ESTABLISHING THE SCIENTIFIC BURDEN OF PROOF IN WILDFIRE SMOKE DAMAGE CLAIMS

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FORENSIC BURDEN OF PROOF IN FIRE CLAIMS - OVERVIEW

- **The investigation must specifically address the claims or allegations being made in the case.**
- **No single piece of evidence will likely solve the case.**
- **Cumulative "*more likely than not*" evidence will determine whether allegations are true, false, or unresolved.**
- **Laboratory analysis results alone will not directly solve claims of "damage" or "contamination".**
- **The burden of proof usually comes down to "proving a negative", or assembling enough evidence to support opposing claims.**

COMPONENTS OF A WILDFIRE

- A "wildfire" is complex mix of combusted materials including lofted soil and vegetation produced by "fire-storm" winds.

- No single analysis tool will give us a concise "silver bullet" answer.

- This complexity often allows differentiation from other combustion sources.

Conventional monitoring parameters

- Transitional acid gases
- Semi-volatiles, VOC's, metals
- Semi-volatile soot / resinous particles
- Quantification of combustion particles (soot, char, ash)

"Assemblage" parameters

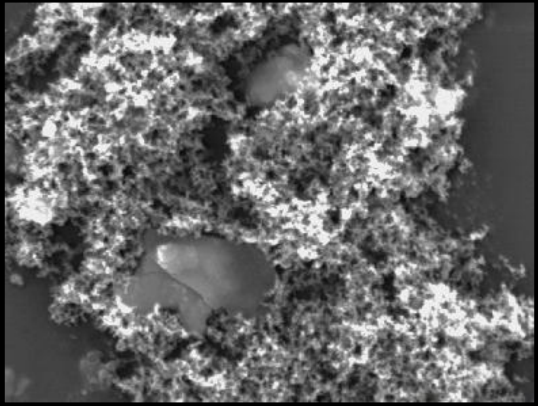
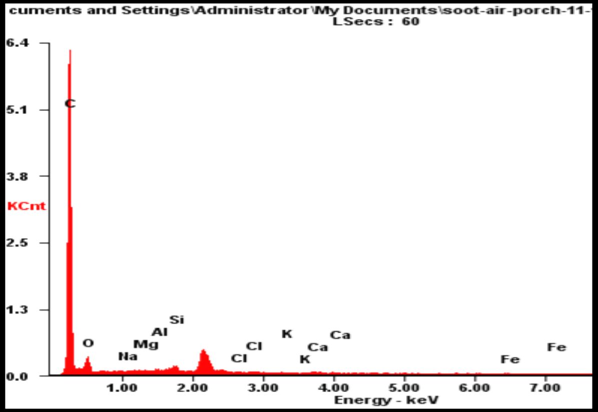
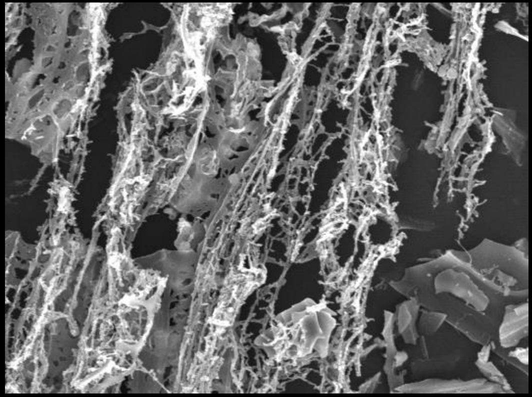
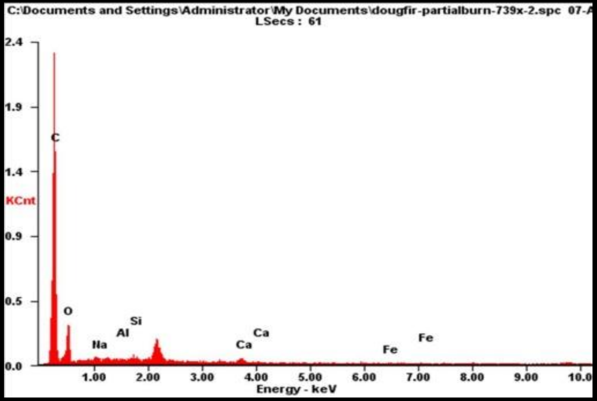
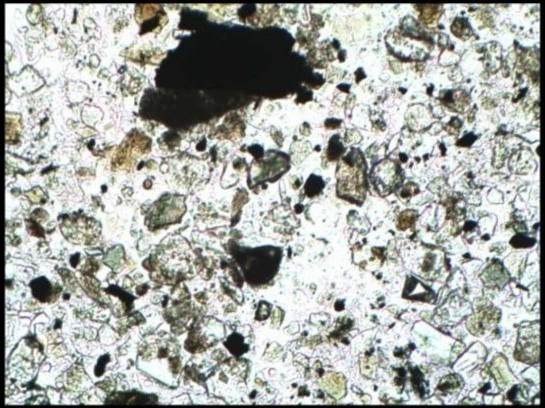
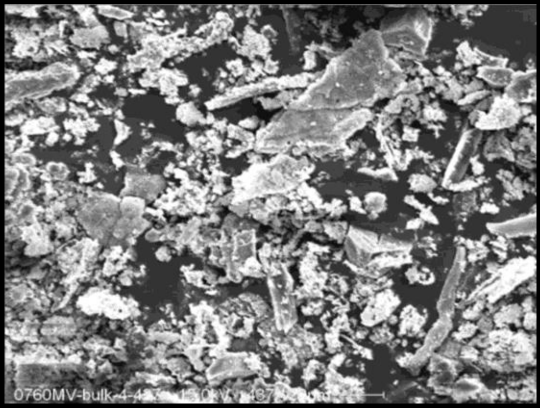
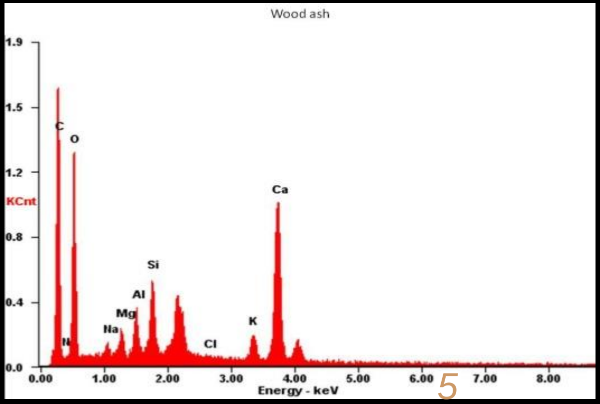
- Re-entrained and wind-lofted "burned" soil particles
- "Identified" vegetation types within the char particles
- Identified components within "ash" (i.e. burned pollen, phytoliths, etc.)

COMPONENTS OF A CAMPFIRE

Photograph 12: Forest After a Wildfire (Las Conchas)

Most of the wood is still present but the leaves, needles, small twigs and some of the bark have been burned and were carried away as smoke particles.

“GENERAL” FIRE RESIDUE PARTICLE CLASSIFICATION

	Optical Microscopy	SEM	Dispersive X-ray
Soot			
Char			
Ash			

Determining Chemical Indicators: Literature Review

Schauer et al., EnvSciTech, 200
n-alkanes
branched alkanes
n-alkenes
branched alkenes
alkynes
diolefins
cycloalkanes
cycloalkenes
aromatic hydrocarbons
polycyclic aromatic hydrocarbon
phenol and substituted phenols
guaiacol and substituted guaiac
syringol and substituted syringols
aliphatic aldehydes
aliphatic ketones
olefinic aldehydes
aromatic carbonyls
dicarbonyls
n-alkenoic acids
resin acids
Sugars (e.g., levoglucosan)
PAH ketones
other compounds

Clark County, Exceptional Event Report, 2003
PM2.5
Organic carbon
Elemental carbon
Elemental Species
- Potassium
- Chloride

CO
CO2
Alkanes (C2-C10)
Alkenes (C2-C9)
Aromatics (BTEX)
Oxygenated VOCs
- Methanol
- Formic acid

Ward, et al., J AWMA 201
Phenol
2-methylphenol
4-methylphenol
2,4-dimethylphenol
Naphthalene
2-methylnaphthalene
Acenaphthylene
Acenaphthene
Dibenzofuran
Fluoreneb Phenanthrene
Anthracene
Fluoranthene
Pyrene
Benzo(a)anthracene
thene
hene
hane
nzene
nzene
ne
e
enzene
enzene

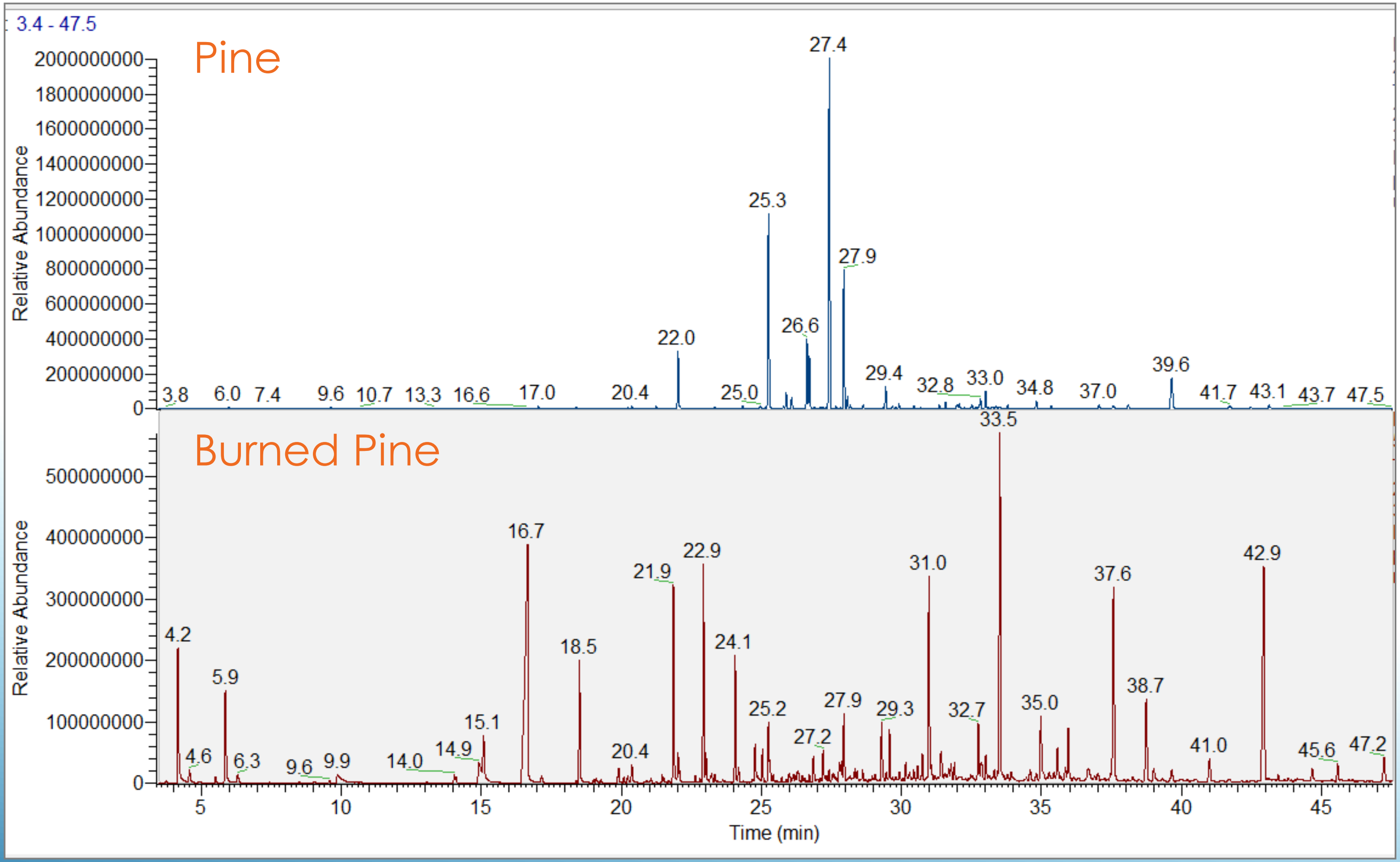
Heitmann et al., Chemosphere 2009, 2011
Acetophenone
Benzyl alcohol
4-Ethyl-2-methoxyphenol
2-Hydroxybenzaldehyde
2-Hydroxy-5-methylbenzaldehyde
2-Methoxyphenol
2-Methoxy-4-methylphenol
2-Methylphenol
3-/4-Methylphenol
Naphthalene

Larson et al., Ann I Health, 1994
Carbon monoxide
Methane
VOCs (Cz--CT)
Aldehydes
Formaldehyde
Acrolein
Propionaldehyde
Butryaldehyde
Acetaldehyde
Furfural
Substituted furans
Benzene
Alkyl benzenes
Toluene
Acetic acid
Formic acid
Nitrogen oxides (NO,N
Sulfur dioxide
Methyl chloride
Napthalene *Substitute napthalenes*
Oxygenated monoarc
Guaiacol (and deriva
Phenol (anc
Syringol (an
Catechol (c
Total partic
Particulate
Oxygenate
PAHs

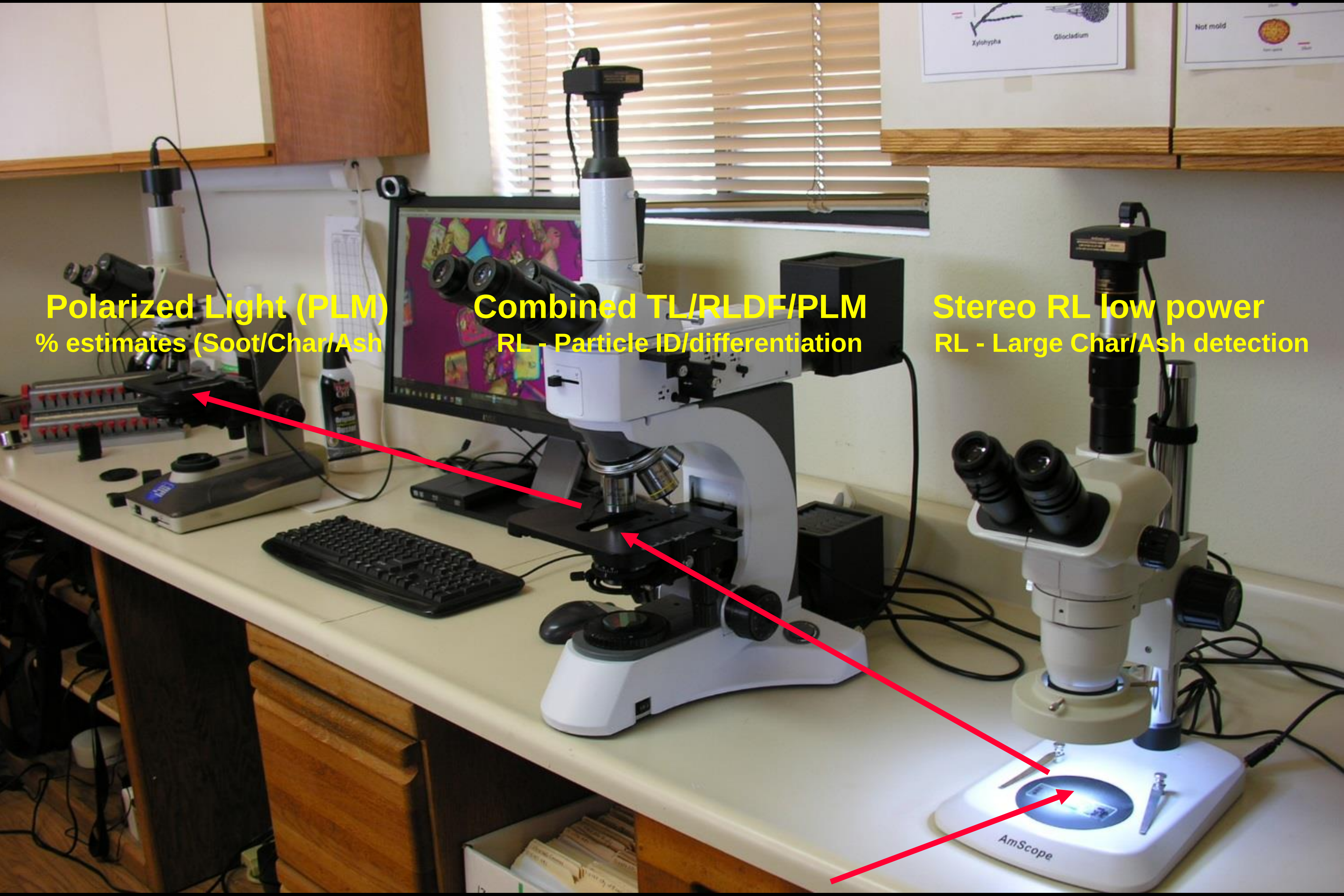
Pechan, Developing NEI-Commercial Cooking: Tech. Memorandum, 2003
VOC
CO
PM
10 PM
2.5 PM
NAPHTHALENE
BENZO[A]PYRENE
ACENAPHTHYLENE
FLUORENE
PHENANTHRENE
FLUORANTHENE
PYRENE
BENZ[A]ANTHRACENE
INDENO[1,2,3-C,D]PYRENE
ACENAPHTHENE
ANTHRACENE
BENZO[G,H,I,]PERYLENE
PAH, TOTAL
BIPHENYL
BENZENE
TOLUENE
ETHYL BENZENE
XYLENES
STYRENE
FORMALDEHYDE
ACETALDEHYDE
DE

Dhammapala et al., Atm Env, 2007
PAHs
Methoxyphenols
Levoglucosan
Elemental Carbon
Organic Carbon

Chemical Indicators - GCMS



Complete Analysis Requires Reflected & Transmitted Light Microscopy



WHAT IS THE FORENSIC RATIONALE IN ADDRESSING FIRE CLAIMS?

3 common allegations encountered in "fire" claims:

- **"Contamination" / Nuisance –**
  Implies the airborne or surface environment is "atypical" or elevated above the normal geographic background, or typical structure utilization.

- **Elevated Health Exposure –**
  The constituents found will produce an adverse impact (disease, irritant, chemical) above normal background.

- **"Damage" –**
  The surfaces or contents have been altered or changed in a manner affecting their appearance, functionality, value, or service life.

WHAT IS THE BURDEN OF PROOF?

More likely than not conclusion "thresholds":

1. "Fire / Combustion residue" is present above the normal or typical background.

2. The "combustion residue" is associated with a specific event, and is <u>not</u> due to other sources or another cause.

3. The level of "combustion residue" could pose a health risk.

4. The condition has caused actual "damage" that significantly alters the pre-loss condition.

5. In order to restore the site to pre-loss condition, cleaning or remediation is required.

Not part of the site investigation but still critical:
Is the alleged loss or event covered in the first place?

WHAT ARE POTENTIAL “DAMAGE” INDICATORS?

- Visual alteration
- Physical alteration
- Chemical alteration
- “Environmental” alteration
- Is the damage temporary or permanent?
- Is simple cleaning, or “restoration” required?
- Can the “damage” be restored to a pre-loss condition?

IS THE “SMOKE” FROM A “WILDFIRE”?

1. The elevated presence of soot, char, and/or ash does not automatically indicate the combustion residue is from a “wildfire”.

2. “Qualitative parameters” and the particle assemblage must also be used to determine if the combustion residue is “consistent” with a “wildfire”.

    - Presence / absence of “large” char and ash particles
    - Presence of “burned” soil or carbonized quartz grains
    - Presence of “burned” pollen grains
    - Presence of plant “phytoliths”

CAN ANALYTICAL TESTING SUPPORT A FINDING OF "DAMAGE" ?

KNOWN FACTS:

- Visual / photographic documentation is the most useful evidence for physical alteration.

- The reactive properties of combustion residue changes over time, and exposure to moisture and UV light.

- Soot / char can cause "cosmetic" / visual alteration and residual odor.

- Wildfire "soot" & "char" are typically at a "neutral" pH and low conductivity. *Result → Actual chemical damage is less certain.*

- The mineral ash components can theoretically cause chemical changes and corrosion in certain materials. At the same time, these components are rarely monitored.

THE INVESTIGATION

Step 1:

GENERAL HISTORY:

Photos of site geography, plume history, meteorological conditions, type of fuel burned, potential re-entrainment, other sources, etc.

SITE CONDITIONS:

Document the presence / absence of physical or visual field evidence (staining, color changes, physical alteration).

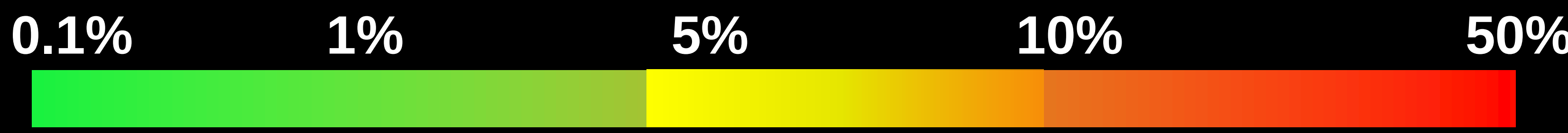
“TYPICAL” vs. “ATYPICAL” FINDINGS?

STEP 2:

Determine if the presence / absence of fire/combustion residue is atypical or above background.

“SUGGESTED” CONTAMINATION GUIDANCE – MICROSCOPY

Optical Microscopy - % Totals of char, ash, & soot-like debris



<1%	**“Typical” or normal background**
1-3%	**“Atypical” conditions unlikely but possible**
3-10%	**“Atypical” conditions are possible to likely.**
>10%	**“Atypical” conditions are present**

Surface fire residue particles - “numerical ratio or area measurements” cannot be directly used as a measure of “damage”.

REMEMBER – The laboratory variability of this type of data is 1% +- 3%

WHAT IS THE SOURCE OF FIRE RESIDUE?

STEP 3:

WHAT IS THE SOURCE?

LABORATORY EVIDENCE:

- **Is the reported “fire residue” assemblage consistent with “wildfire”?**

    Burned soil, carbonized quartz grains, burned pollen, etc.

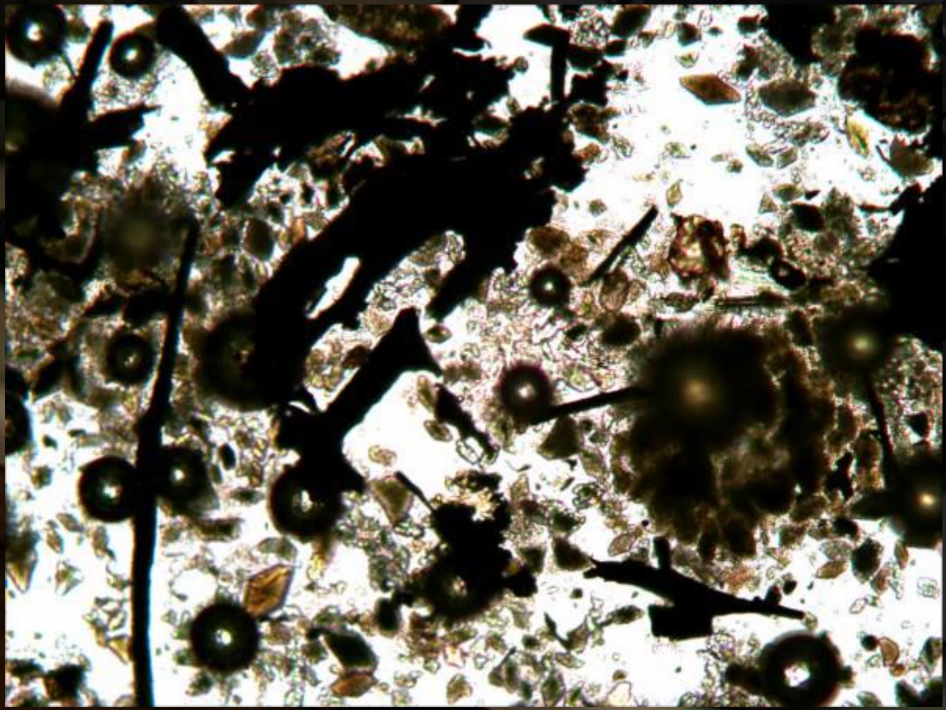
- **Is the ash “fresh” and comprised of caustic components that could cause physical damage?**

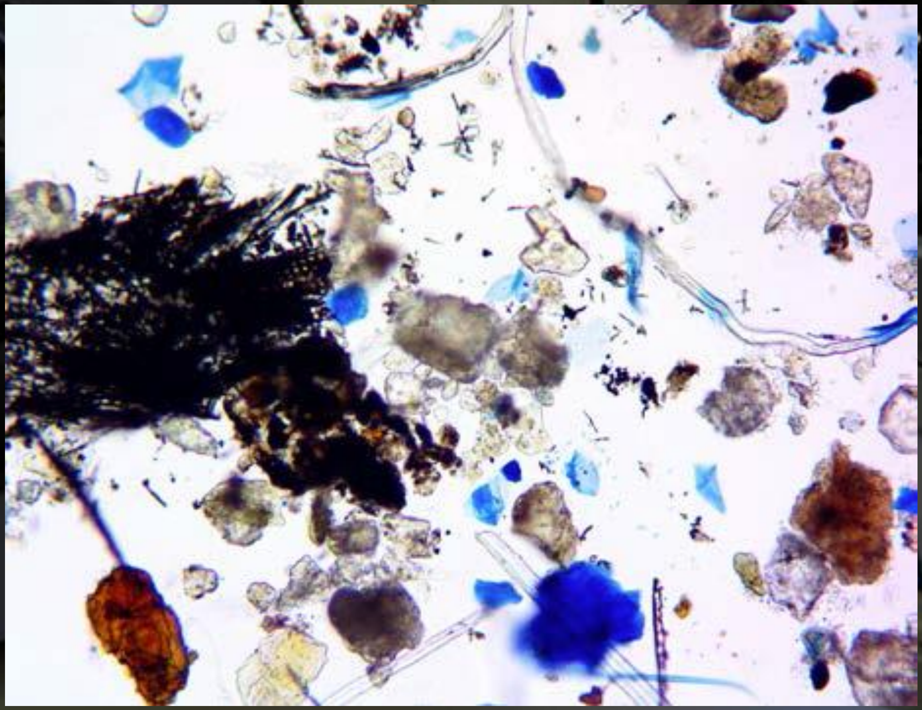
    pH and conductivity analysis

IS THE "SMOKE" FROM A "WILDFIRE"?

QUALITATIVE PARAMETERS ASSEMBLAGE:

Presence of residual "burned" leaf, brush, or grass vegetation
Presence of "burned" pollen grains
Presence of "carbonized" quartz grains
Presence of "burned" clays
Presence of plant "phytoliths"





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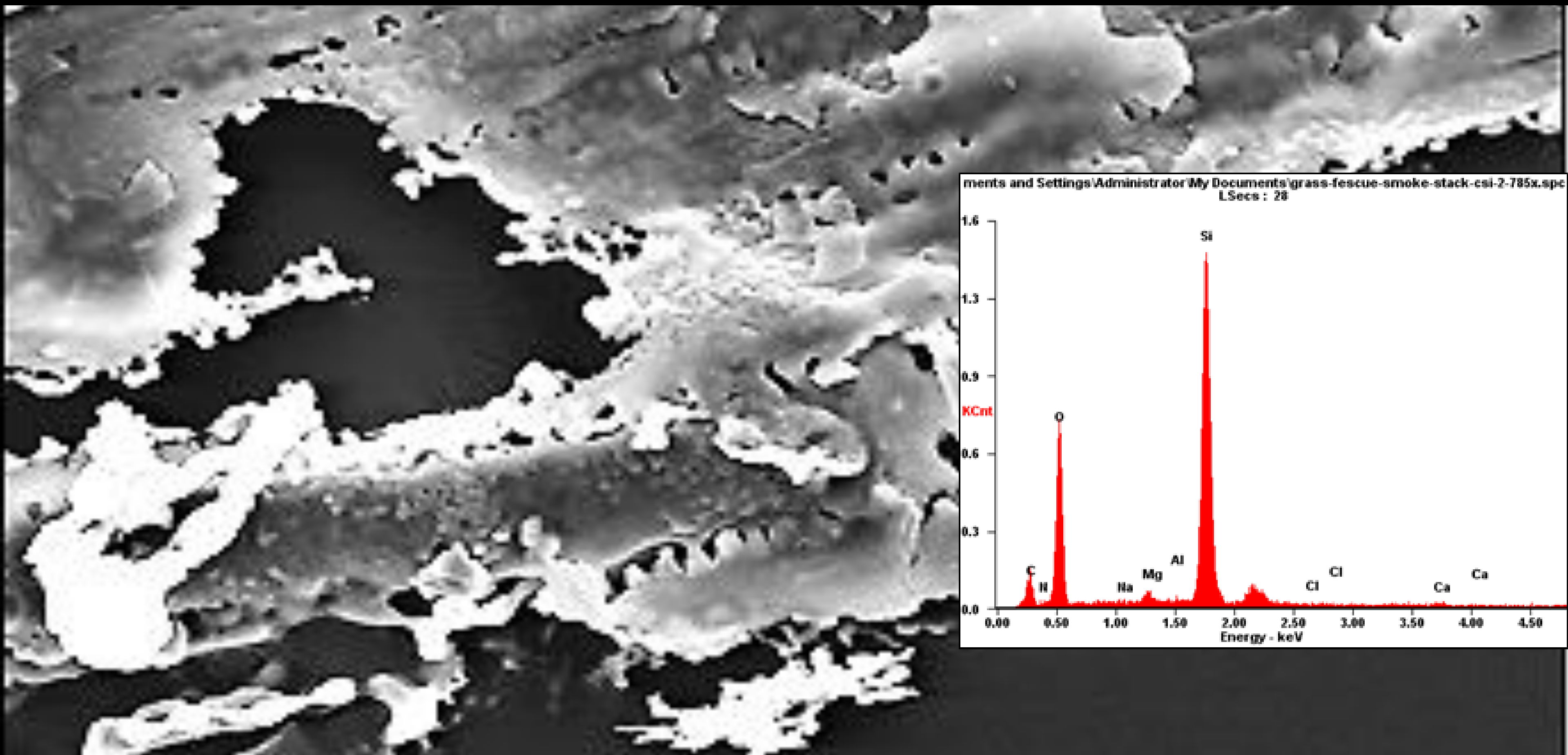
Presence of plant "phytoliths"



Burned & "de-carbonized" grass (Fescue) – 785x

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Presence of residual “burned” vegetation

Presence of “burned” pollen grains

Presence of “carbonized” quartz grains

Presence of “burned” clays

Presence of plant “phytoliths”

Normal pine pollen

“Burned pine pollen

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Presence of "burned" or "carbonized" quartz grains
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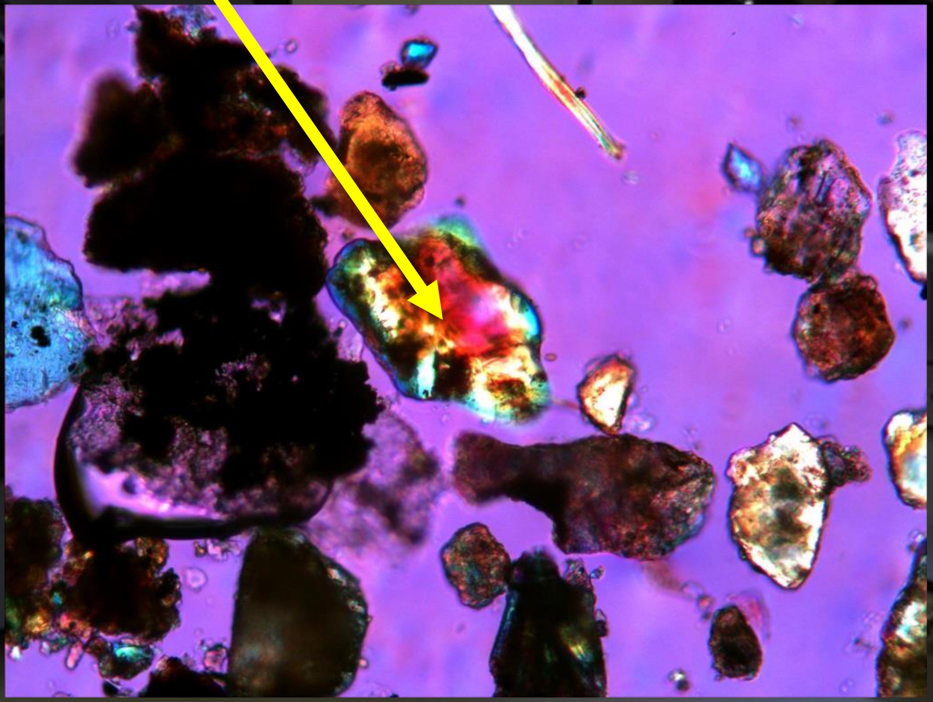

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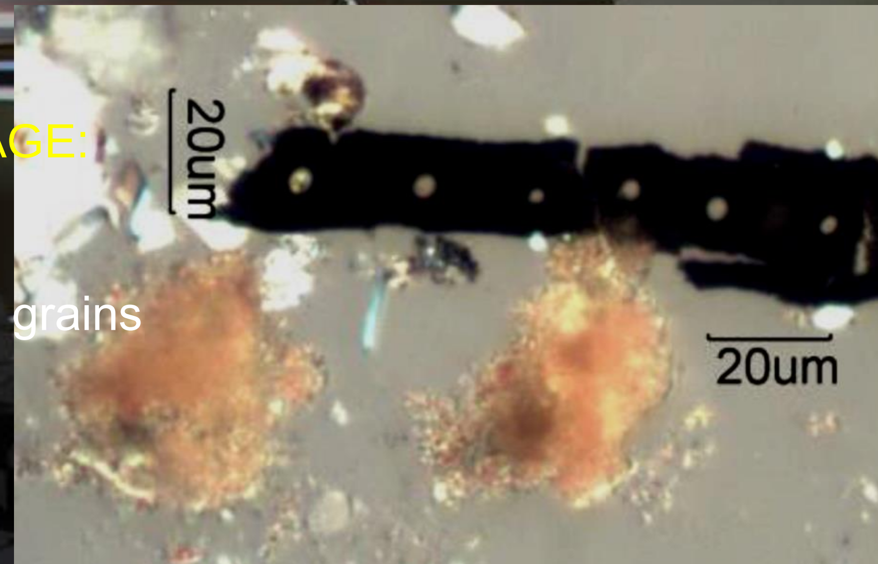
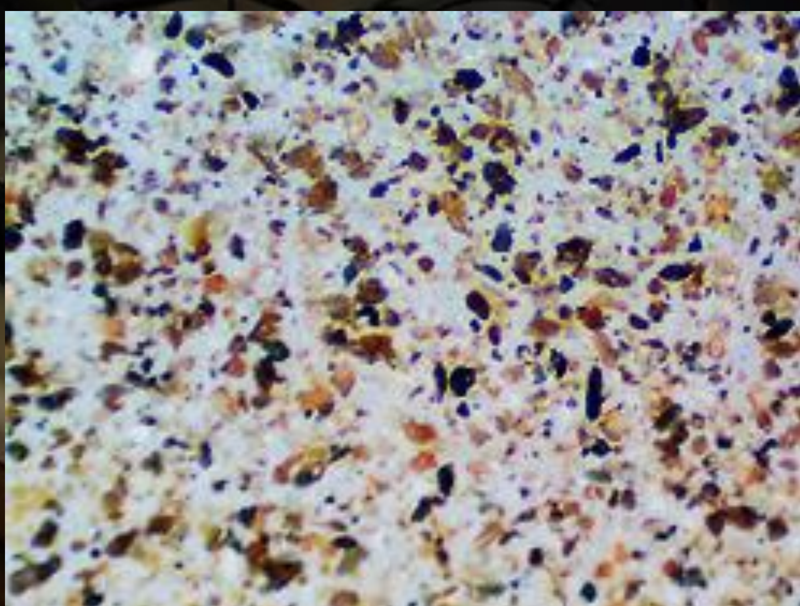
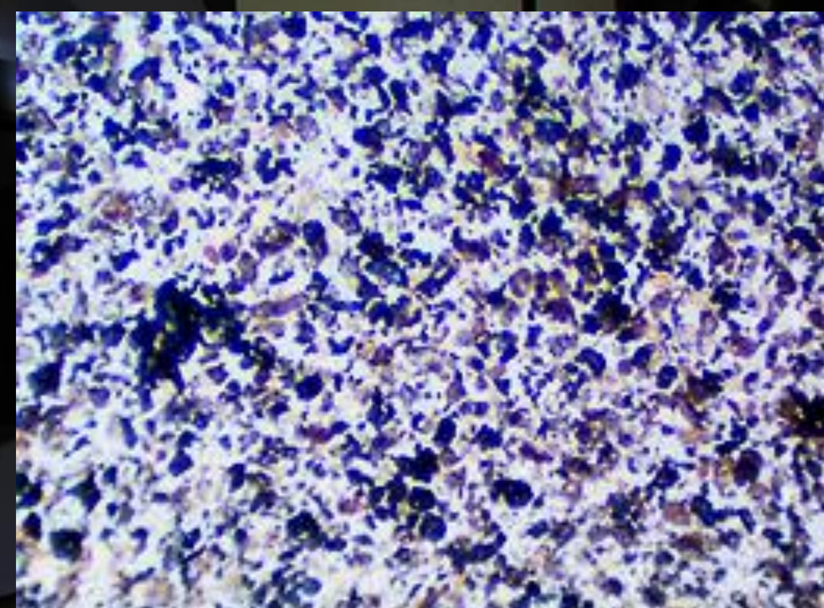


Photo courtesy of MicroLab Northwest – burned clays



“Normal soil” 62um fraction (RL)



“Burned soil” 62um fraction (RL)

IS THE "SMOKE" FROM A "WILDFIRE"?

QUALITATIVE PARAMETERS / ASSEMBLAGE:

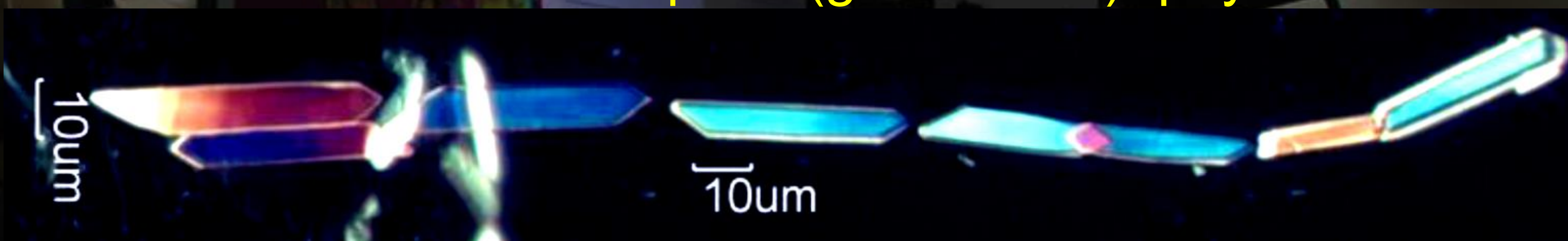
Presence of residual "burned" leaf or grass vegetation

Presence of "carbonized" quartz grains

Presence of "burned" clays

Presence of "burned" pollen grains

Presence of plant (grass / leaf) "phytoliths"



Pine phytolith – Photo courtesy of MicroLab Northwest

Charred silica phytolith- Photos courtesy of MicroLab Northwest

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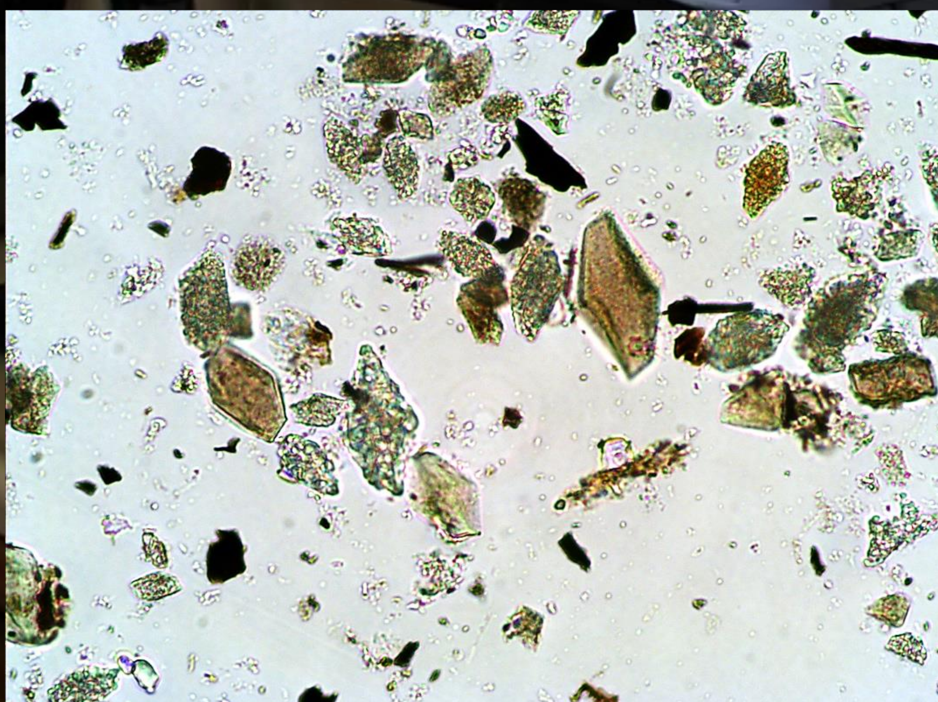
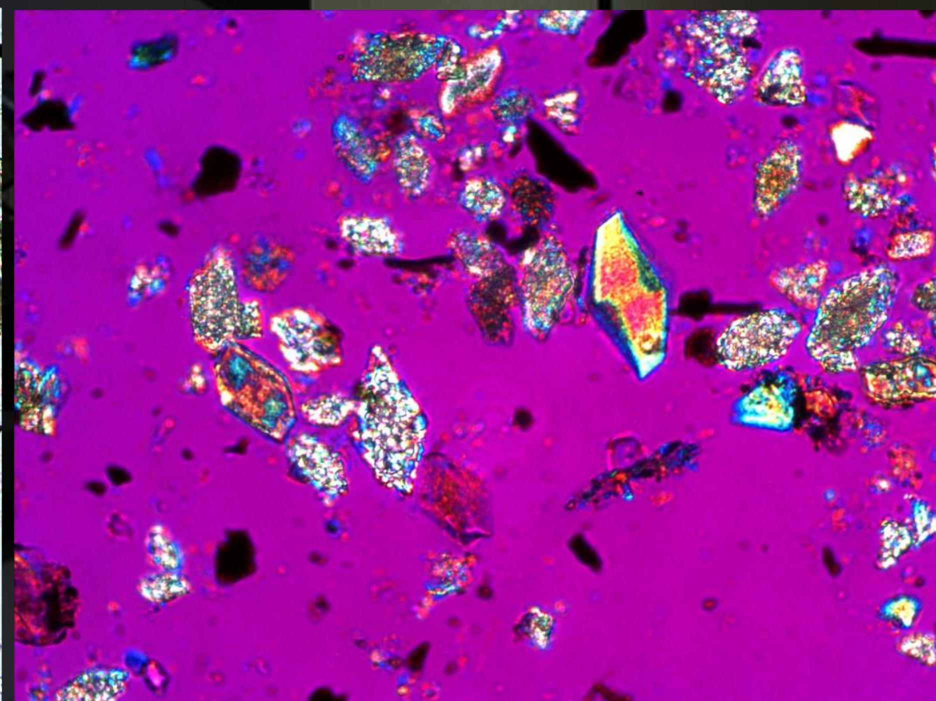
Presence of "burned" pollen grains
Presence of "carbonized" quartz grains
Presence of "burned" clays
Presence of plant (wood / bark) "phytoliths"

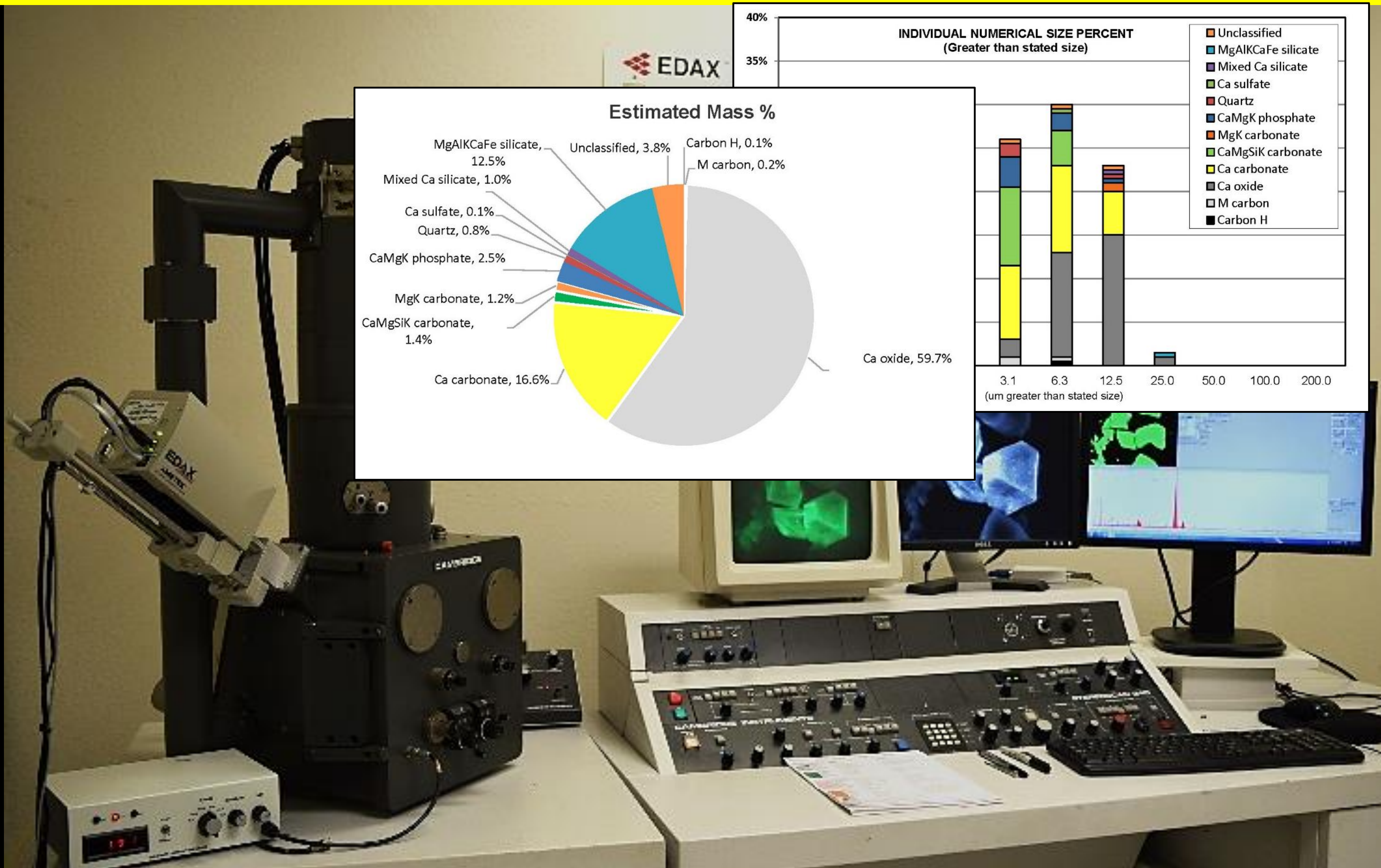




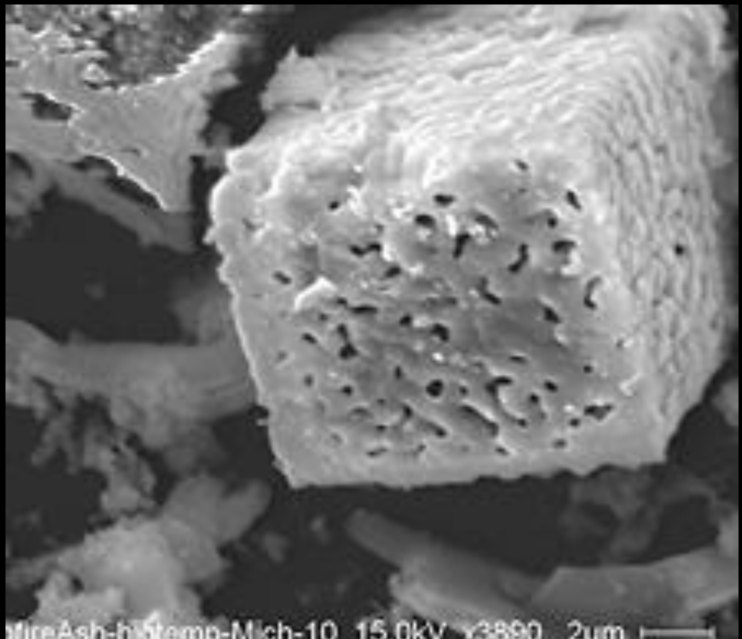
Campfire ash (Primarily Oak) – Bright field / Polarized Light

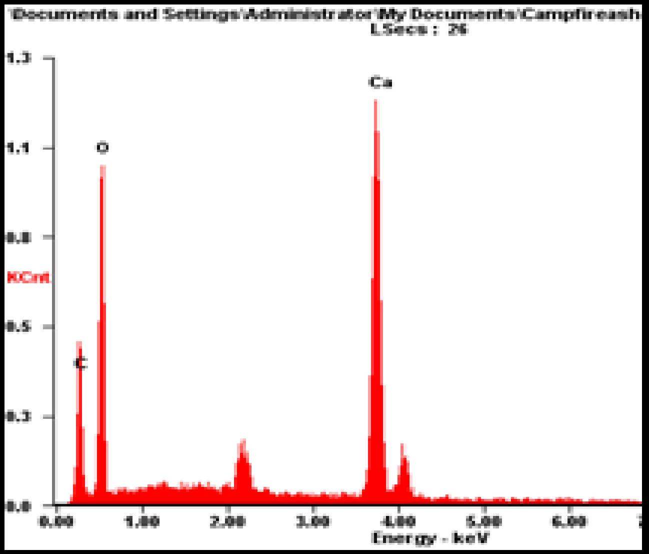
AUTOMATED SEM / X-RAY – Ash / Phytolith Analysis

Definitive morphology, size, and compositional analysis

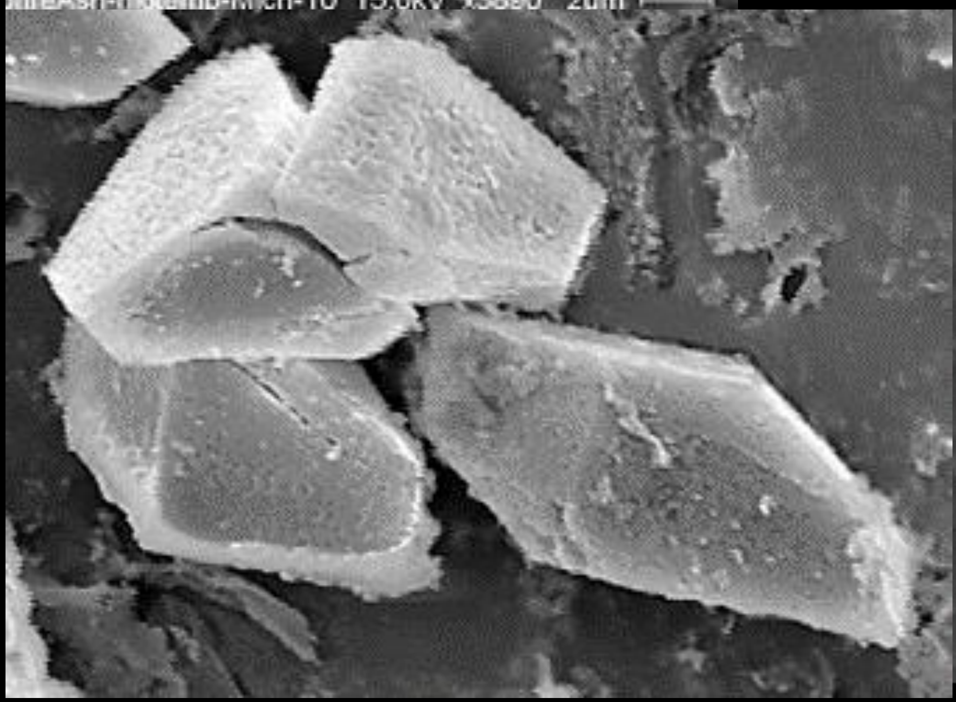


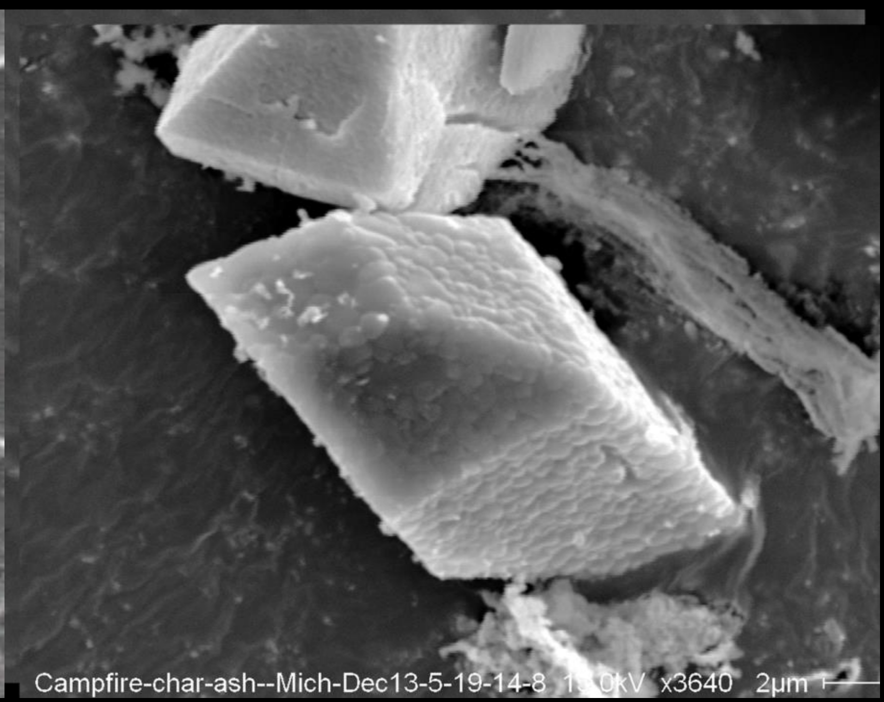
SEM - OAK ASH - INDICATORS





Insoluble salts CalciumOxide / Oxalate) phytoliths





LAB REPORT PARAMETERS?

The <u>burden of proof</u> likely requires the blended analysis of quantitative "fire residue" concentrations, and the presence / absence of assemblage indicators

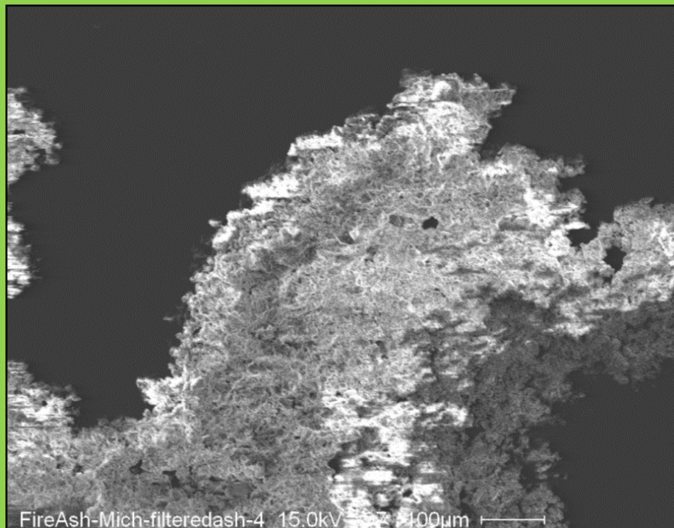
The correct answer is not always defined by the "percentage" in the sample

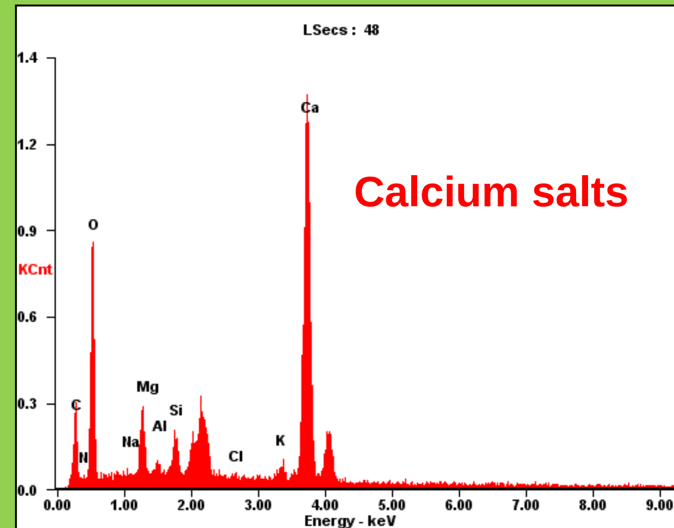
SUMMARY CONCLUSIONS : * Fire/combustion residue measured above typical background concentrations
Qualitative observations indicate the presence of fire/combustion particles

QUALITATIVE ASSEMBLAGE OBSERVATIONS -Reflected Light Microscopy (10-200x) / Polarized Light (100-600x)		
Lab sample description (color /texture)		
Is a smoke or fire odor present ?	No	
Are large char particles observed in reflected or polarized light ?	Yes - isolated	
Are large ash-like particles observed in reflected or polarized light?	No	
Are "burned" soil particles, pollen, or plant phytoliths observed?	Yes - isolated	*<-- Wildland fire indicators*

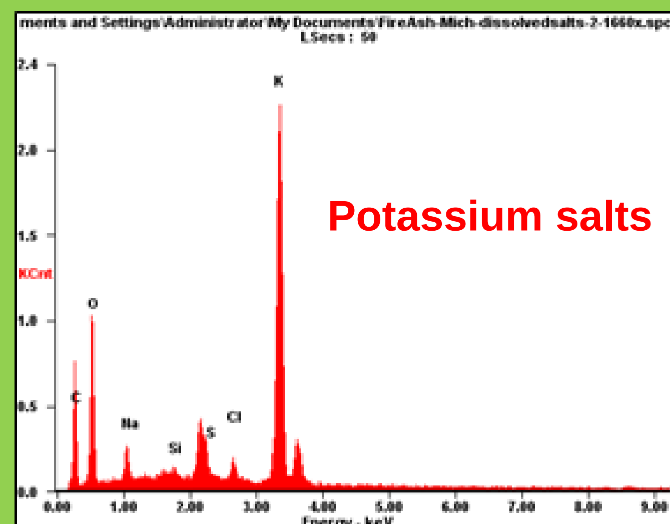
	FIRE / COMBUSTION RESIDUE CONSTITUENTS	**Total %**	**5.5 %**
	Aciniform / soot-like fine particles		not detected
	Char (Pyrolized plant material)		4.8
	Ash -like mineral residue particles		0.2
Other	Burned pollen grains		0.5

OTHER INDICATORS? pH / Conductivity - SOLUBLE vs. NON-SOLUBLE ASH





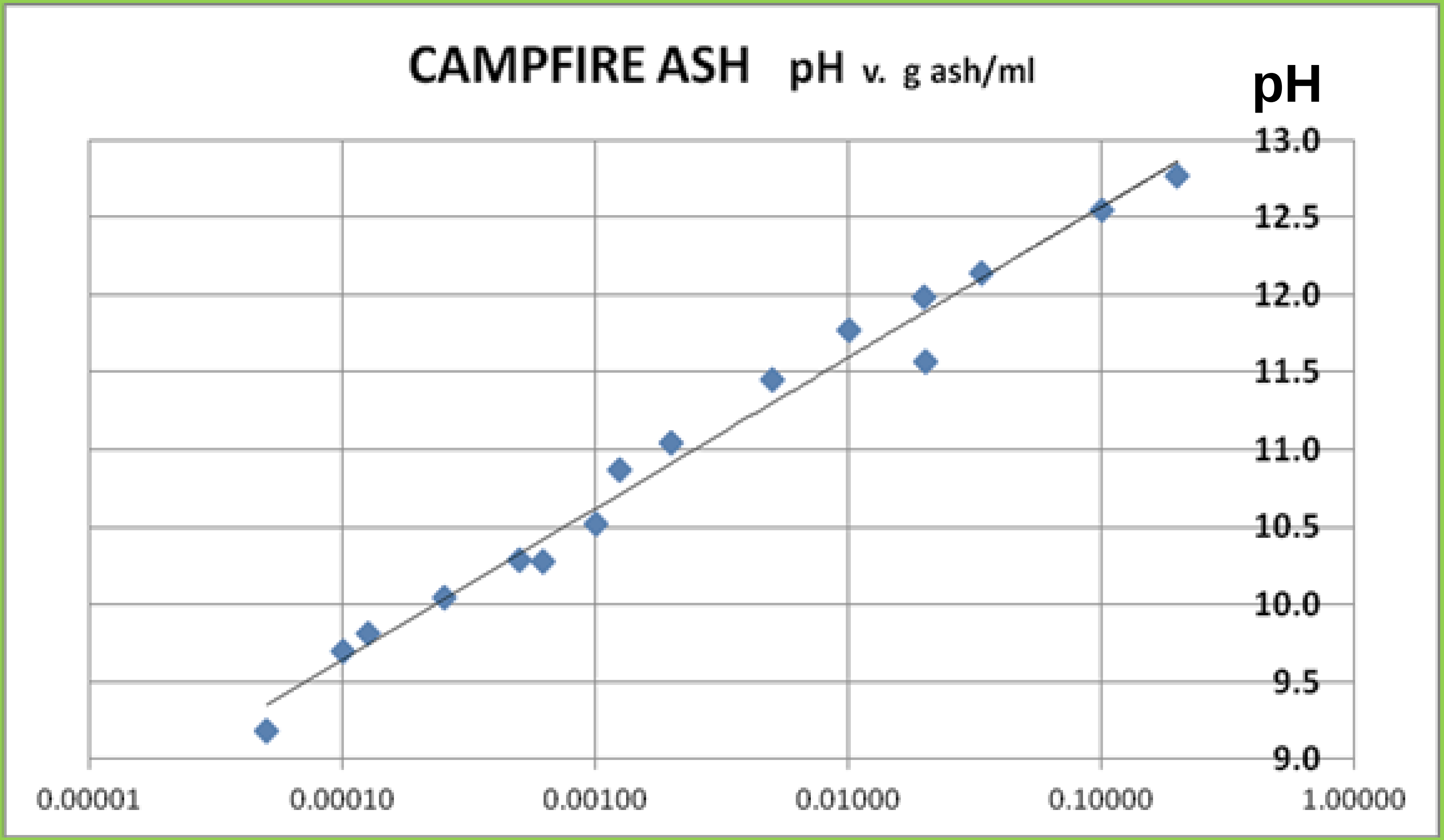
X-ray composition of the fire ash filtrate **"solids"** after a triple rinse of distilled water



X-ray composition of the fire ash supernatant solution crystals after evaporation

pH ANALYSIS METHOD – EAA

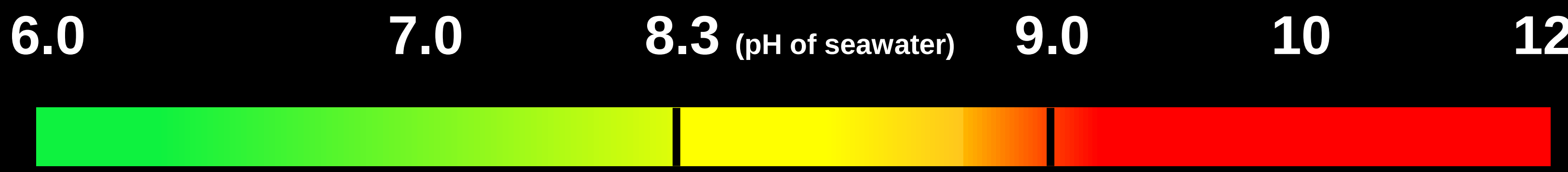
pH v. g/ml -- Serial dilution



Fire pit ash (grams)

SUGGESTED “ASH” CONTAMINATION GUIDANCE

pH Analysis (Wildfire residue only)



6 - 7.5 “Typical” / normal background

7.5 – 8.3 “Typical” / normal background
Coastal Marine or carbonate soil areas (sea salt influence)

8.3 – 9.0 Possible ash residue.

>9.0 Ash likely present

All measurements based on dilution of >0.001 grams dust diluted to 3ml distilled water.

SUMMARY CONCLUSIONS / BURDEN OF PROOF

- **Address the allegations made in the claim.**
- **Effectively communicate the concept of “normal / typical” levels.**
- **Address potential background sources.**
- **Address the historical “re-entrainment” potential.**
- **Explain how the sampling protocol addresses the claim.**
- **Sampling should include both positive and negative controls.**
- **Properly apply the laboratory data to the scope of the claim.**
- **Be aware that the knowledge base, suggested methods, and tools are rapidly changing.**

THE END

Are there any questions?