Main particle sources in underground rail systems

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Open Day on "Air quality in rail subway systems"
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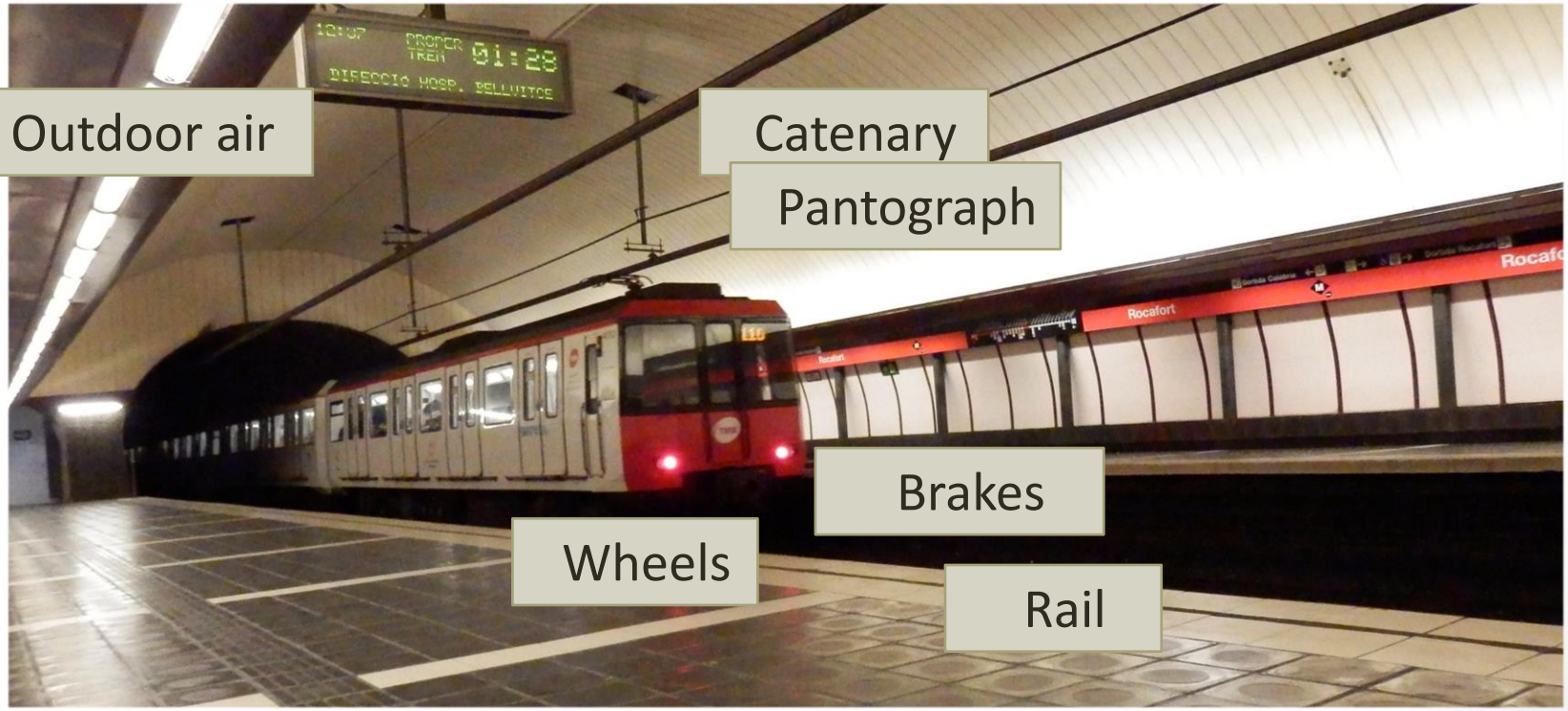
LIFE13 ENV/ES/000263

Outline

- Introduction
- Particulate matter collection
- Chemical composition
- Source apportionment
- Conclusions

Introduction

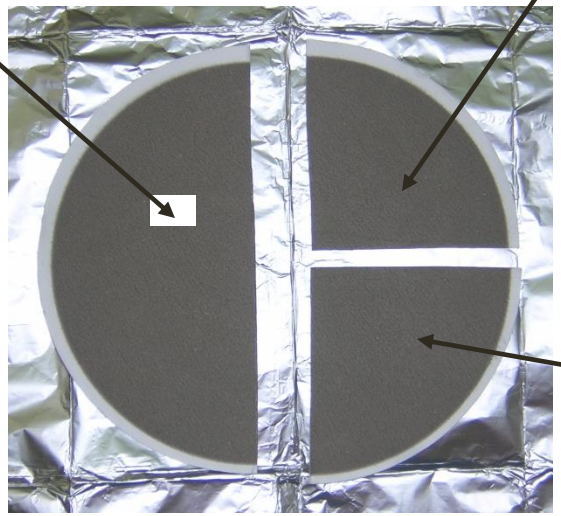


Particulate matter collection

Chemical composition

Total carbon

Sunset analyzer



Acid digestion

ICP-AES:

Al, Ca, K, Na, Mg, Fe, Ti, P

ICP-MS:

Li, Ti, V, Cr, Co, Ni, Cu, Zn, As, Se, Rb, Sr, Y, Zr, Cd, Sn, Cs, Ba, La, Ce, Pr, Nd, Hf, Tl, Pb, Bi, Th, U

Leaching

Ion Chromatography:

NO_3^-, Cl^-, SO_4^{2-}

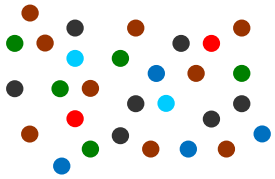
Selective electrode:

NH_4^+

Sum of components: 76-98% $PM_{2.5}$

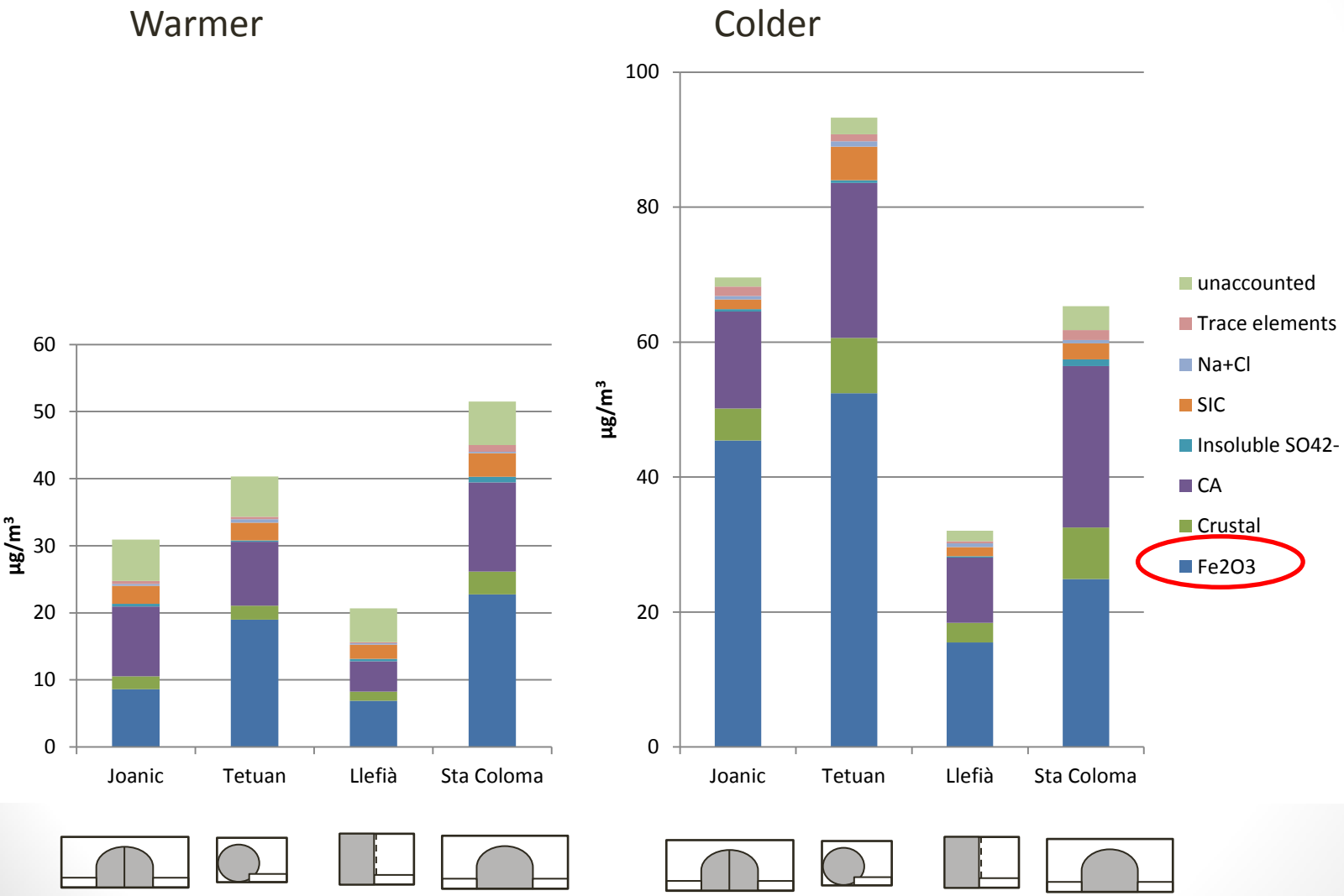
Chemical composition

$PM_{2.5}$

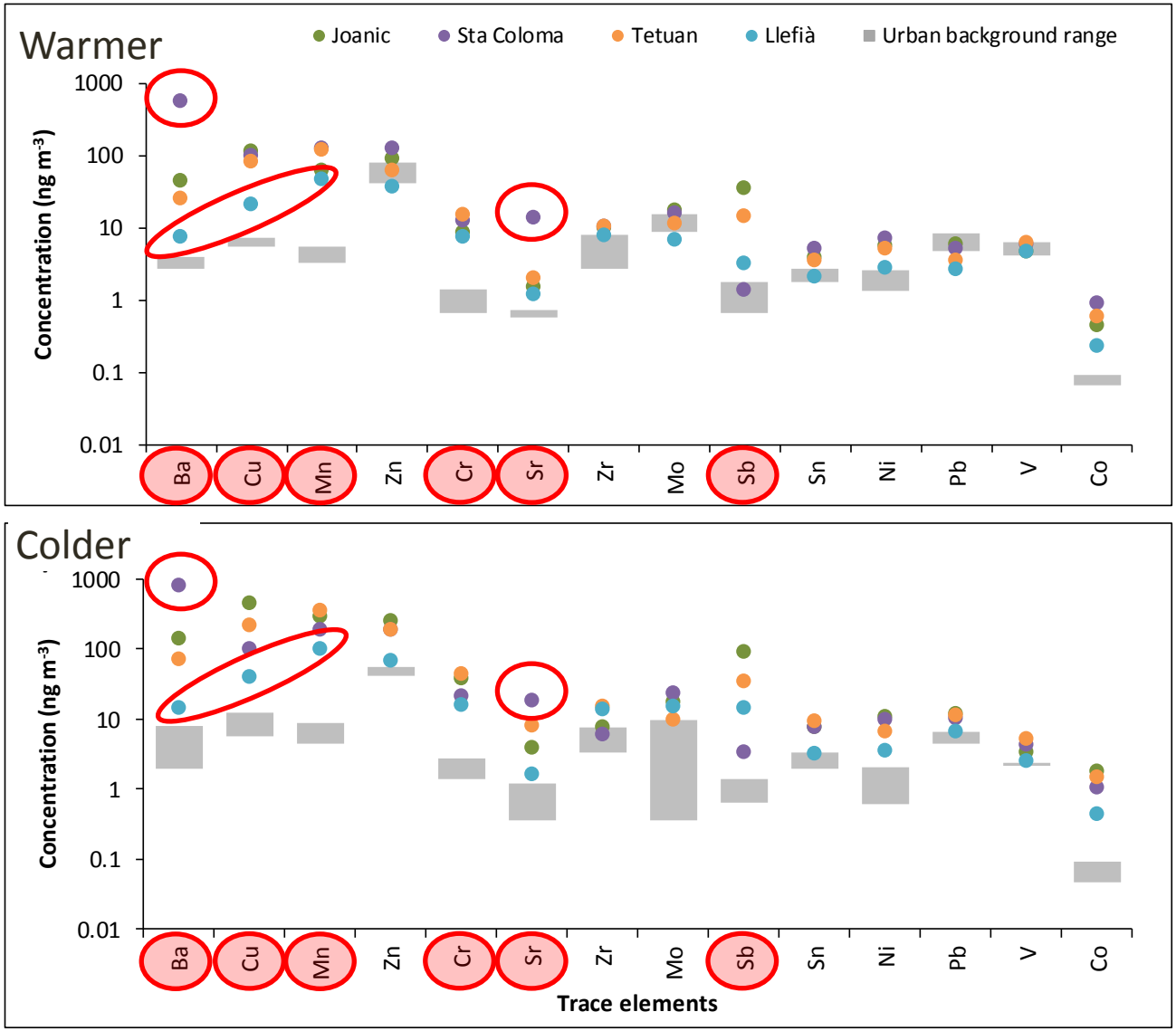


Hematite	Crustal species	Carbonaceous aerosols	Secondary Inorganic compounds	Sea spray	Trace elements
=	+	+	+	+	+
Fe_2O_3	Al_2O_3, SiO_2, Ca, Mg, CO_3^{2-}, K, Fe, Ti, P	CA	SO_4^{2-}, NO_3^-, NH_4^+	Na, Cl	Li, Zn, Zr, As, Pb, Cd, Se, Rb, Cs, Ba, Sb, …

Chemical composition

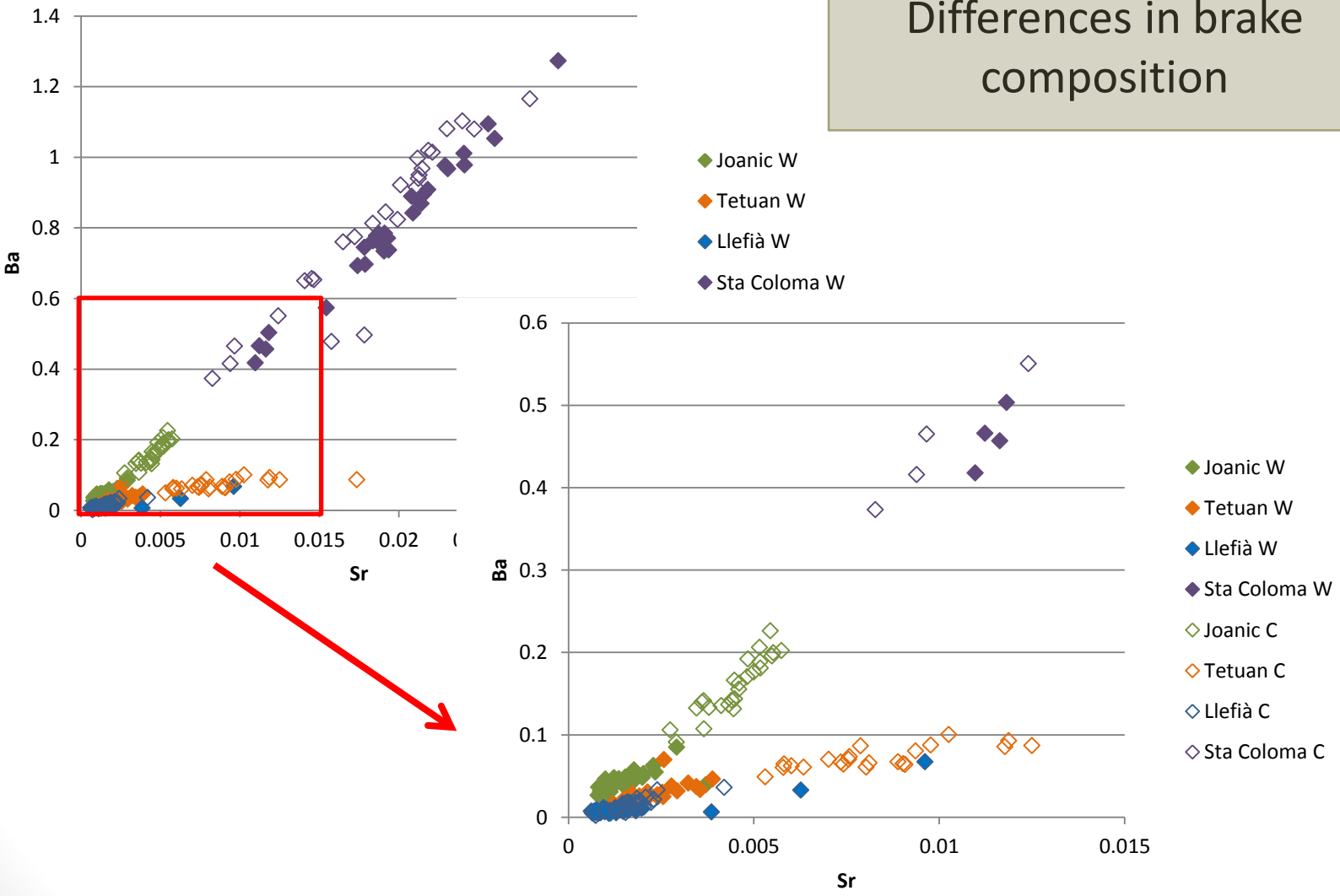


Trace elements



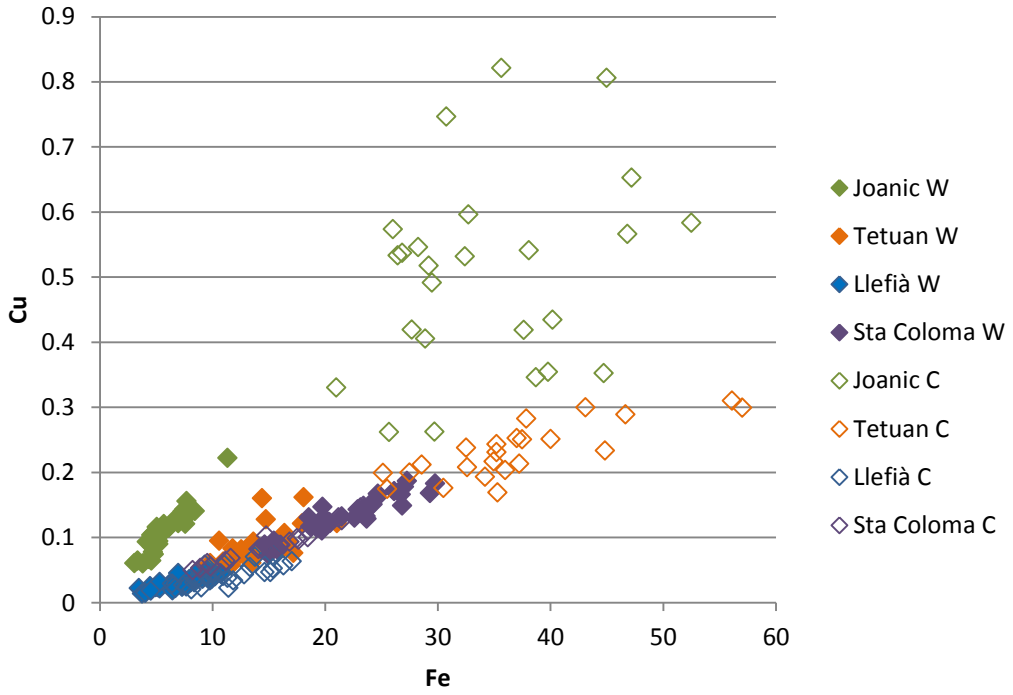
Trace elements

Differences in brake composition

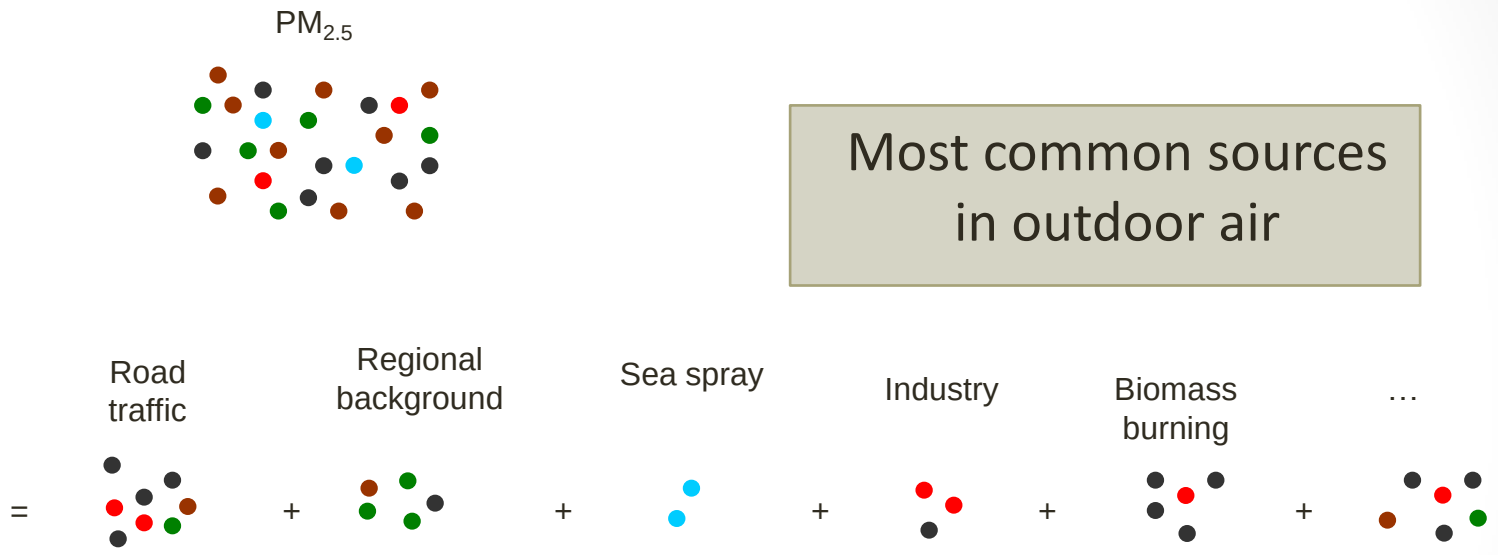


Trace elements

Differences in catenary/pantograph composition



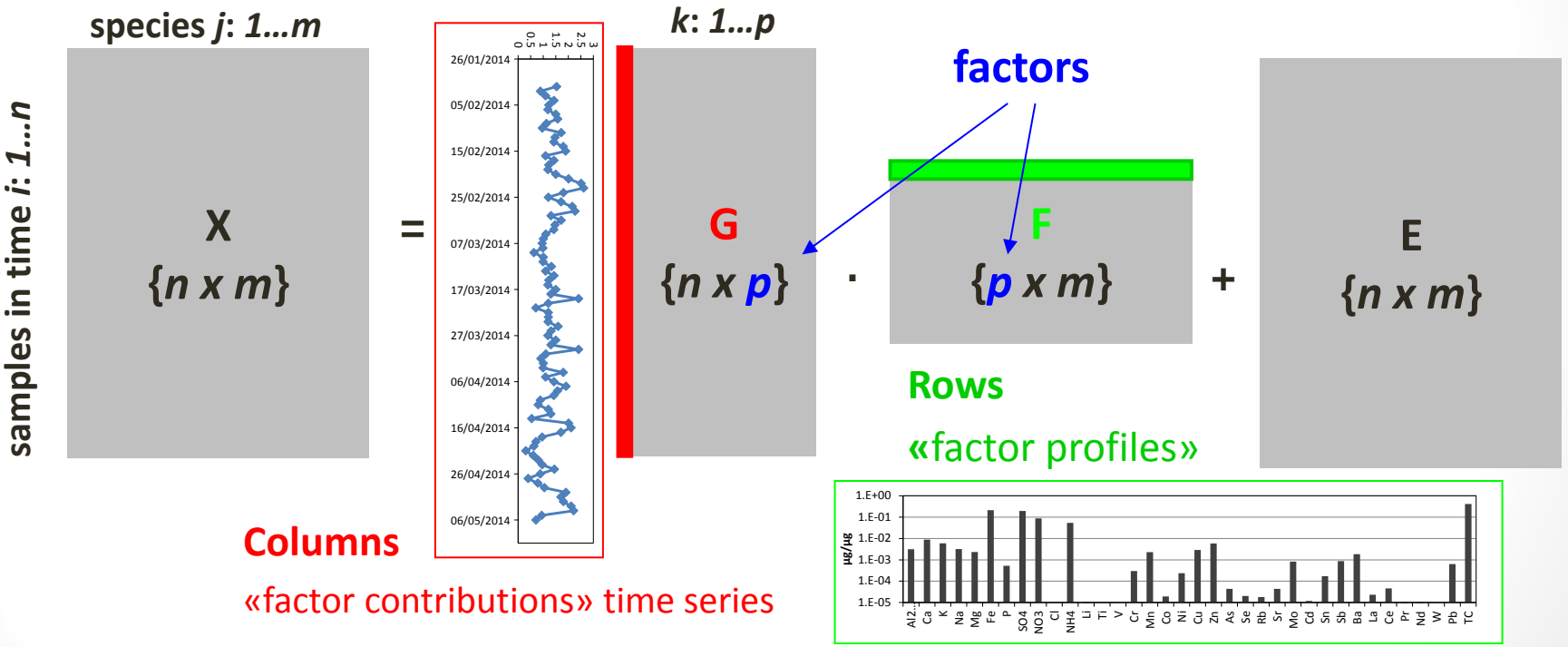
Source apportionment



Source apportionment

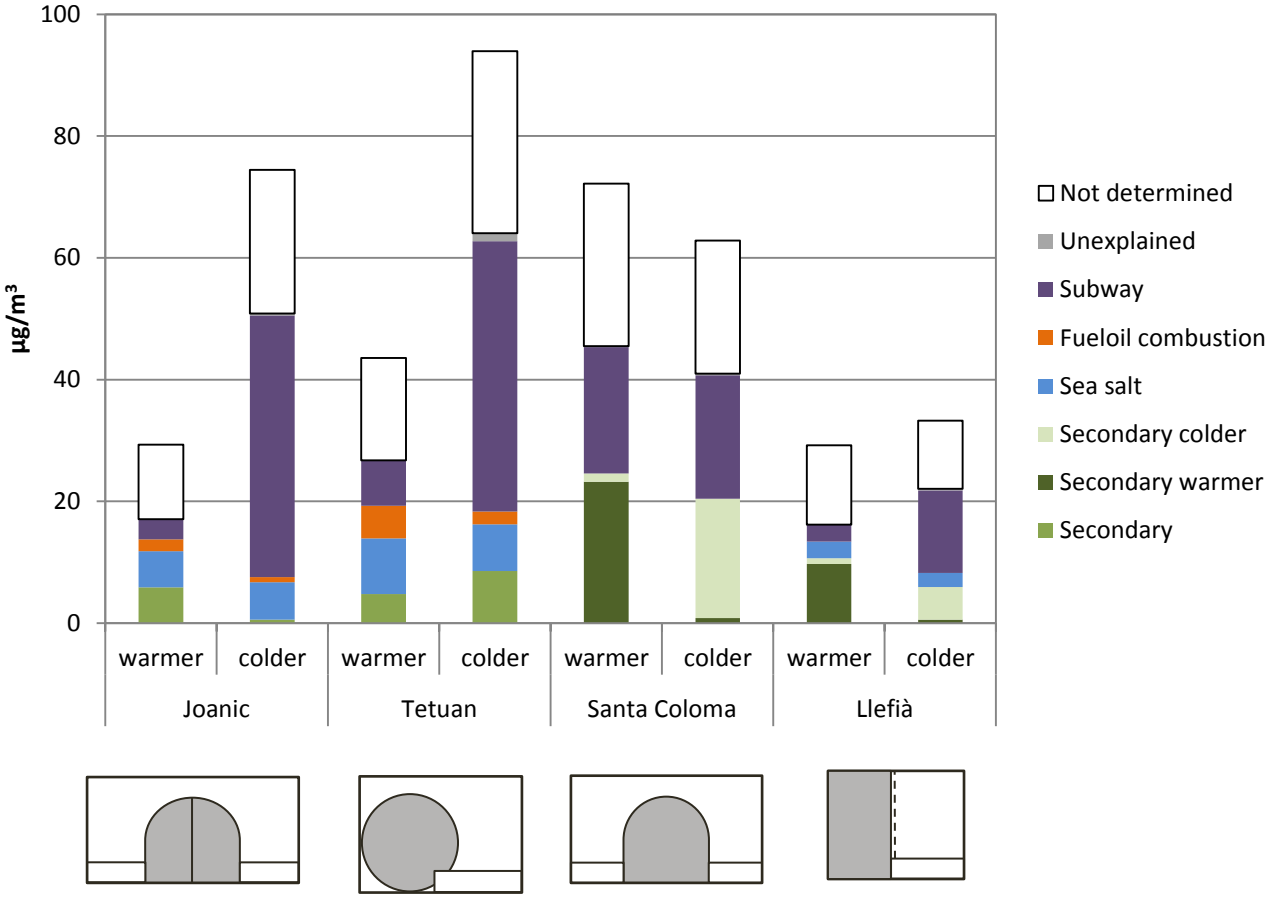
$$X_{measured} = X_{model} + E_{model}$$

$$X_{measured} = G_{model} \cdot F_{model} + E_{model}$$

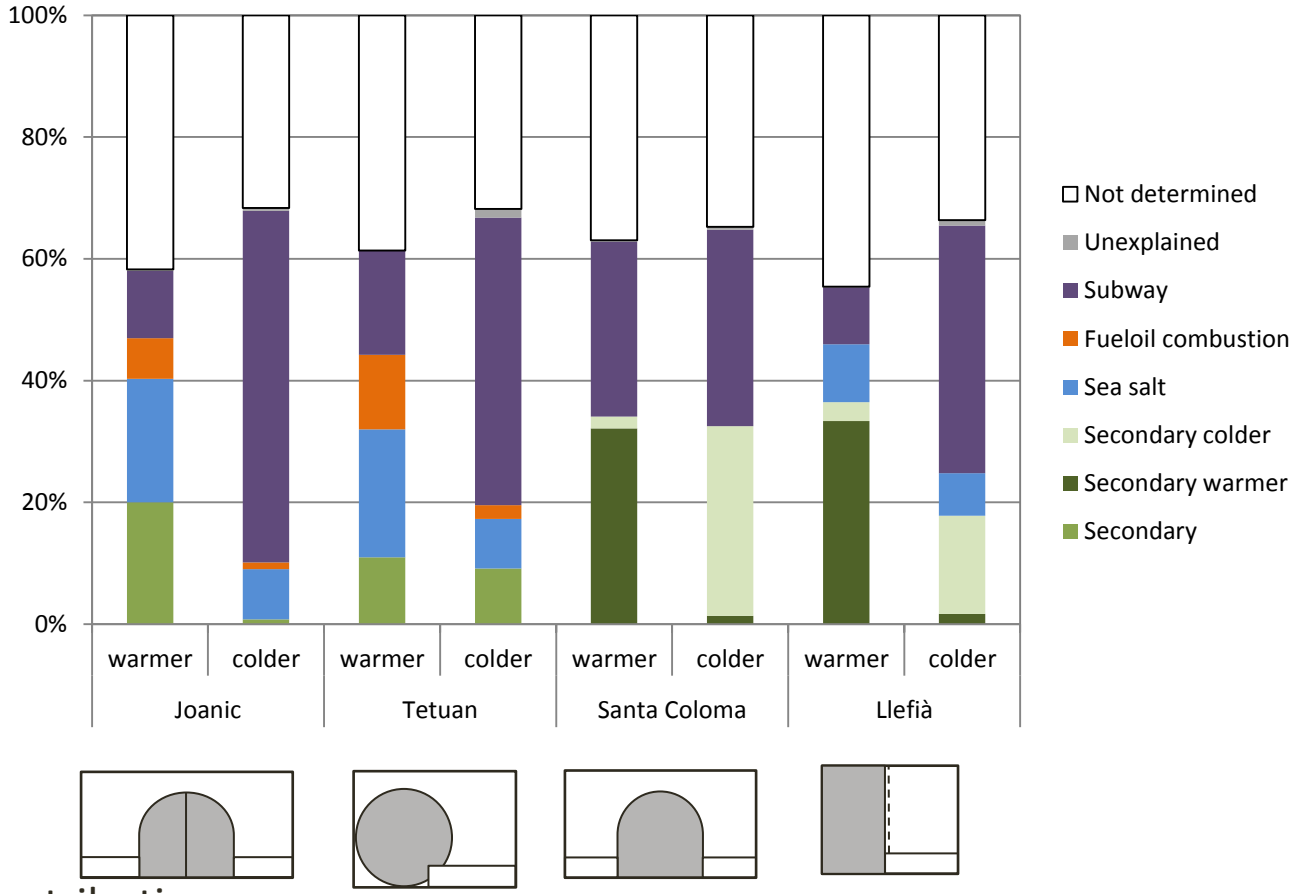


Paatero and Tapper 1994

Source apportionment



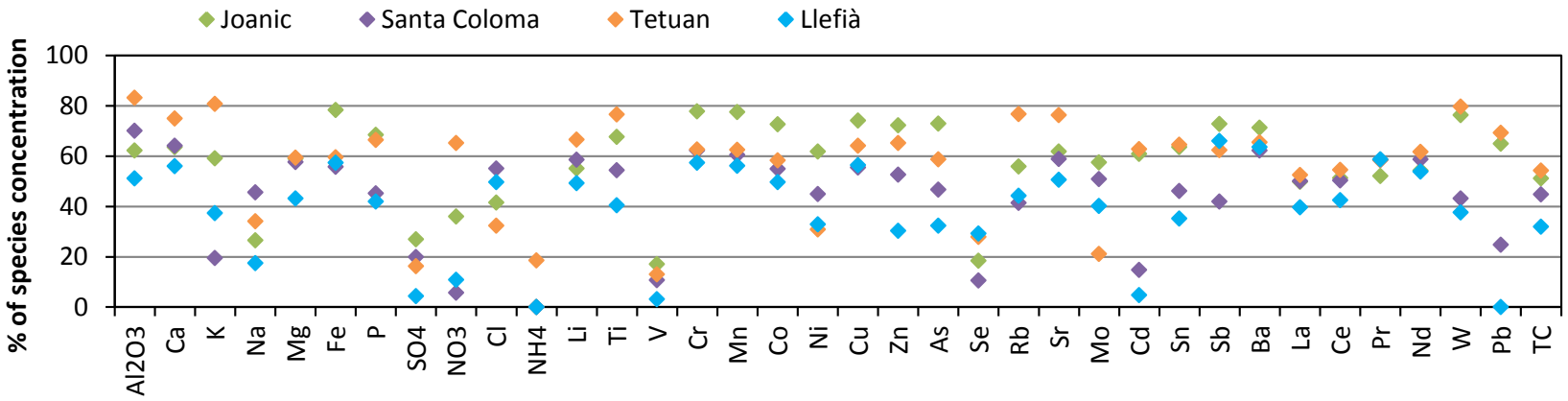
Source apportionment



Subway contribution:

- lower during the warmer period: 9 to 17% of $PM_{2.5}$
- Higher during the colder period: 32 to 58% of $PM_{2.5}$

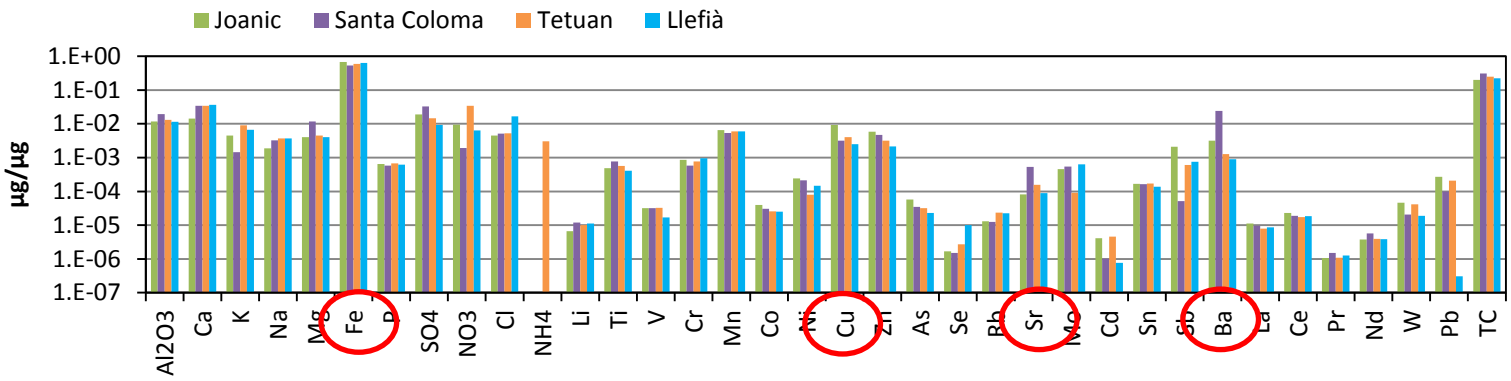
Source apportionment



Subway source responsible for:

> 50% to the concentration of Al_2O_3, Ca, Fe, Cr, Mn, Cu, Sr, Ba, Pr, and Nd

Source apportionment



- Fe dominates the composition of this source at all stations (53%-68%)

- Cu/Fe ratio varies from 0.004 – 0.007 in Llefià, Santa Coloma, and Tetuan to 0.013 in Joanic
  - ➢ Catenary- pantographs emissions

- Ba/Sr ratio varies from 8 – 10 in Tetuan and Llefià to 39 – 45 in Joanic and Santa Coloma
  - ➢ brakes composition

Conclusions

- The analysed $PM_{2.5}$ chemical components accounted for 76 and 98% of the total $PM_{2.5}$ mass
- Subway aerosol is a complex mixture of compounds characterized by high concentrations of hematite (28 – 65%) and carbonaceous aerosol (21 – 37%)
- Fe concentration in the old stations is between 1.5 to 3 times higher than in the new station with platform screen doors
- PM components concentrations varied depending on the seasonal period and the station characteristics, including design, composition of railway, catenary and train components.
- Some trace elements (Ba, Mn, Cu, Cr, Sb, Sr, among others) were recorded in higher concentrations than outdoors.

Conclusions

- Subway contribution to $PM_{2.5}$ was 9-17% in the warmer period and 32-58% in the colder period
- Subway source is responsible for more than 50% of Al_2O_3, Ca, Fe, Cr, Mn, Cu, Sr, Ba, Pr, and Nd concentrations
- Subway $PM_{2.5}$ source
  - is dominated by Fe (53% to 68%)
  - has a different chemical profile for each of the stations
  - the Cu/Fe ratio was clearly different for Joanic, reflecting the different catenary/pantographs composition
  - the Ba/Sr ratio varied reflecting the different types of brakes

The control of the ventilation conditions and the composition of the subway components may result in an improvement of the particle ambient concentrations in the subway environment

Thank you for your attention

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