Characterization of nanoparticles composition of Ostrava urban aerosol

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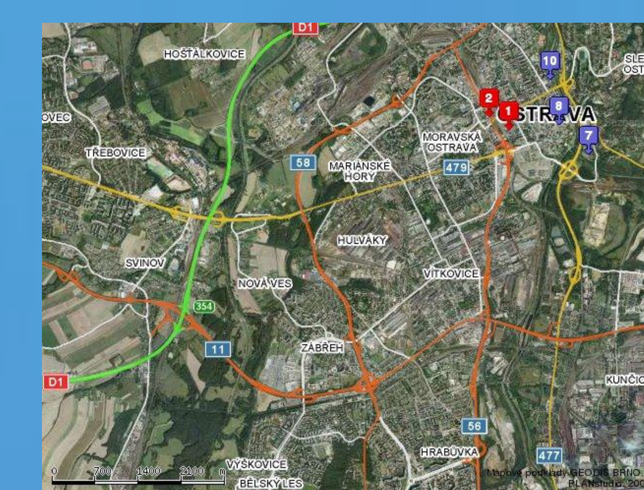
Introduction

The Ostrava city and it´s suburbs have been rightfully considered the localities with unsatisfactory environment with respect to atmosphere in the long term. Comparing the number of days during which the immission limit of PM_{10} daily concentration can be exceeded - 35 days/year with the real situation, which is about 6 times worse, evidence of significant health effects related to polluted air in Ostrava population illustrate importance of situation. As the scientists in Ostrava region concentrate on source apportionment determination in PM_{10} , $PM_{2.5}$ and ultrafine fraction of airborne aerosol and discuss the contribution of industrial emission sources, local heating combustion emissions, originating from various biomass, black coal or even worse material, including brown coal, coal sludge or plastic waste, contribution of transportation and re-suspended particles, the matter of nanoparticles can play a meaningful role in this process. In this work we present results of nanoparticles characterization conducted under different meteorological conditions at four locations in Ostrava: Ostrava-Poruba, which is considered to be a suburb with a relatively low pollution level, Ostrava-Přívoz, close to the city centre and the coking plant, Ostrava-Mariánské hory and Ostrava-Bartovice considered to be the most polluted locality in the region. The concentration, size distribution, physicochemical properties of particles with respect to metals content, trace elements and PAH´s bounced on particles were measured and on-line monitored using FMPS spectrometer, NanoID sampler, ICP-MS, SEM and TEM microscopy.

Sampling location in Ostrava area.
1-4 stationery sites of air monitoring and aerosol sampling



Four Ostrava locations where nanoparticle concentration and distribution were measured

Motivation

Characterisation of submicron particles by particle size distribution and further examining the physicochemical properties like shape, surface observation by SEM and chemical compositions by ICP-MS with emphasis on the fraction below 100 nm might help in process of pollutant source identification in residential localities. Ongoing analyses focused on analyses in samples of particulate matter, trace elements analyses seem to be promising support methods for industrial, local heating, transportation source apportionment.

Methods

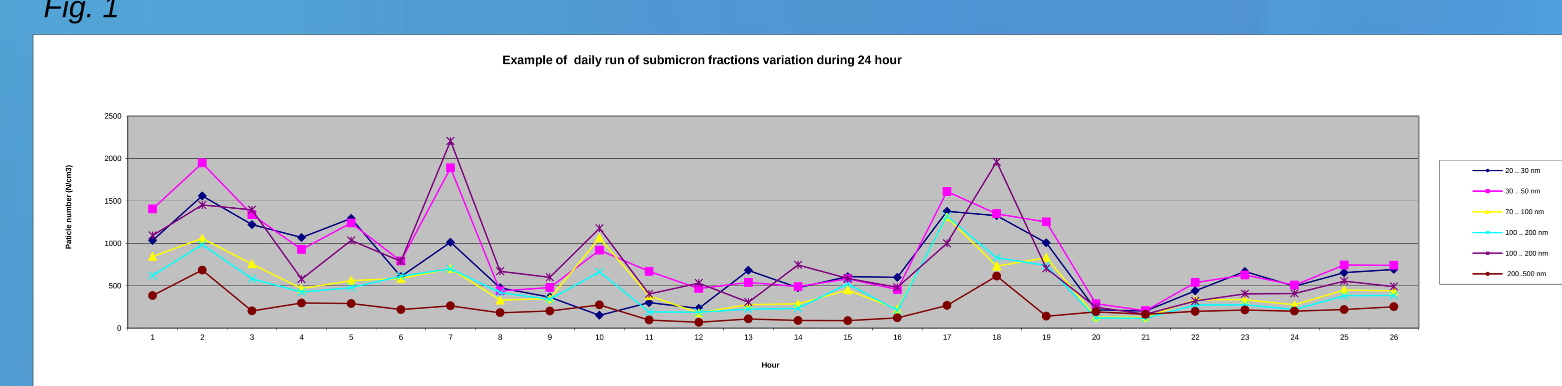
Of four stationary sampling locations where the PM_{10} and $PM_{2.5}$ fractions concentration and PAH and metals content have been routinely monitored, the two were employed for complete nano data collection, Zelená street in Ostrava – Mariánské Hory and Bartovice locality. Moreover, in Zelená street locality the new particle counting method has been introduced, based on electrical mobility of particles. Another spectrometer routinely exploited in workplace atmosphere monitoring with 1 sec response was used for measurement of concentration and particle size distribution during short episodes, when also nanosampler had been used for collecting airborne particulate matter of 0,25 to 20 μm aerodynamical diameter size. Additional samples the particulate matter of the same size were collected on the carbon layer treated glass slides, and particles of 0,002 to 0,25 μm were collected on nylon and stainless steel nets using the NanoID Wrass system and a grids using thermal precipitator.

Results

The total particle number and particle size distribution shows remarkable variations in all localities, primarily characterised by size distributions modality, given by place but also by different date. All existing data are related to heating season. The daily variation in number distribution of six submicron fractions (20 – 500nm) having been measured continuously match with previous results based on mass distribution of the submicron particles, for fraction 200 – 500 nm(fig. 1). For smaller particles, up to 100 nm, the daily variation seems likely to reflect the transportation contribution, with peaks of both fractions 20 – 30 and 30 – 50 nm at 2 periods, 6 – 8 o´clock AM and 2-4 o´clock PM.

Peaks in number concentrations were observed at different diameters in all localities. With respect to the same place in different sampling time, the diameter of peak value changes significantly, for example in Zelená Streel locality at 10 and 200 nm on February 1, while 10 and 100 at March 30, 2011 . This fact can result partly from microclimatical conditions at particular sampling localities, notably the wind direction and wind speed, with regard to potential sources of particle emissions. The elemental content of fractionated particulate matter (ICP-MS) and also EDAX analyse of individual size particles or their aggregates collected on glass slides, grids and nylon nets by NanoID Wrass system and thermal precipitator, also refers to differencies of emissions sources. For example samples obtained at Bartovice but also Zelena street during episode characterised by dominant wind direction 180- 250 degrees adverts to consideration of industrial emission of metal or metal oxides particles (fig. 3, 4) or industrial byproducts (fig.5). HPLC analyses of organic material aimed at PAHs bounced on particles approved insufficient volume of air sampled by WRAS System related to limit of detection of analytical method and lead to consideratios of furter methods combination of analyse.

Fig. 1

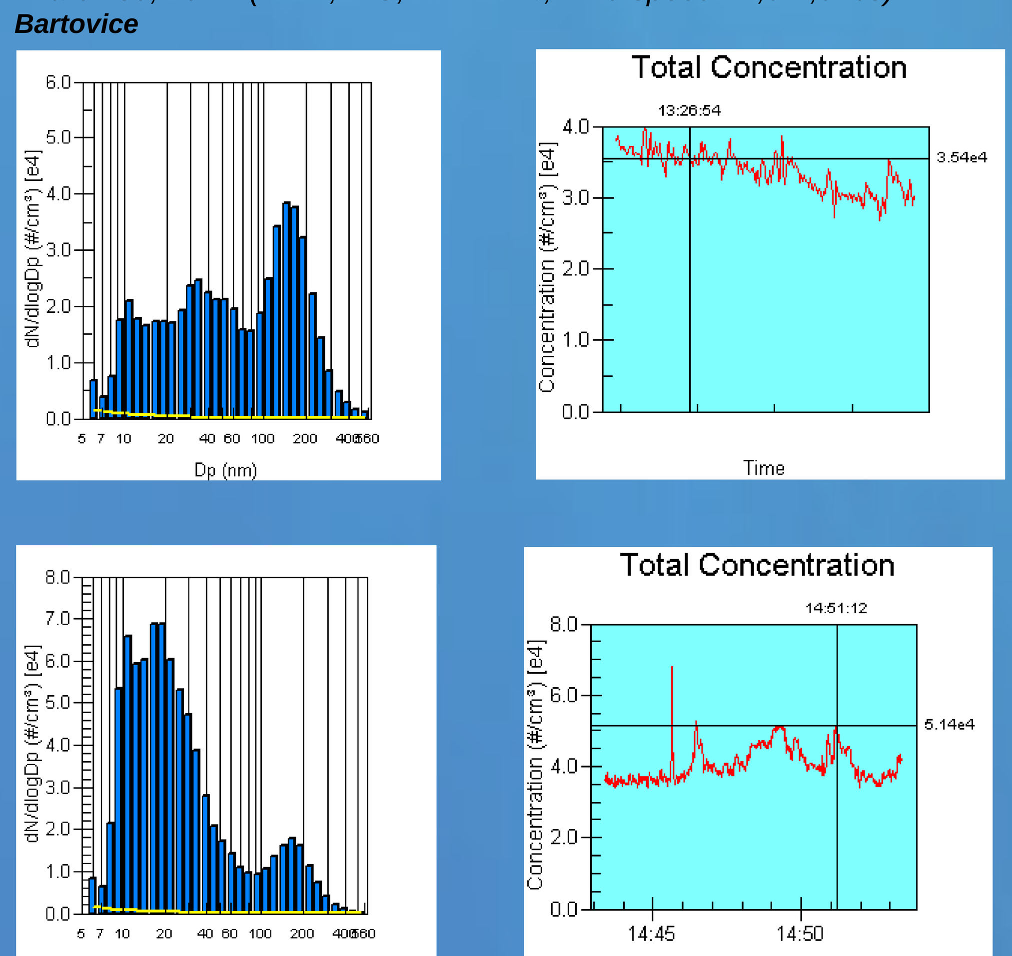


Discussion and conclusion

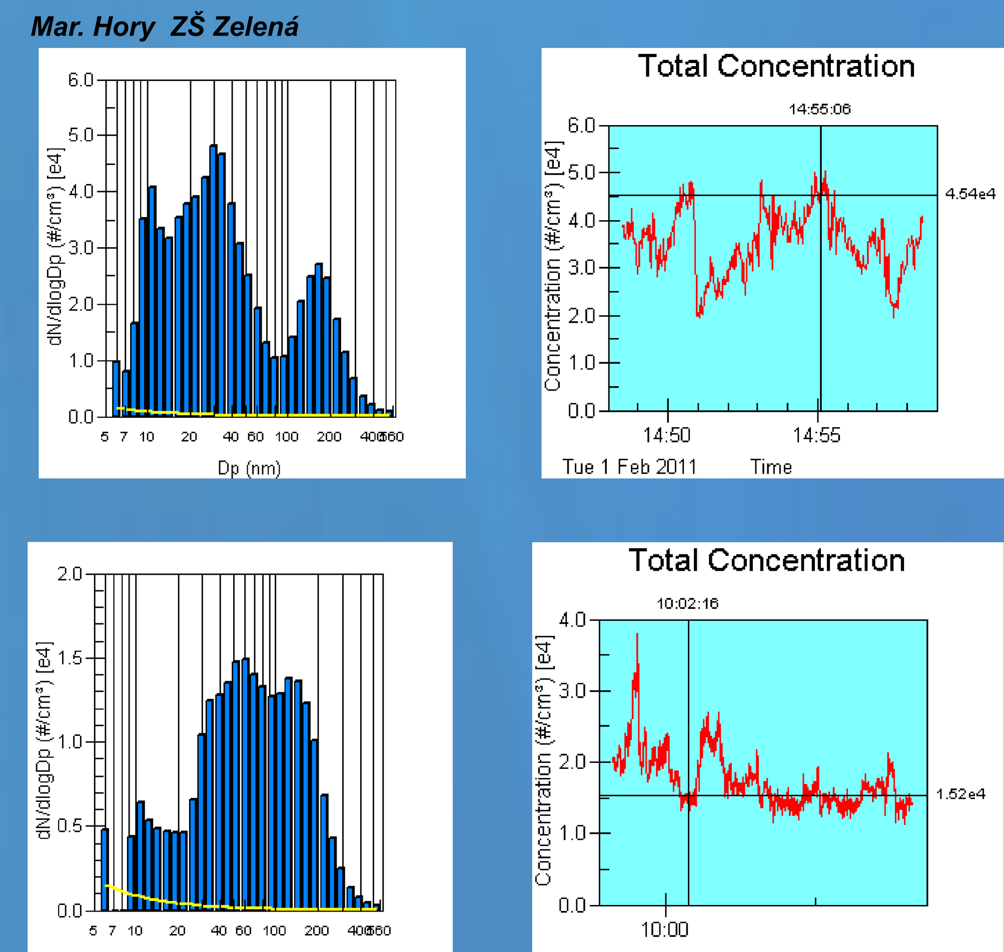
The total particle number and particle size distribution shows remarkable variations in all localities. The run of continuous monitoring of 20 – 500 nm nanoparticles at Zelená street locality in the city centre reflects influence of transportation and is characterised by concentration peaks of raw particle couts in typical hours of city transport activity. Short episodes from the same daytime measurement by spectrometer with 1 sec response show that during a 15 minute period, necessary for continuos spectrometer equalization of the concentration of particles data, the particle size distribution modality does not change significantly, but the total concentration weight by number of particles can range over two orders.

Fig. 2: Comparison of particle size distribution and concentration of submicron particles at 5.6 – 560nm range at four Ostrava localities on March 30, 2011.
February 2, 2011, (T= - 5,6 °C, RH= 80%, wind speed =4,5 m/s)
March 30, 2011 (T=24,1 °C, RH=22 %, wind speed =2,0-4,0m/s)

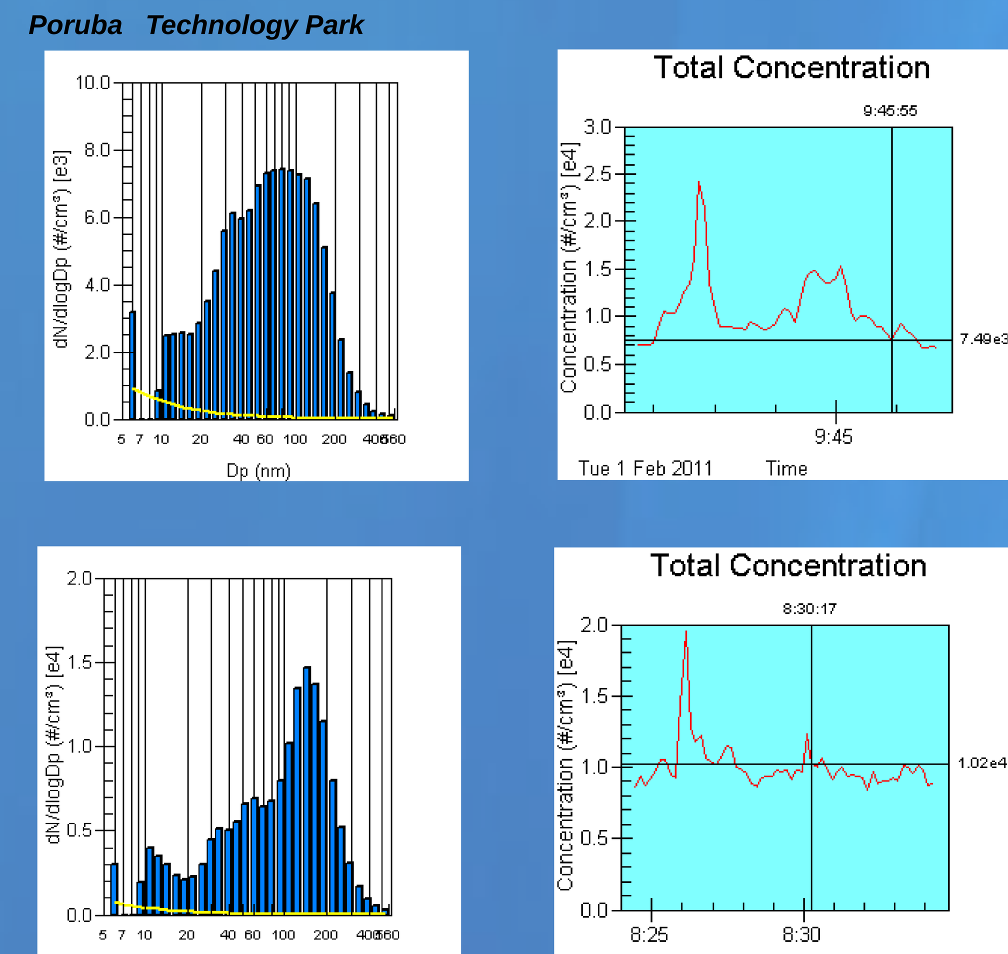
Bartovice



Mar. Hory ZŠ Zelená



Poruba Technology Park



Institut of Public Health

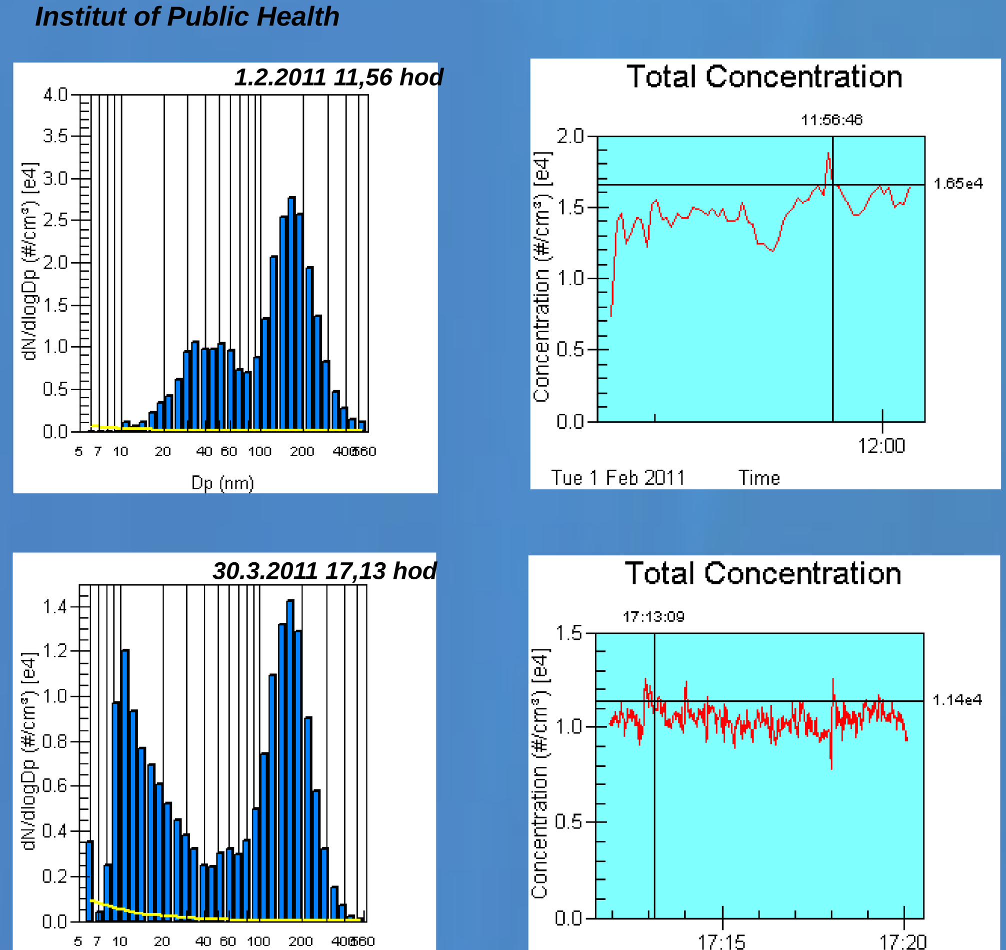
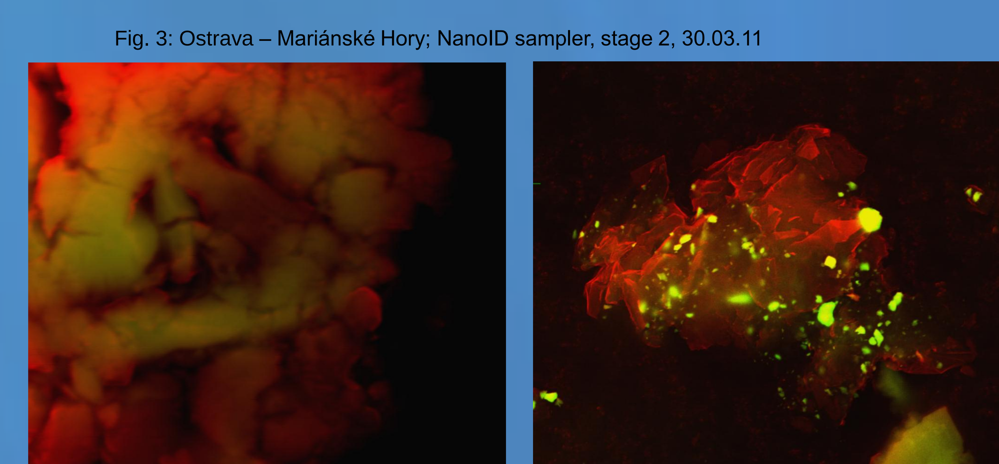


Fig. 3: Ostrava – Mariánské Hory; NanoID sampler, stage 2, 30.03.11



Detail of Pb particle

Lead particles trapped in soot's matrix

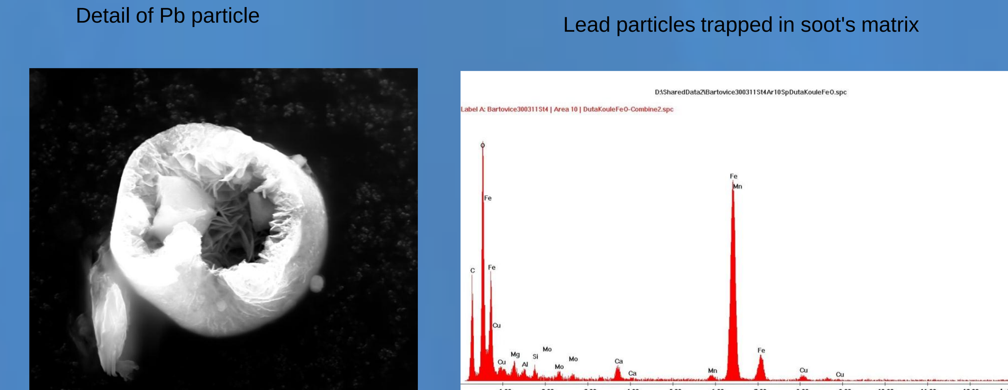


Fig. 4: Hollow particle of iron oxide; NanoID sampler, stage 4, 30.03.11

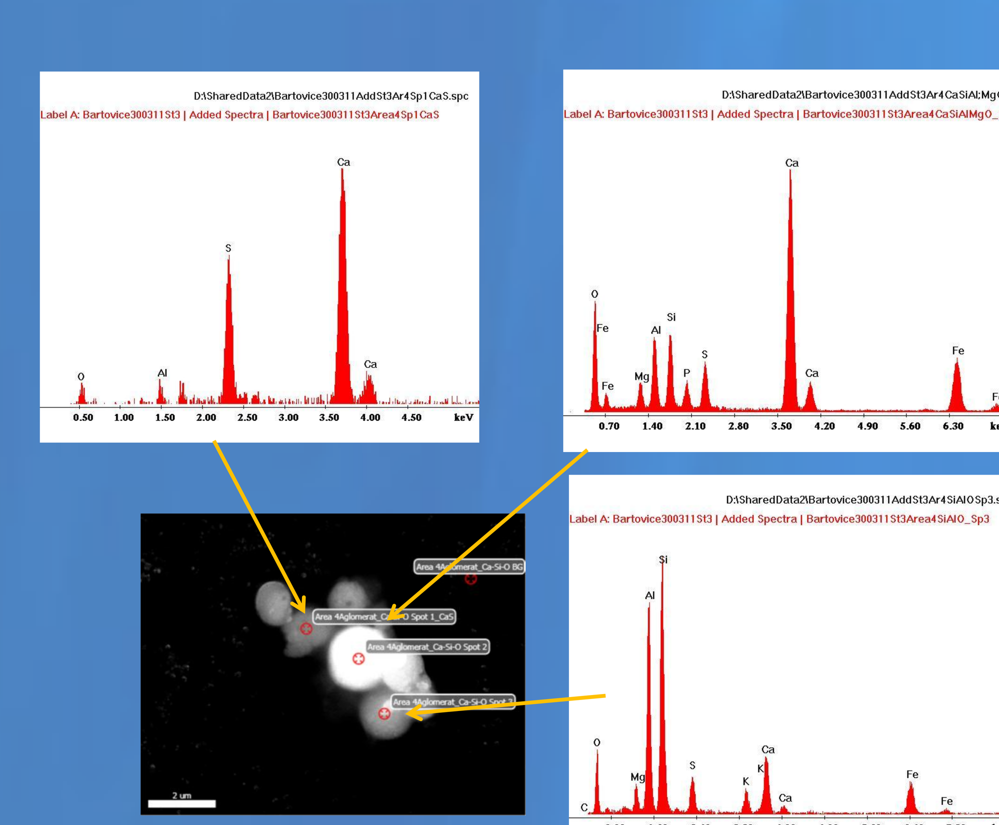


Fig. 5: Agglomerate particles – molten slag is very likely to be the source of this formation