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Characterisation of the filter inlet system on the FAAM BAe-146 research aircraft and its use for size-resolved aerosol composition measurements

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Effect of temperature in the inlet characterization equations

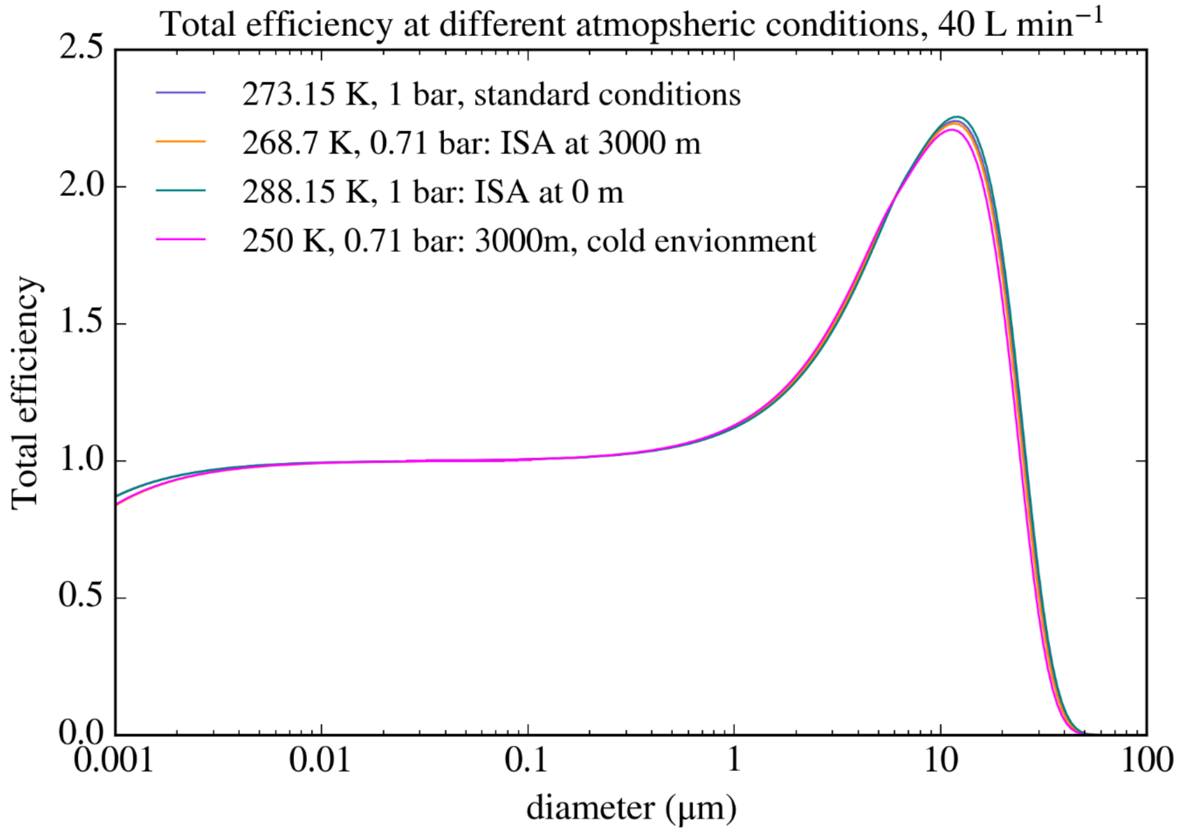


Figure S1. Total efficiency of the inlet system at 40 L min-1 at different atmospheric conditions based on all the mechanisms described in Sect. 2.2. Different sets of pressure and temperature have been chosen; the first one corresponds to standard conditions, the second and third correspond to values at 0 and 3000 m (the operational range of the filter inlet system) given by the International Standard Atmosphere (ISA) model. The last one corresponds to the pressure at 3000 m given by the ISA but at a colder temperature.

SEM aerosol particle classification scheme

The classification was done within the AZtecFeature software by Oxford instruments. The software allows the user to create a custom made categorisation scheme based on the chemical and morphological properties of the features detected by the software. Each particle is tested against a set of rules in order to categorise them (we introduce the flow chart of rules below). In this study the 32 raw categories are simplified into 10 atmospherically relevant categories. For a particular dataset, the number of categories could be increased or decreased if necessary according to the characteristics of the sample.

For some unclear reason, the secondary peaks of the Ir peak can be mislabelled as minor (but detectable) concentrations of other elements as Si and Cu. We noticed that these EDS peaks coming from random places of the filter, not only aerosol particles. As a consequence, we observed that a carbonaceous particle (especially the small ones) could be wrongly labelled as Si only or Metal rich (Cu). Therefore, we added some rules in the classification scheme to avoid this problems (rules 2 and 28). These rules may not work for all the Si and Cu artefacts, and they may also hide some actual signals of Si and Cu coming from aerosol particles, but adding them creates a more representative analysis.

As mentioned in the Sect. 4, all the Cr dominated particles were removed from the analysis since they are very likely to be artefacts from the filter as one can see in the Fig. S1, where the size-resolved composition of blank and handling blank filters is presented. For an individual case in which Cr is a very frequent element, they could be included if necessary.

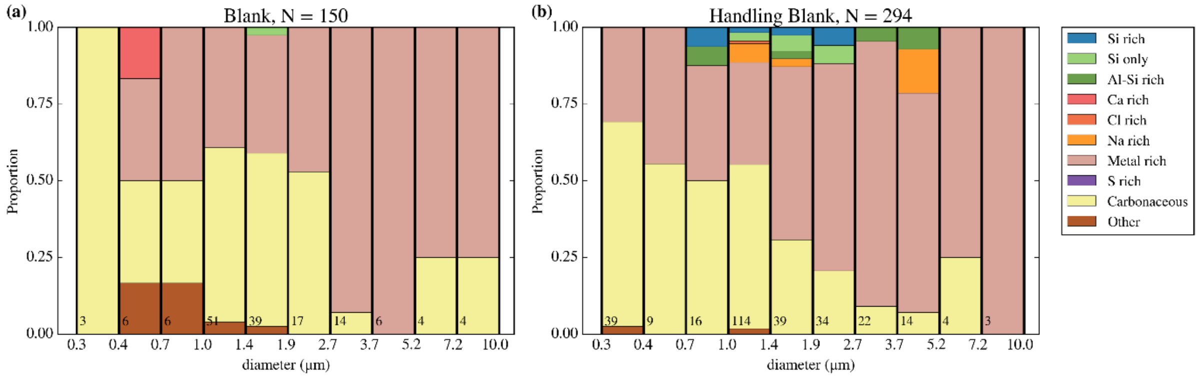
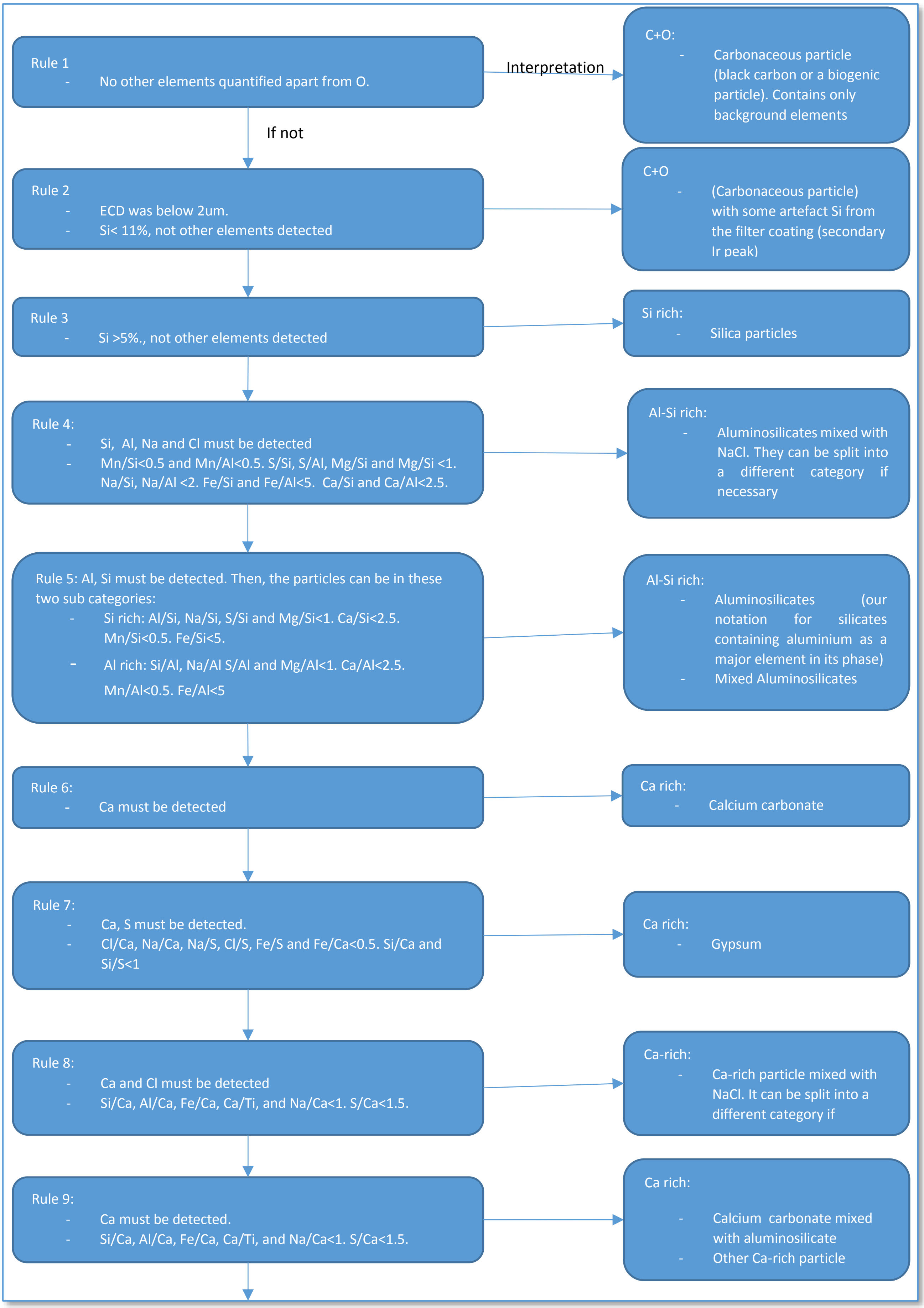
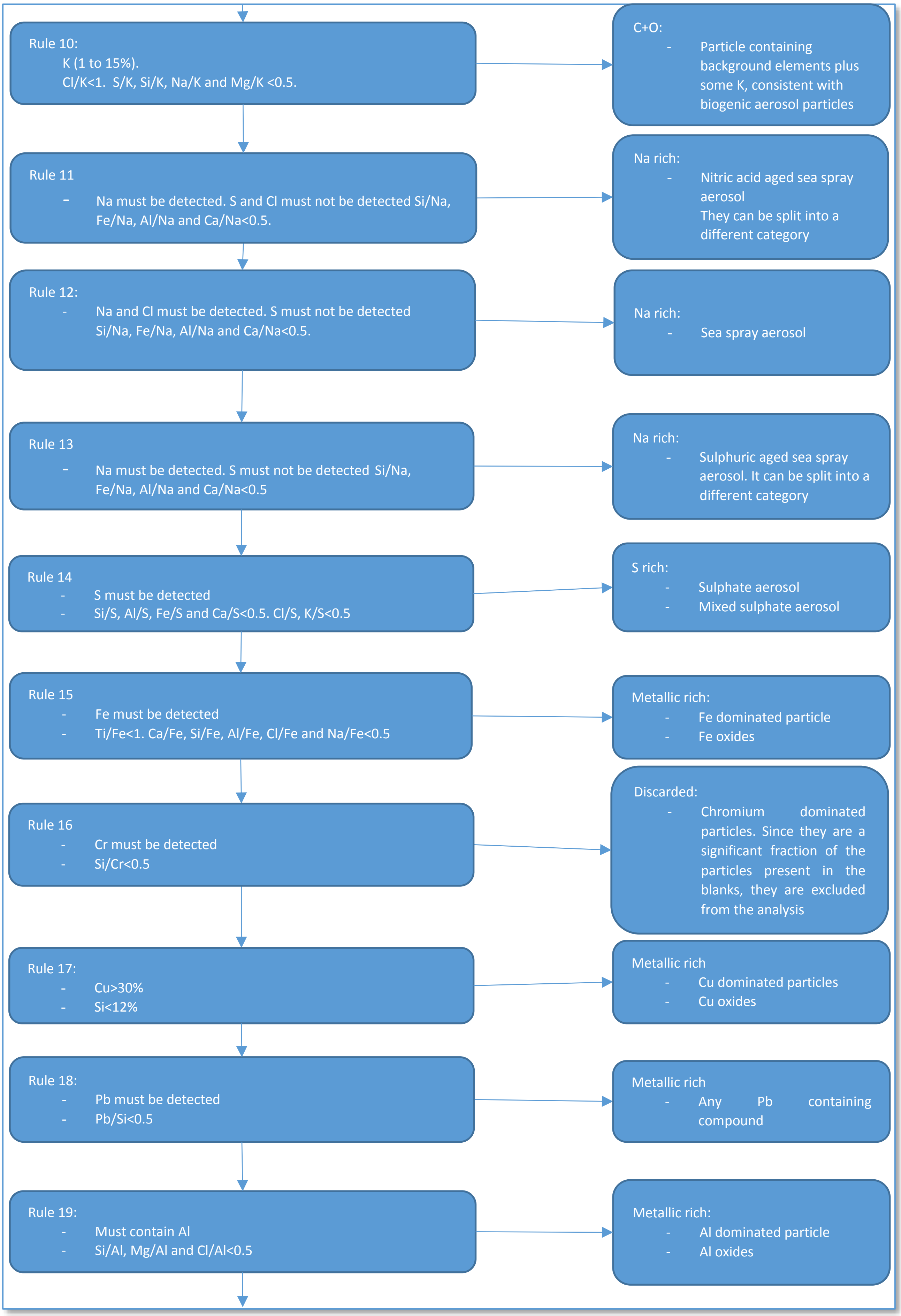


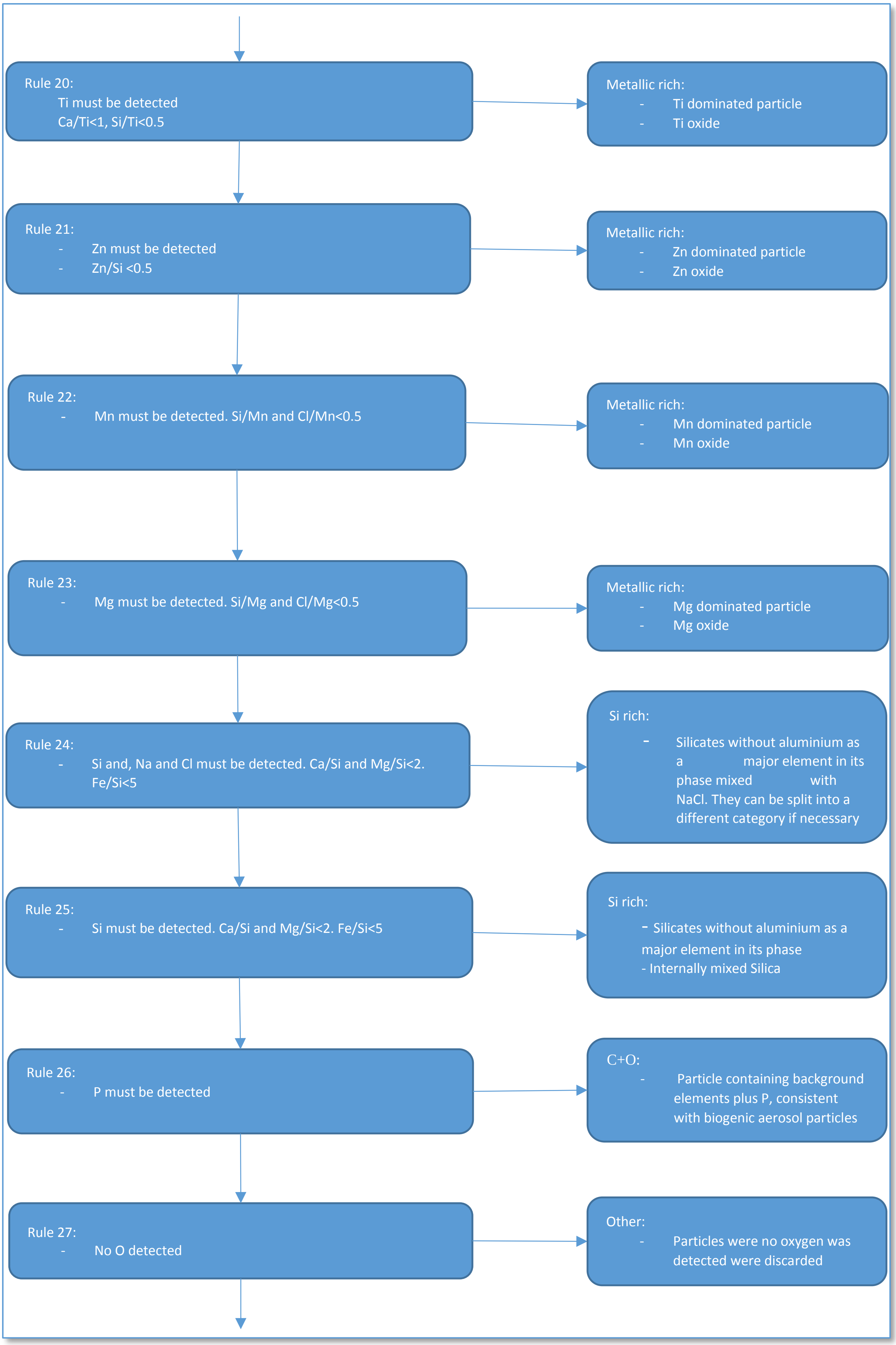
Fig. S2. Size segregated composition of the artefact particles found in 3 blank filters (a) and a handling blank filter (b). The number of particles analysed in each case appears in each image. Almost all the particles present in the Metallic rich category (97 and 96 % respectively) were Cr rich particles.

In Fig. S2 one can see the classification scheme. C and Ir are present in the filter material and coating at all locations on the filter, therefore these elements have been excluded from the classification analysis. O is also a background element, but has been included to aid particle identification. Elemental totals (excluding C and Ir) were normalised to 100% and then classified by AZtecFeature using the rules described in the figure SI 3. Even though it is not stated in each rule, O detection was a requirement in all the rules. If the morphological and chemical properties of a particle match with a particular rule in the scheme, the particle is labelled with that rule. One or more rules can be summarised as a category when plotting the data. We have summarised all the rules into 10 categories, which were explained in Sect. 7 of the main text. An interpretation of the type of aerosol particle for each rule is also given in the table, as well as the final category it belongs to. The number of categories can be changed if the conditions of the sample need it, for example, Al-Si rich particles could be split into Al-Si rich particles containing Na+Cl (rule 4) and Al-Si rich particles not containing Na+Cl (rule 5). This would be interesting, for example if studying the mixing of mineral dust with sea spray aerosol in a particular environment.


Rule 1
- No other elements quantified apart from O.
Interpretation
C+O:
- Carbonaceous particle (black carbon or a biogenic particle). Contains only background elements
If not
Rule 2
- ECD was below 2um.
- Si< 11%, not other elements detected
C+O
- (Carbonaceous particle) with some artefact Si from the filter coating (secondary Ir peak)
Rule 3
- Si >5%., not other elements detected
Si rich:
- Silica particles
Rule 4:
- Si, Al, Na and Cl must be detected
- Mn/Si<0.5 and Mn/Al<0.5. S/Si, S/Al, Mg/Si and Mg/Si <1. Na/Si, Na/Al <2. Fe/Si and Fe/Al<5. Ca/Si and Ca/Al<2.5.
Al-Si rich:
- Aluminosilicates mixed with NaCl. They can be split into a different category if necessary
Rule 5: Al, Si must be detected. Then, the particles can be in these two sub categories:
- Si rich: Al/Si, Na/Si, S/Si and Mg/Si<1. Ca/Si<2.5. Mn/Si<0.5. Fe/Si<5.
- Al rich: Si/Al, Na/Al S/Al and Mg/Al<1. Ca/Al<2.5. Mn/Al<0.5. Fe/Al<5
Al-Si rich:
- Aluminosilicates (our notation for silicates containing aluminium as a major element in its phase)
- Mixed Aluminosilicates
Rule 6:
- Ca must be detected
Ca rich:
- Calcium carbonate
Rule 7:
- Ca, S must be detected.
- Cl/Ca, Na/Ca, Na/S, Cl/S, Fe/S and Fe/Ca<0.5. Si/Ca and Si/S<1
Ca rich:
- Gypsum
Rule 8:
- Ca and Cl must be detected
- Si/Ca, Al/Ca, Fe/Ca, Ca/Ti, and Na/Ca<1. S/Ca<1.5.
Ca-rich:
- Ca-rich particle mixed with NaCl. It can be split into a different category if
Rule 9:
- Ca must be detected.
- Si/Ca, Al/Ca, Fe/Ca, Ca/Ti, and Na/Ca<1. S/Ca<1.5.
Ca rich:
- Calcium carbonate mixed with aluminosilicate
- Other Ca-rich particle



Rule 10:
K (1 to 15%).
Cl/K<1. S/K, Si/K, Na/K and Mg/K <0.5.
C+O:
- Particle containing background elements plus some K, consistent with biogenic aerosol particles
Rule 11
- Na must be detected. S and Cl must not be detected Si/Na, Fe/Na, Al/Na and Ca/Na<0.5.
Na rich:
- Nitric acid aged sea spray aerosol
They can be split into a different category
Rule 12:
- Na and Cl must be detected. S must not be detected Si/Na, Fe/Na, Al/Na and Ca/Na<0.5.
Na rich:
- Sea spray aerosol
Rule 13
- Na must be detected. S must not be detected Si/Na, Fe/Na, Al/Na and Ca/Na<0.5
Na rich:
- Sulphuric aged sea spray aerosol. It can be split into a different category
Rule 14
- S must be detected
- Si/S, Al/S, Fe/S and Ca/S<0.5. Cl/S, K/S<0.5
S rich:
- Sulphate aerosol
- Mixed sulphate aerosol
Rule 15
- Fe must be detected
- Ti/Fe<1. Ca/Fe, Si/Fe, Al/Fe, Cl/Fe and Na/Fe<0.5
Metallic rich:
- Fe dominated particle
- Fe oxides
Rule 16
- Cr must be detected
- Si/Cr<0.5
Discarded:
- Chromium dominated particles. Since they are a significant fraction of the particles present in the blanks, they are excluded from the analysis
Rule 17:
- Cu>30%
- Si<12%
Metallic rich
- Cu dominated particles
- Cu oxides
Rule 18:
- Pb must be detected
- Pb/Si<0.5
Metallic rich
- Any Pb containing compound
Rule 19:
- Must contain Al
- Si/Al, Mg/Al and Cl/Al<0.5
Metallic rich:
- Al dominated particle
- Al oxides


Rule 20:
Ti must be detected
Ca/Ti<1, Si/Ti<0.5
Metallic rich:
- Ti dominated particle
- Ti oxide
Rule 21:
- Zn must be detected
- Zn/Si <0.5
Metallic rich:
- Zn dominated particle
- Zn oxide
Rule 22:
- Mn must be detected. Si/Mn and Cl/Mn<0.5
Metallic rich:
- Mn dominated particle
- Mn oxide
Rule 23:
- Mg must be detected. Si/Mg and Cl/Mg<0.5
Metallic rich:
- Mg dominated particle
- Mg oxide
Rule 24:
- Si and, Na and Cl must be detected. Ca/Si and Mg/Si<2. Fe/Si<5
Si rich:
- Silicates without aluminium as a major element in its phase mixed with NaCl. They can be split into a different category if necessary
Rule 25:
- Si must be detected. Ca/Si and Mg/Si<2. Fe/Si<5
Si rich:
- Silicates without aluminium as a major element in its phase
- Internally mixed Silica
Rule 26:
- P must be detected
C+O:
- Particle containing background elements plus P, consistent with biogenic aerosol particles
Rule 27:
- No O detected
Other:
- Particles were no oxygen was detected were discarded

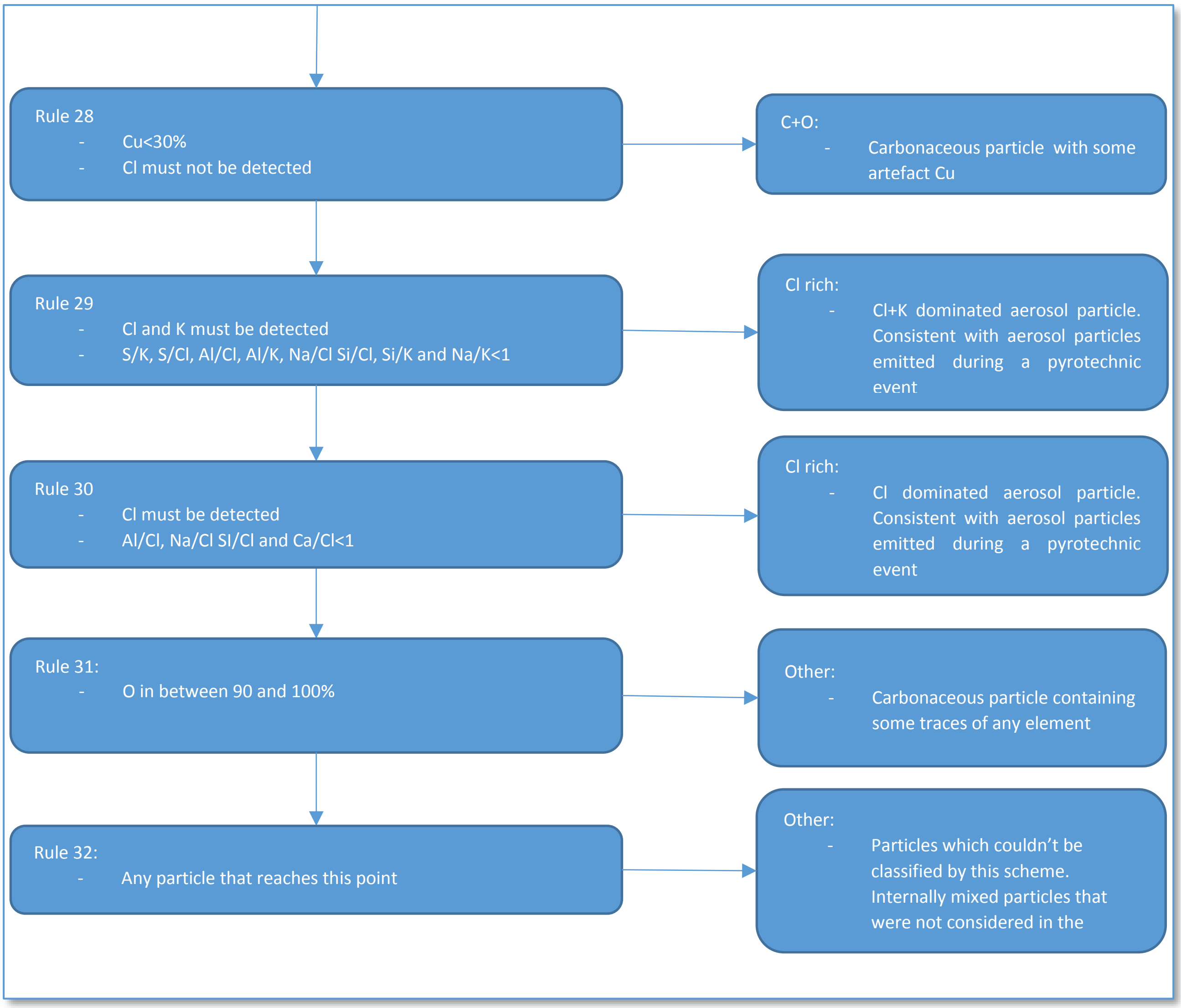


Figure S3. Description of the classification scheme. The 32 sets of rules used to categorise aerosol particles can be seen in a descendant order. C and Ir was excluded from all the particles for this analysis. In spite of not being mentioned, presence of O was required in all the sets of rules.