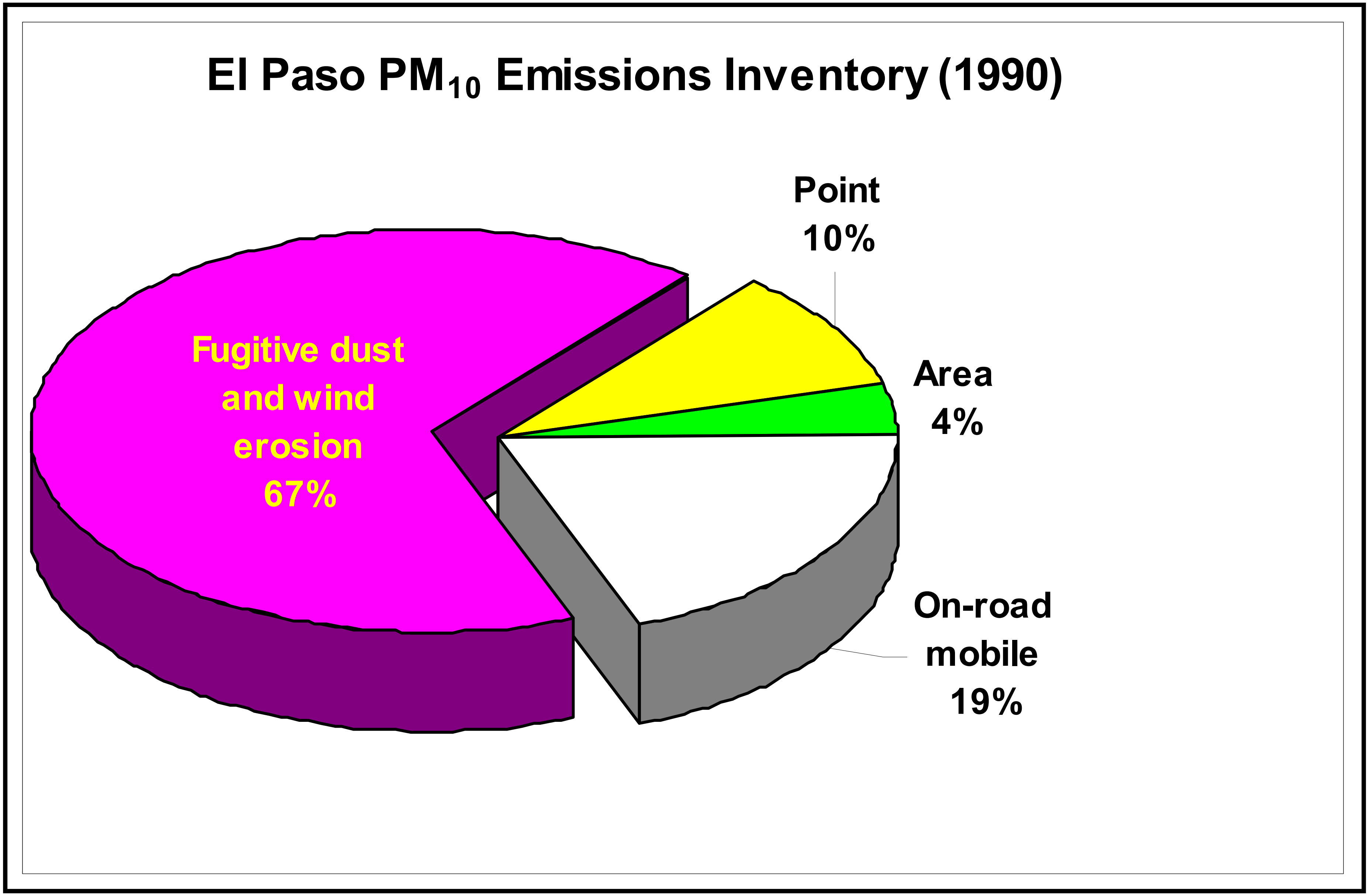
Definition

Dust particles put into the air by the disturbance of exposed granular surfaces

Causes

1. Aridity of the climate
2. Sparse vegetation
3. High soil erodibility
4. Large number of unpaved roads

PM_{10} Production



Historical Soil Data for PdN Region

- Air and soil metals concentrations decreased with distance to ASARCO

- Percentage of children with blood lead levels higher than 40 µg/dl decreased with distance from ASARCO

Away from ASARCO, no sign of metals contamination

- Devanalli (1994) As, Cd, Cu, Pb, and Zn had low concentrations in downtown El Paso
- Srinivas (1994) No point sources or large-scale contamination in East and Northeast El Paso

EPA (2001) Highest lead concentrations occurred in UTEP

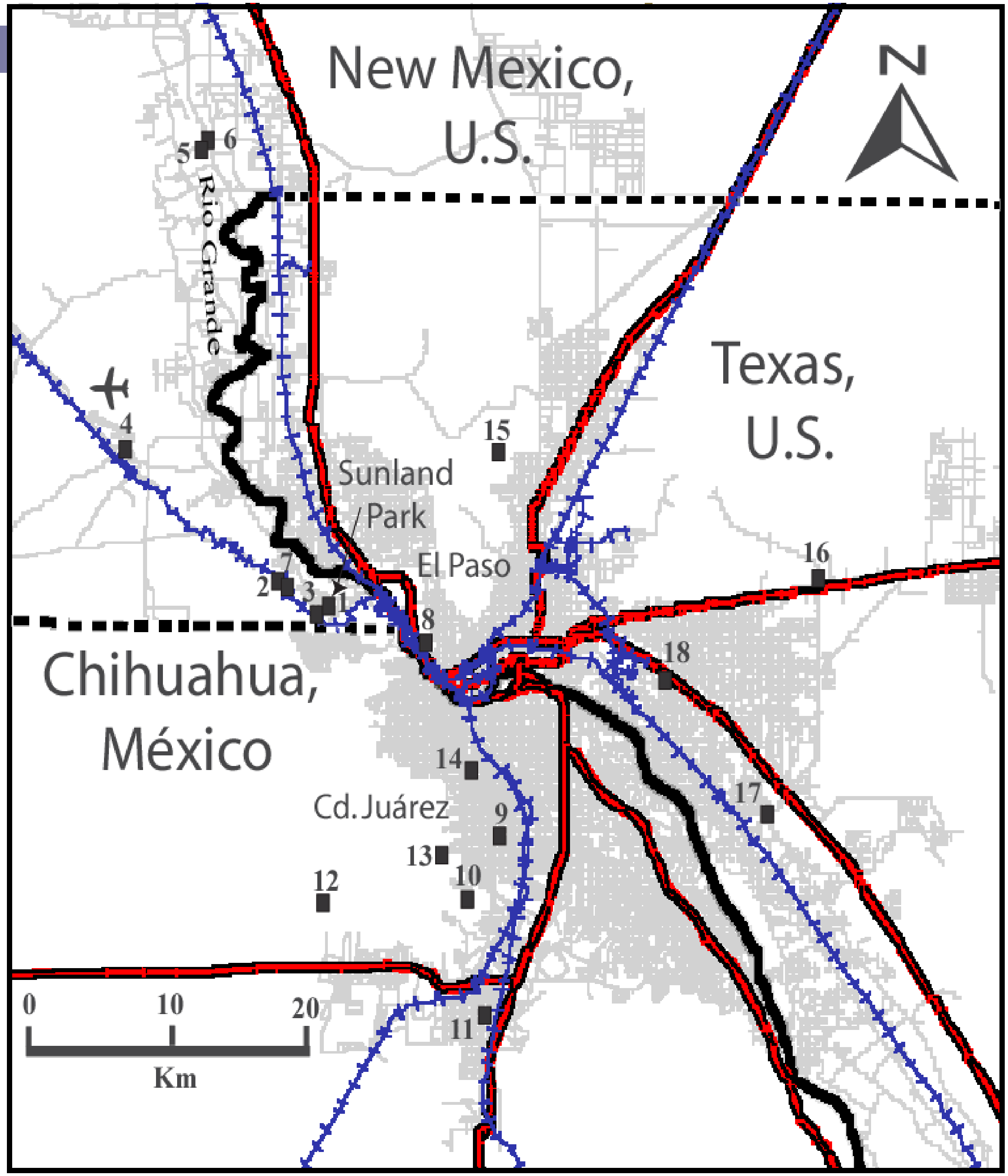
Monitoring Sites Location

Samples collected 23-25 /02/ 2000

6 sites in Cd. Juárez
7 sites in Doña Ana
5 sites in El Paso

Meteorological and geographical review

Representative of different land uses, high wind erosion sites, soil types, and lithologic units



Site	Sites Description
1	Open field off Anapra Road, South of Sunland Park
2	Open field ~ .5 mile NE of Camino Real Landfill, SW of Sunland Park
3	Paved Road (Anapra Road) near Site 1
4	Open field Southwest of Weather Service Office at Santa Teresa Airport
5	Plowed agricultural field
6	Dirt road less than a mile to the East of Site 5
7	Dirt road ~ .5 miles from Site 2
8	Hill ~100 ft North of parking lot off Sun Bowl Drive on UTEP campus
9	Brick kiln area in Ciudad Juárez
10	Immediately Southeast of cement plant
11	Edge of junkyard South of large mound of calcium sulfate at NorFluor Plant
12	Open field Southwest of large rock quarry
13	Foundry corner of fenced parking lot in center of Cd. Juárez near dichotomous air sampler
14	Immediately Southwest of steel mill
15	Vacant lot just off East of large quarry on McKelligon Canyon Road
16	Open field near Montana Avenue and Highway 375
17	Open field near North Loop Road and Highway 375
18	Vacant lot at Industrial Avenue and East Side Road

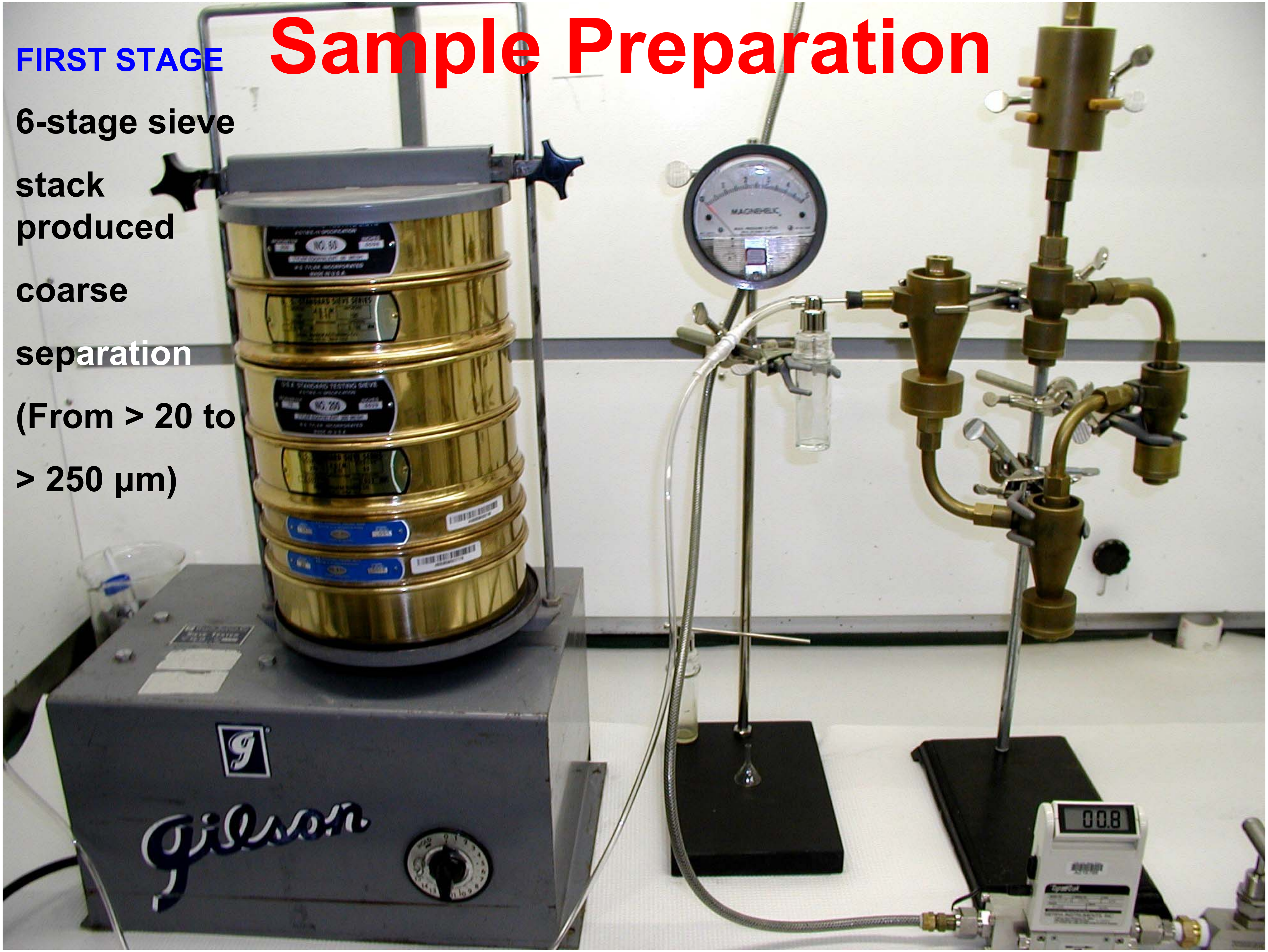
Sampling Sites Main Characteristics

Site	WEG	Lithologic Unit	Soil Type
1	2	Qalr	PBW
2	2	Qalr	PBW
4	3	Qalr	WPC
5	4L	Qws	GAH
6	4L	Qws	GAH
7	2	Qalr	PBW
8	8	Qalr	DCN
15	8	Qao	RO
16	2	Qws	HWB
17	4L	Qao	HGG
18	2	Qao	BBP

Sample Preparation

FIRST STAGE

6-stage sieve stack produced coarse separation (From > 20 to > 250 µm)



Sample Preparation … (2)

SECOND STAGE

a). The material collected in the collection pan was aerosolized with a powder blower into a 5-stage cyclone train to produce finer material (7.93, 3.36, 2.49, 1.40, and 0.82 µm)

b). Aliquots of the 11 size-fractioned samples were digested in an acid cocktail and analyzed by ICP-MS. A second set of aliquots was extracted with water and analyzed by IC

Descriptive Statistical Analyses

Database

- 40 elements concentrations (ppm) for the bulk and 11 size-separated fractions. Main focus on: As, Be, Cd, Co, Cr, Mn, Pb, Ni, Sb, Ag, Al, Ba, Ca, Cu, K, Mo, Na, and Zn

Elemental concentrations and sites

- Z value = (Bulk element concentration – Mean) / s

Elemental concentrations and lithologic units

- Range value = (Max Z – Min Z)
  across the same lithologic unit

Elemental concentrations and soil types

- Zsoil value = (Mean Z) across the same soil type

Multivariate Analysis

Cluster Analysis

- Applied to the Z bulk elements concentrations using Ward's Method and Euclidian distances

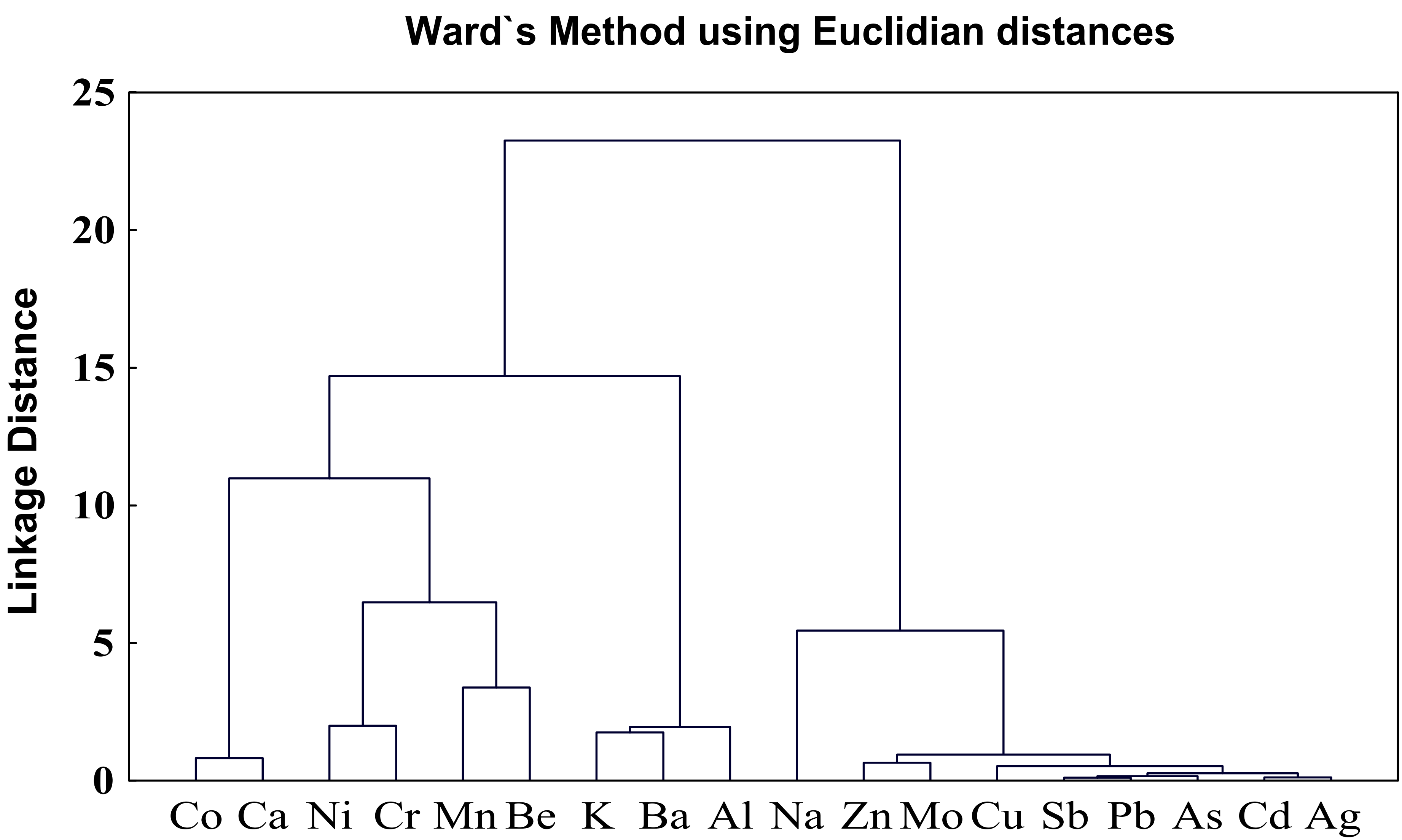
Principal Components Analysis

- Applied to the Z bulk elements concentrations using VARIMAX normalized rotation

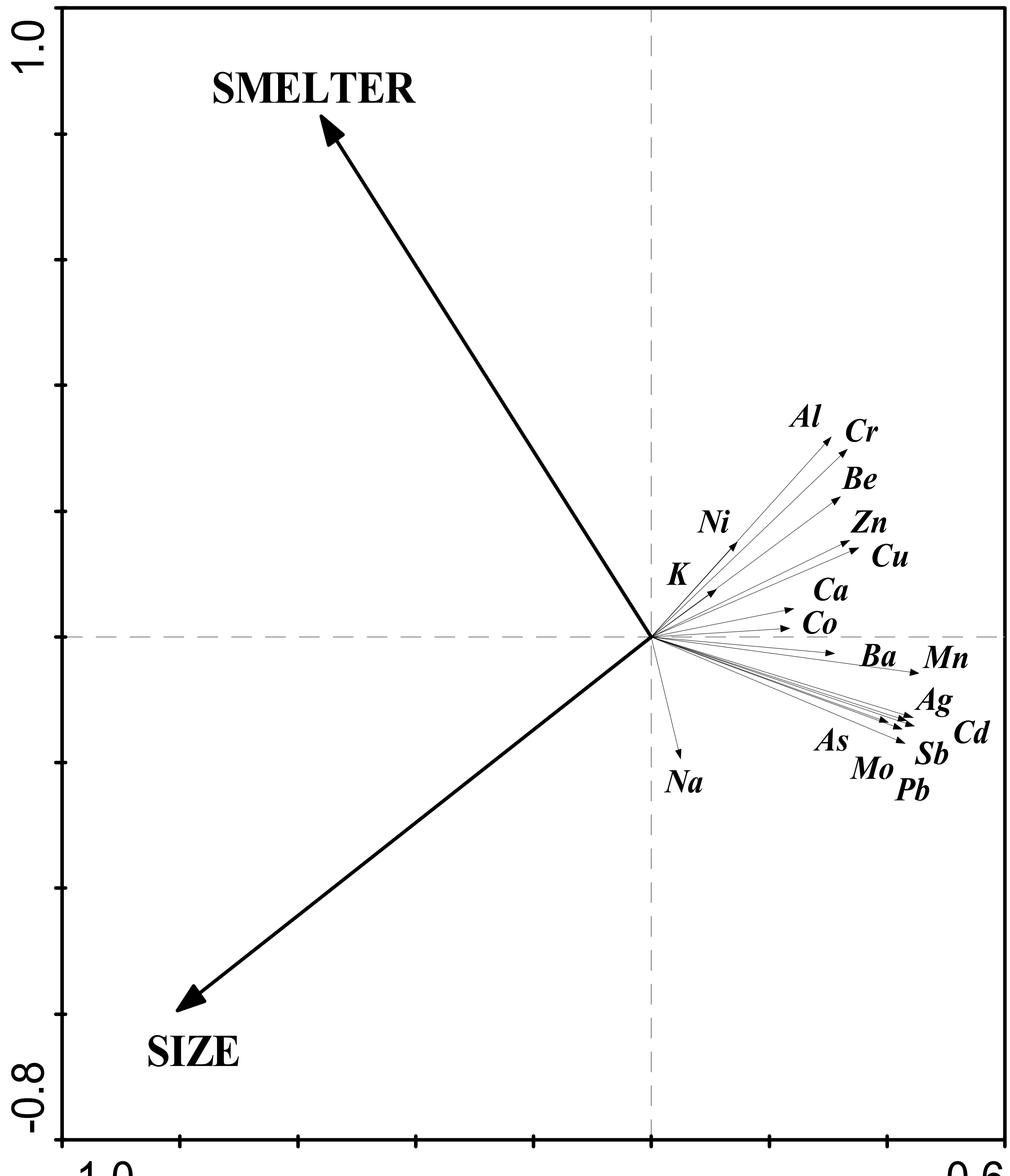
Redundancy Analysis

- Applied to the logarithmically transformed size-fractioned elements concentrations using SMELTER and SIZE as explanatory variables

Cluster Analysis



Redundancy Analysis



Enrichment Factor Analysis

- Applied to the bulk and size-fractioned material (fine and coarse particles)
- EF = [element / reference element] $_{sample}$ / [element / reference element] $_{crustal}$
- Aluminum as the reference element
- Taylor and McLennan's compilation (1995)

Final Results

Elements	Site with Highest Z	Highest Range and Zsoil values on	Correlation to SMELTER	Correlation to SIZE	Enrichment Factors
Ag, As, Cd, Cu, Mo, Pb, Sb, Zn (51 %)	Site 8	Qalr and DCN	Negative (Concentrations decrease with distance from the smelter)	Negative (Highest concentrations on the smaller sized particles)	Highest on fine size fraction at Site 8
Na	Site 8	Qalr and DCN	Strong Negative	Positive	Low in all size fractions

Final Results (…2)

Elements	Site with Highest Z	Highest Range and Zsoil values on	Correlation to SMELTER	Correlation to SIZE	Enrichment Factors
Al, Ba, K, Ca, Co (28 %)	Site 1 (Al, Ba, K) Site 15 (Ca and Co)	Qalr and Qao (K and Ca) RO (Except for K)	Low or null	Strong or moderately negative	Low for Ba and K
Be, Cr, Mn, Ni (12 %)	Site 6 (Except for Mn and Cr)	Qws and GAH for Be and Cr DCN for Mn and Ni	Low (Except for Mn)	Negative	Highest on Fine at Site 14 for Be and Ni Highest on Coarse at Sites 13 and 8 for Cr and Mn respectively

Conclusions

1. The application of multivariate statistical techniques and enrichment factor analysis proved to be useful for determining groups of related elements.

2. There appears to be impacts from the smelter and quarry, with possible minor impacts from agriculture.
   The materials presumed to be from the smelter stayed in a relatively confined area.

3. Several elements are in crustal or near crustal proportions.

4. The re-suspension of previously deposited contaminants should be assessed because represents a potentially significant long-term source.

Acknowledgments

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Questions?

Comments?

Suggestions?