COMPOSITION AND CHEMISTRY OF MUSEUM AIR

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TWO DECADES OF CHANGE

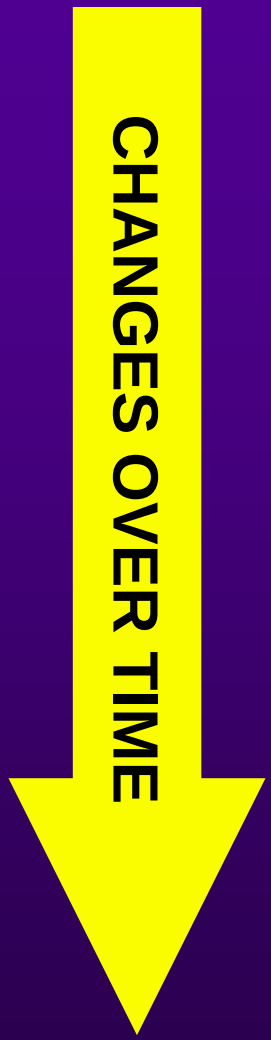
- In the 1980's I became interested in museum atmospheres – a literature ultimately published in Atmos. Env. (1991)
- **IAQ Museum Pollution : Detection and Mitigation of Carbonyls** Strathclyde University June 1998.

1990's PERSPECTIVE

- Monitoring- sensitive inexpensive
- Emission factors from display materials
- Deposition velocities on key materials
- Chemical transformations:
  - particles in air
  - oxidation of HCHO
- Critical levels

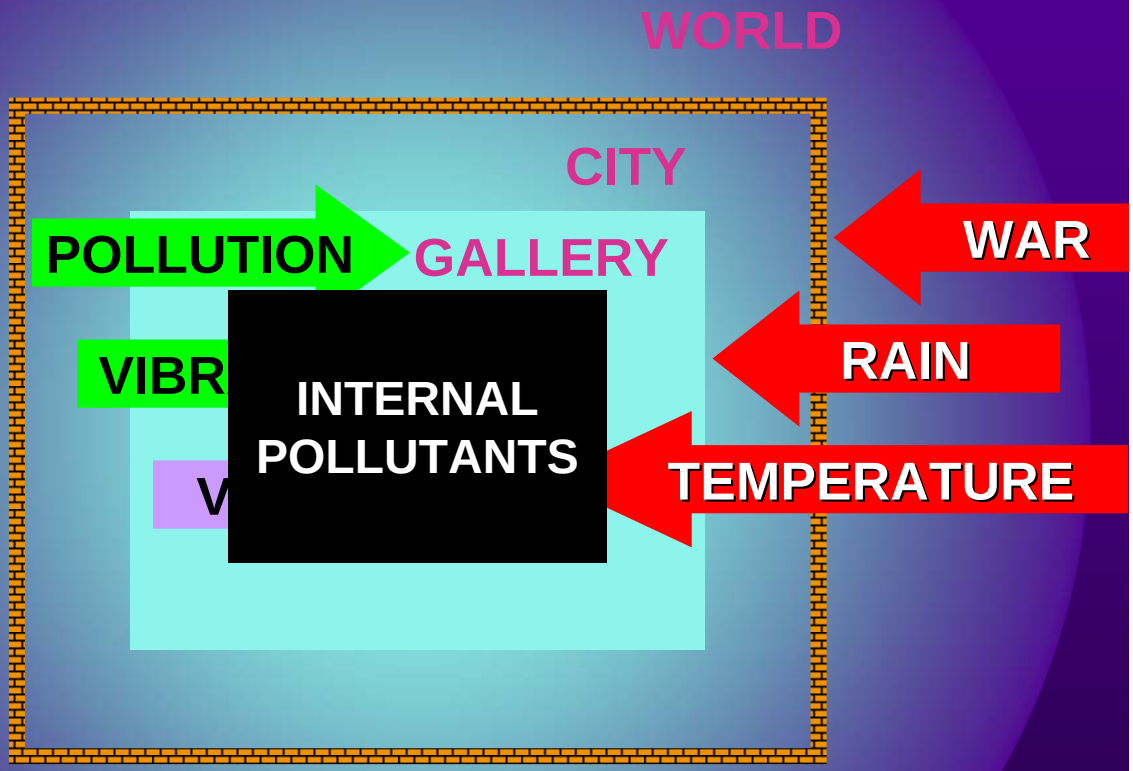
EU FUNDING

- Exterior stone work
- Metals, wood, paper, movables
- External factors, restoration treatments, socio-economic issues

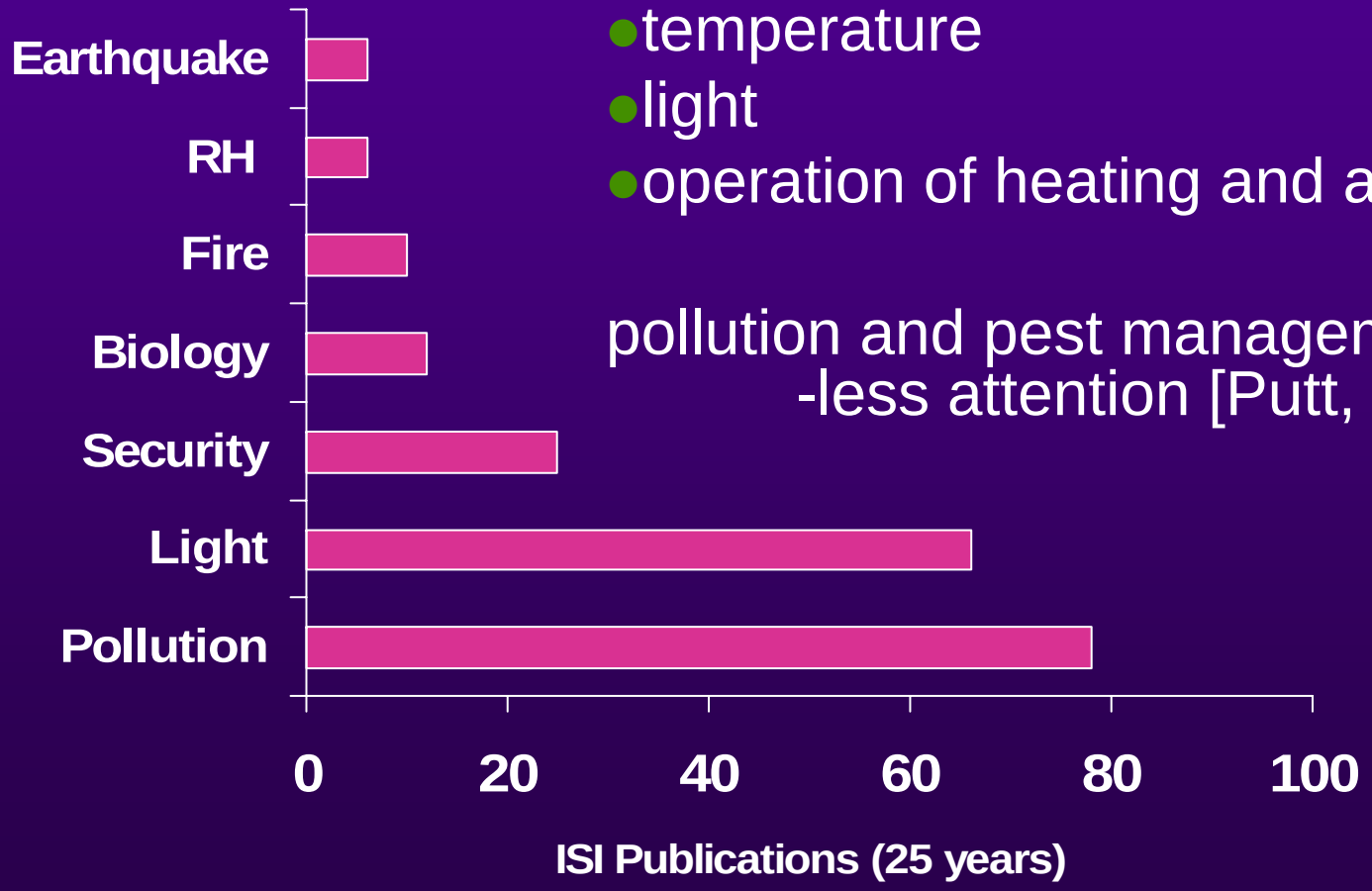


THE MUSEUM ENVIRONMENT

- Like most cultural environments that of pictures is a restricted yet imposes both internal and external threats



RESEARCH INPUT



MANAGEMENT PERSPECTIVE

- relative humidity
- temperature
- light
- operation of heating and air conditioning

pollution and pest management
-less attention [Putt, 2001].

FACTORS THAT DAMAGE CULTURAL HERITAGE

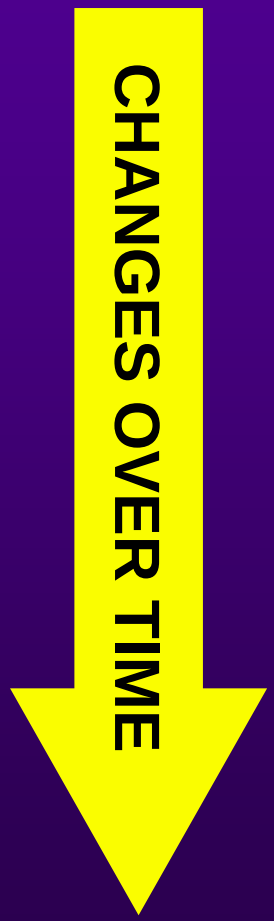
- War and vandalism
- Urban development
- Earthquakes and storms
- Temperature
- Humidity
- Light
- Air pollution

Appear as:

impulses
cycles
cumulative doses

FOCUS ON RELEVANT GASES

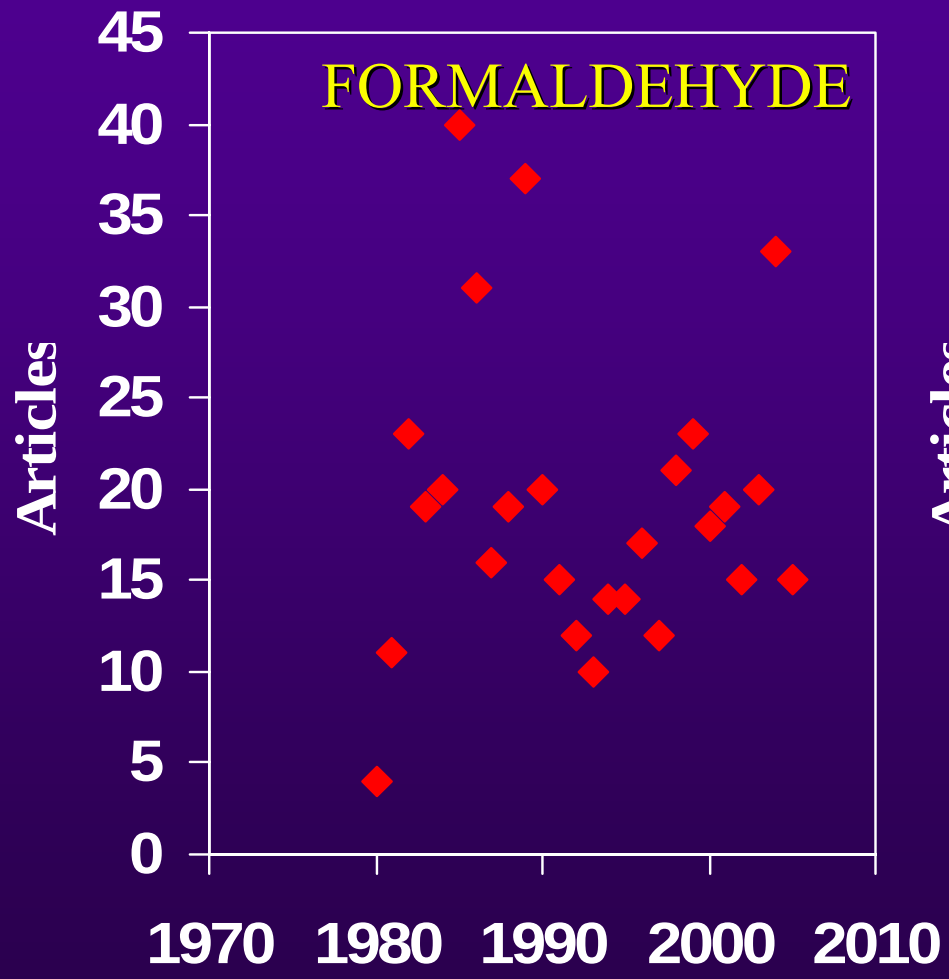
- Sulfur dioxide
- Nitrogen dioxide
- Ozone
- Formaldehyde
- Formic acid
- Hydrogen sulfide
- Carbonyl sulfide
- Pesticides, surfactants

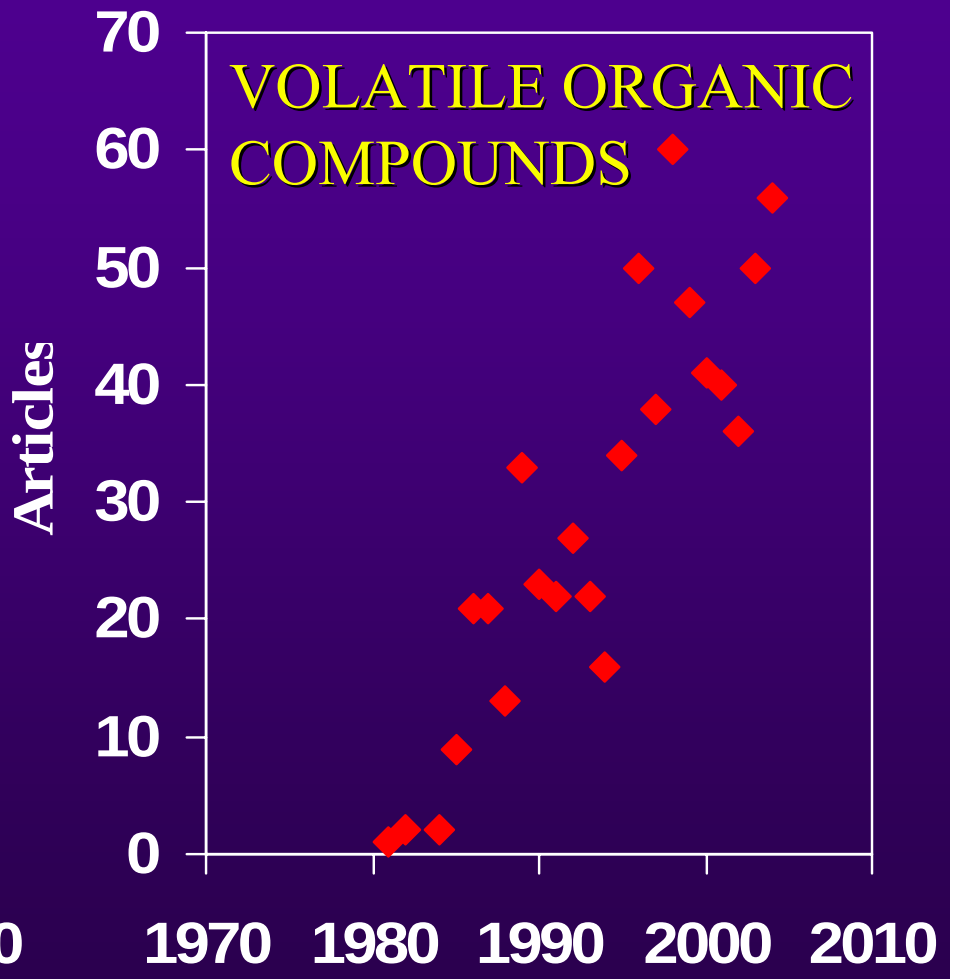


AVANCES IN INDOOR AIR SCIENCE

- Health motivation – SBS
- More interest in air chemistry
- Outgassing and reactive emissions of surfaces

DISCIPLINARY TRENDS





CUMULATIVE PROCESSES
POLLUTANTS AND LIGHT

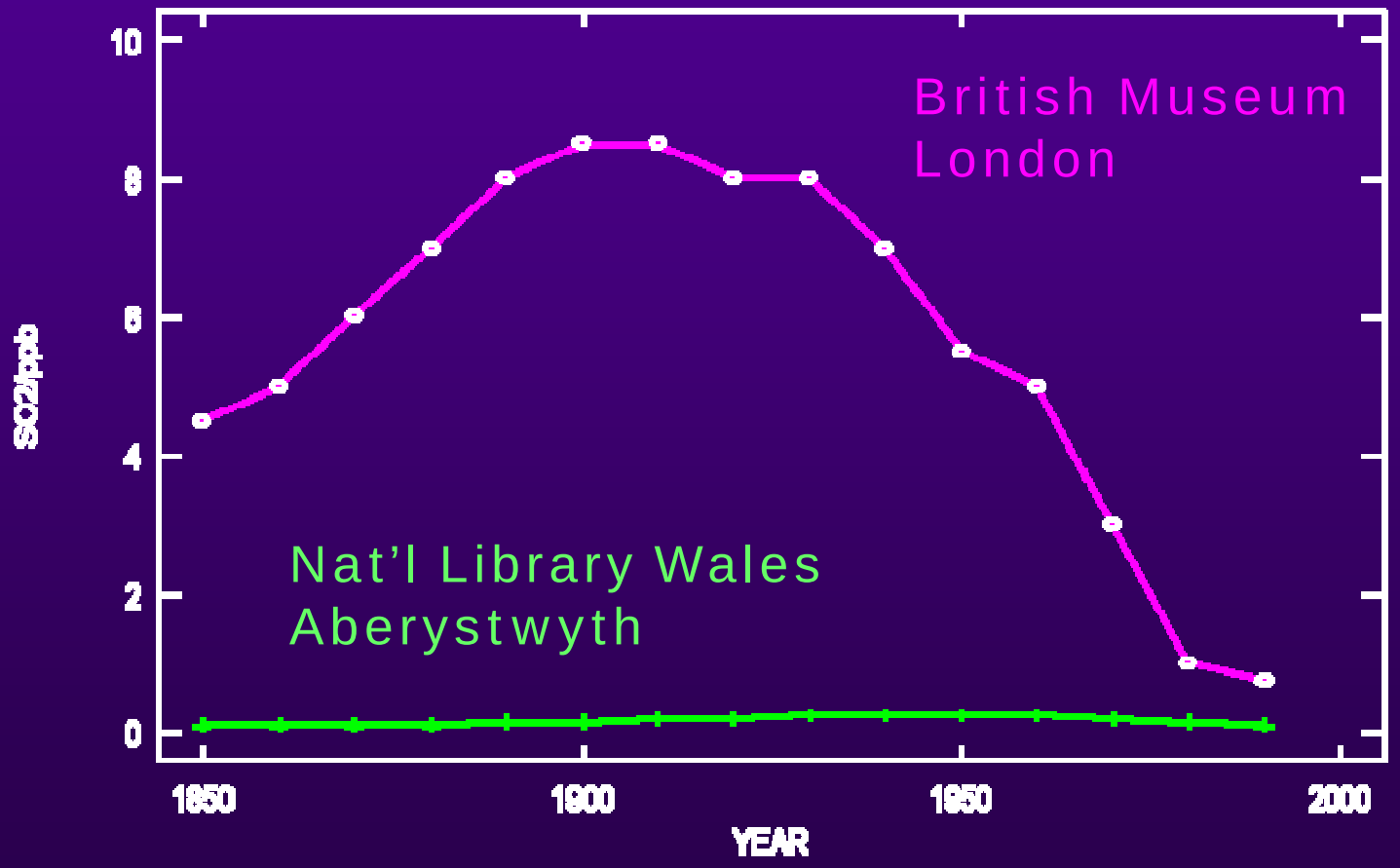
A lead weight severely corroding,
due to chipboard bottom of show case.

from an Austrian museum

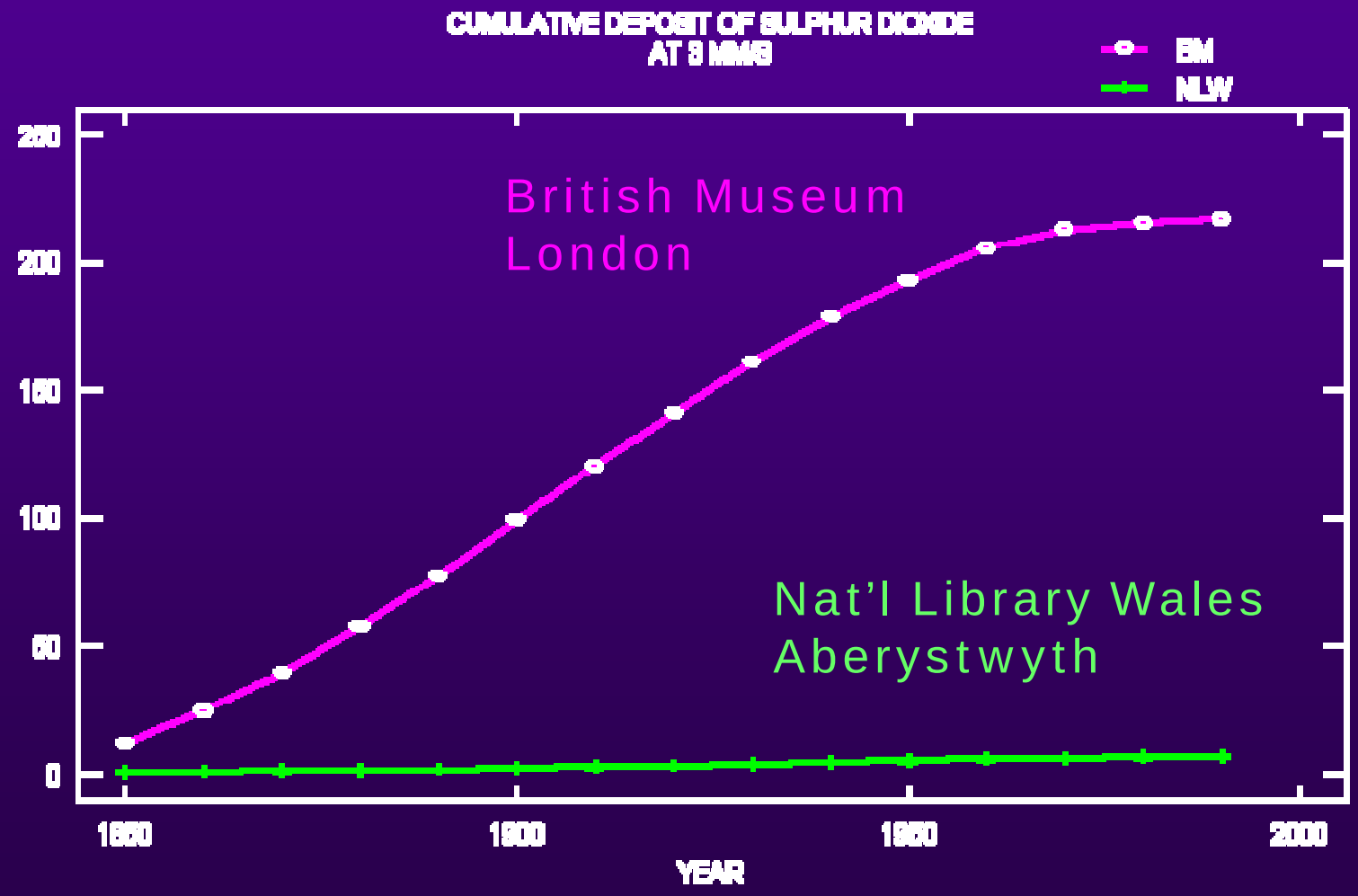
…a long
departed pollutant?

…mitigation though
filtration

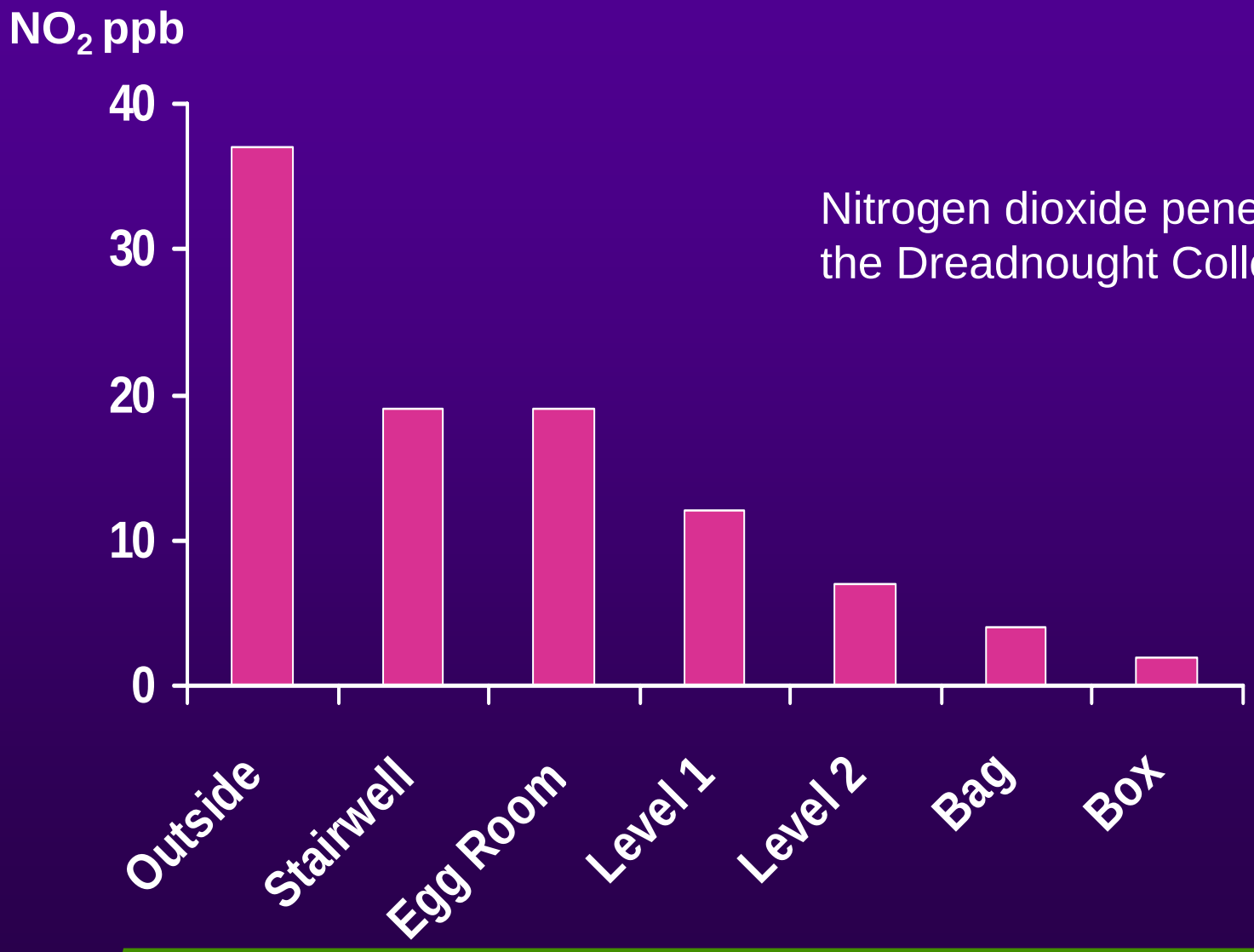
HISTORIC INDOOR SULPHUR DIOXIDE



CUMULATIVE SULPHUR DEPOSITION



POLLUTANTS INDOORS



Nitrogen dioxide penetration at the Dreadnought Collection

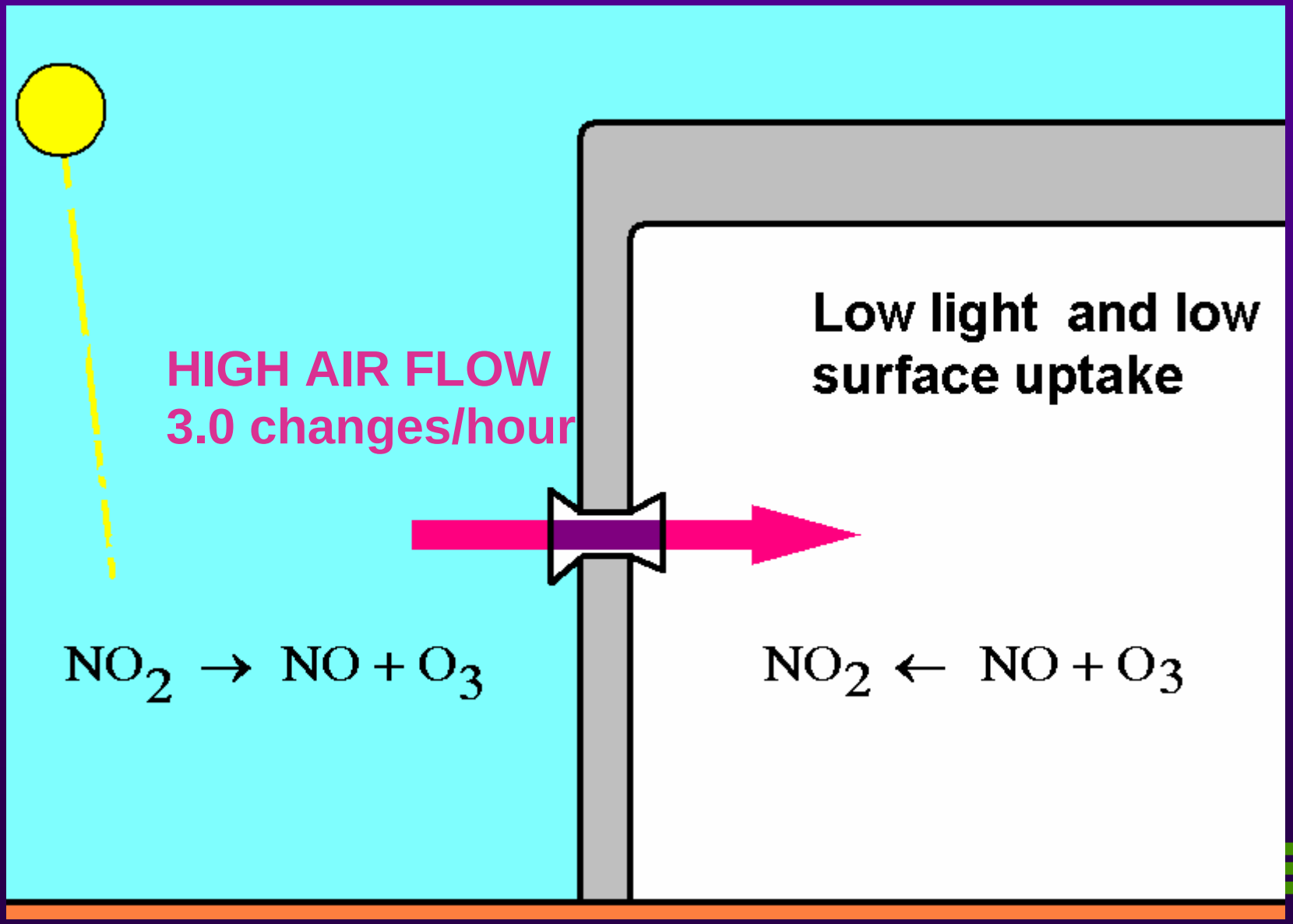
INDOOR OUTDOOR RATIOS

- Very unifying concept that compares interiors
- >1 indoor source
- <1 indoor loss mechanisms

  O_3 and SO_2 very effective loss

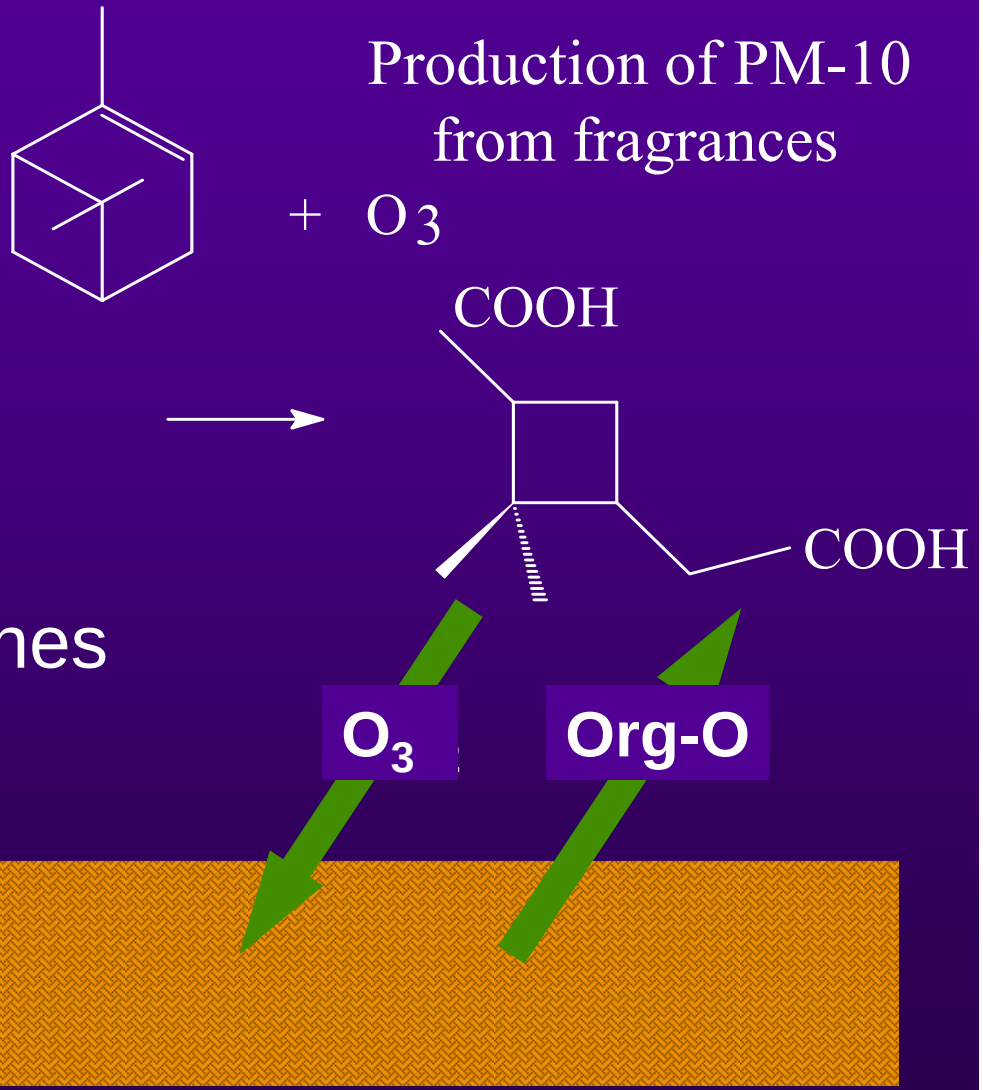
INDOOR/OUTDOOR NO_2

0.79 winter
1.32 summer-autumn



INDOOR AIR POLLUTANTS

- Gas desorption-
- Secondary emissions-
  O_3 reaction fabrics
- Secondary products -
  O_3 reaction with terpenes



PERSIAN LEATHER SADDLE BAGS

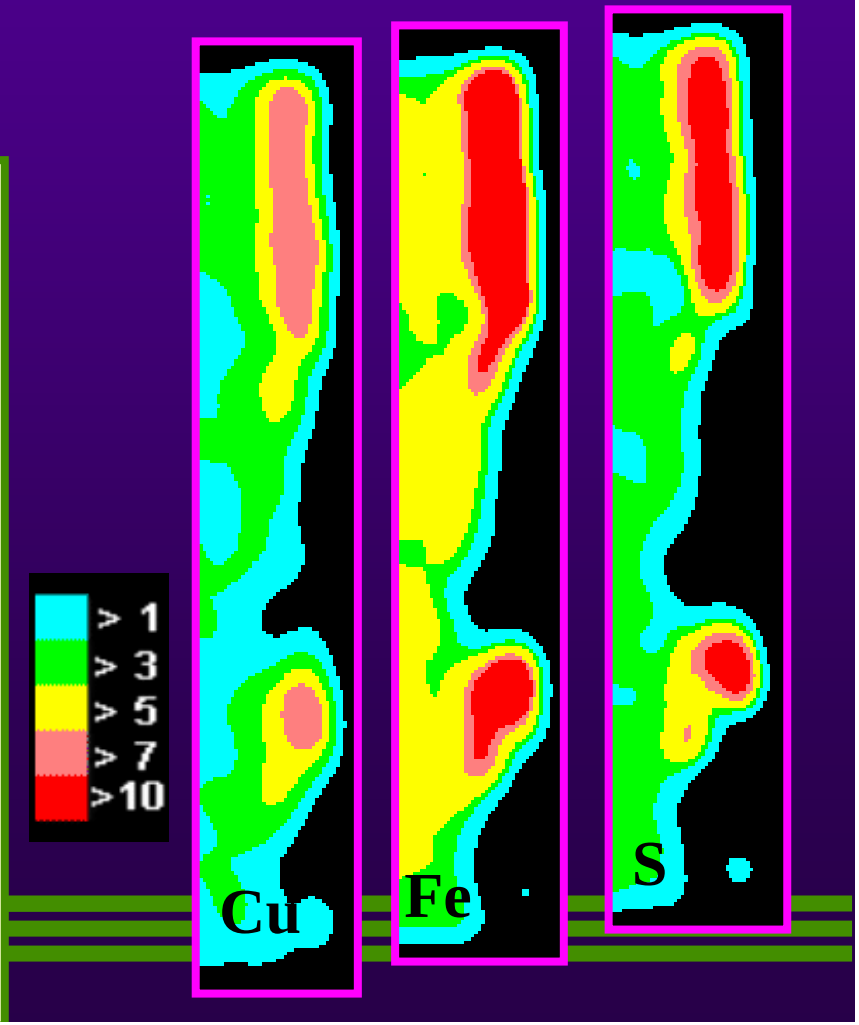
- **Iron or green copper pigment at leather surface may catalyze sulfuric acid formation**

DAMAGED SADDLE BAGS

Deutsches Leder und Schuhmuseum

100μ

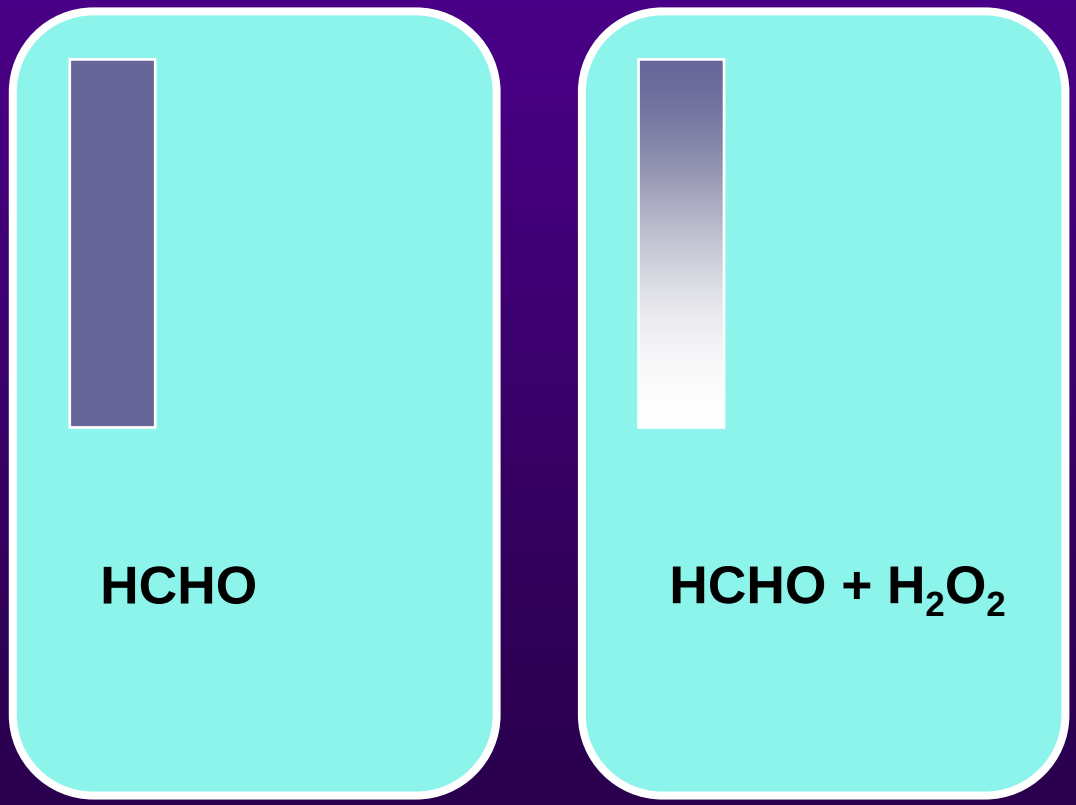
CROSS-SECTION ↔



REACTIONS IN MUSEUM CASES

Lead in a formaldehyde atmosphere only corrodes on oxidation to formic acid...

Michele Raychaudhuri



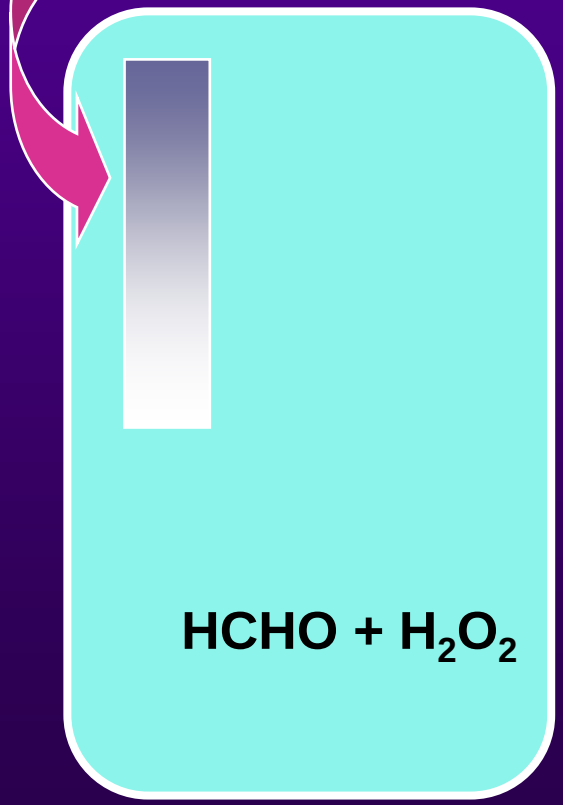
Oxidation potential not concentration relevant to damage…

MECHANISMS & UNEXPECTED PRODUCTS

Lead formate expected, but carbonates often found… especially

plumbonacrite, $Pb_{10}(CO_3)_6(OH)_6O$

hydrocerussite, $Pb_3(CO_3)_2(OH)_2$



$$Pb(HCOO)_2 + H_2O + CO_2$$

$$= 2HCOOH_{(g)} + PbCO_3$$

Carbonate stabilised at low formic acid pressures

PEROXIDE ATTACK - PHOTOGRAPHS

Right print was pinned to a chipboard notice board for six months,

Morten Ryhl-Svendsen

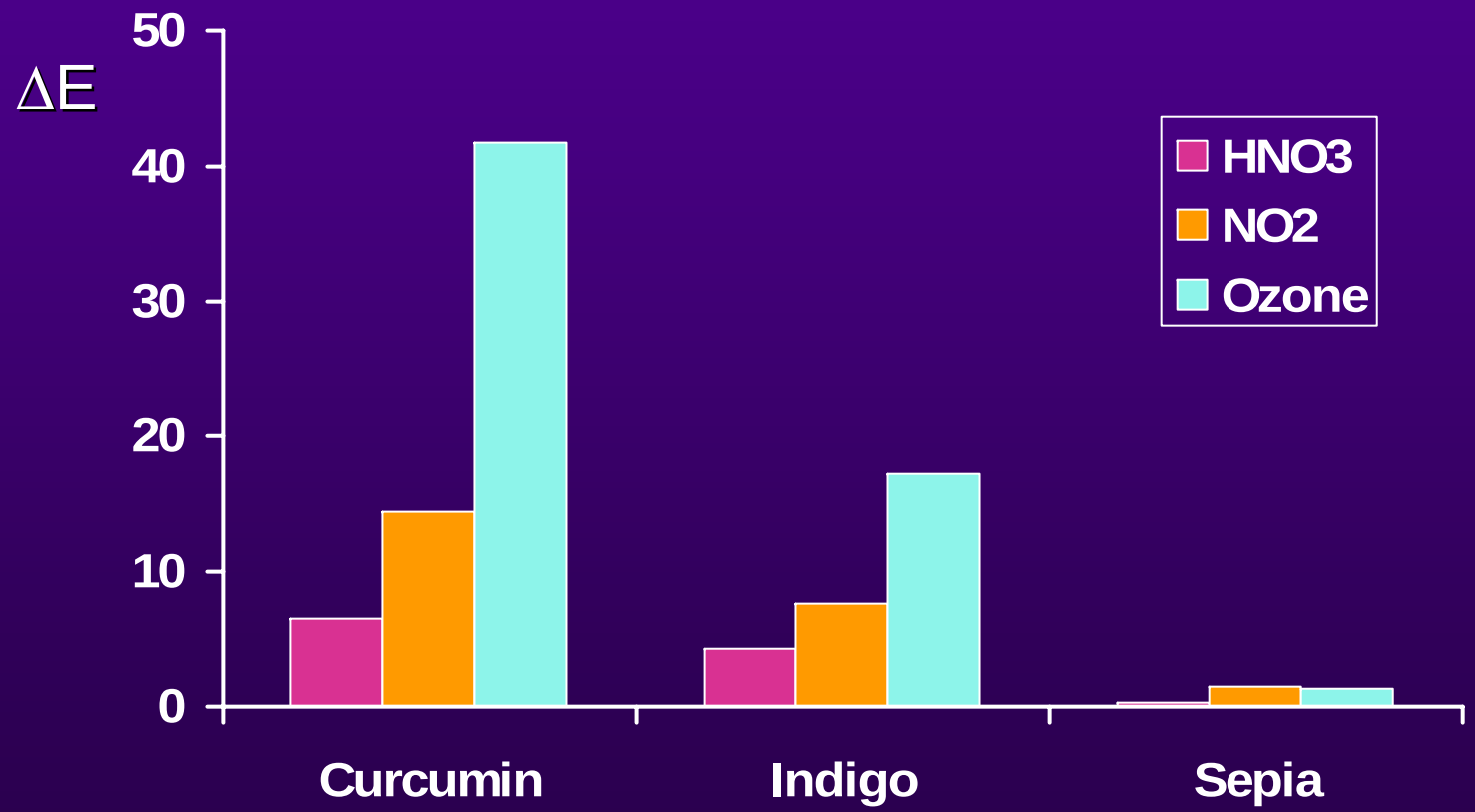
GAS FADING

- Now a huge problem from ozone and ink jet printers
- Loss of aerial perspective
- …but copper from verdigris (copper acetate) binds to fatty or resin acids

Gunn *et al Studies in Conservation* 47 (1): 12-23 2002

NATURAL ORGANIC COLORANTS

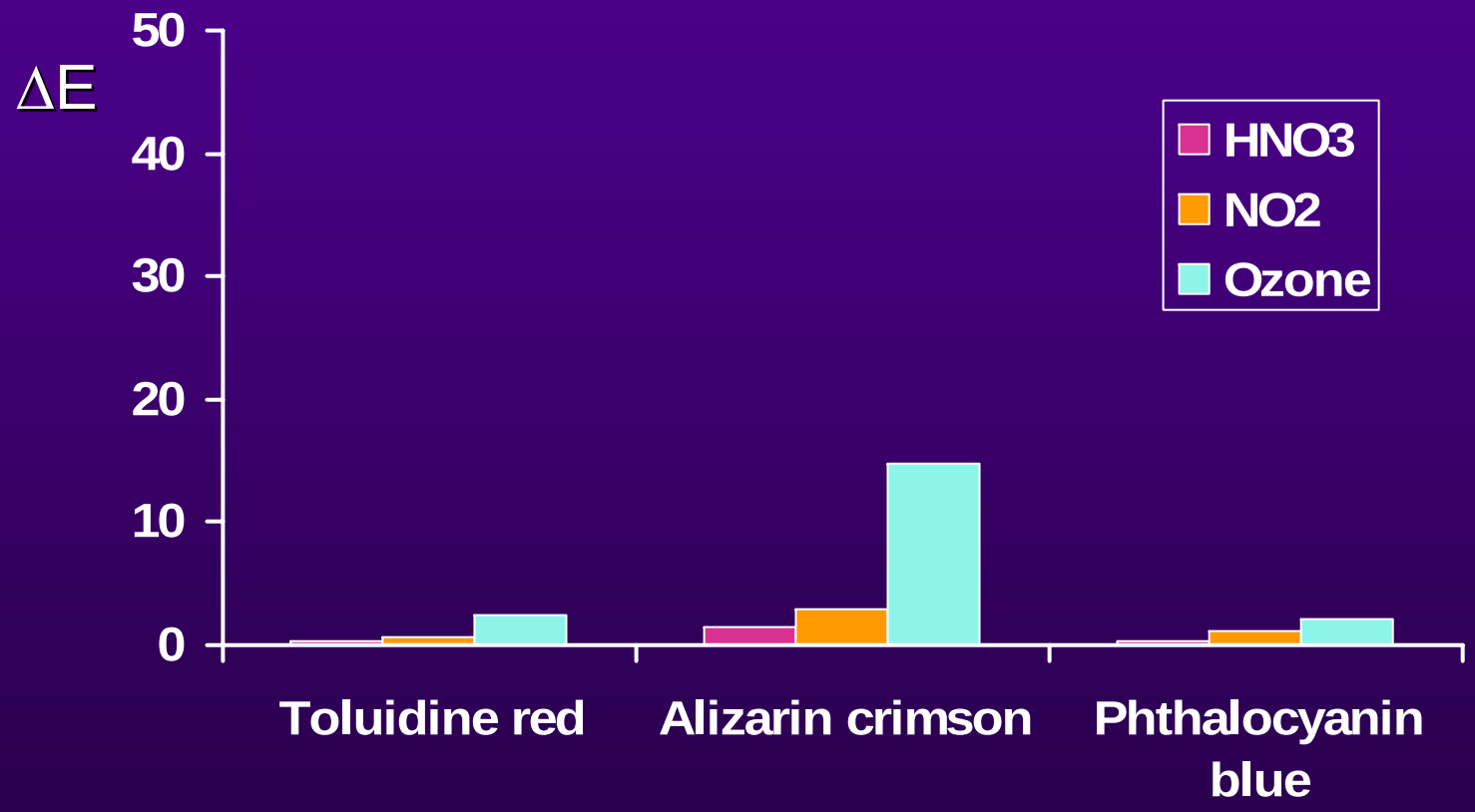
Exposures 12 week
HNO_3 12ppb
NO_2 500ppb
O_3 400ppb



Grosjean *et al* *Environ Sci Technol* **26**: 952-959 (1992)

SYNTHETIC ORGANIC COLORANTS

Exposures 12 week
HNO_3 12ppb
NO_2 500ppb
O_3 400ppb



Grosjean *et al* *Environ Sci Technol* **26**: 952-959 (1992)

SULFIDES AND SILVER SILPROT

Wool and many other materials generate sulfides which tarnish silver….
often not H_2S!

$$COS + Ag_2O = AgS + CO_2$$

Synergisms…

Early silver bicycle trophy
http://www.juliaauctions.com/

HYDROGEN SULFIDE and LEAD PIGMENTS

Special problem in volcanic regions, such as Rotorua New Zealand. Snow in painting goes black!

$$2PbCO_3.Pb(OH)_2 + H_2S \rightarrow PbS + \ldots.$$

RESTORATION

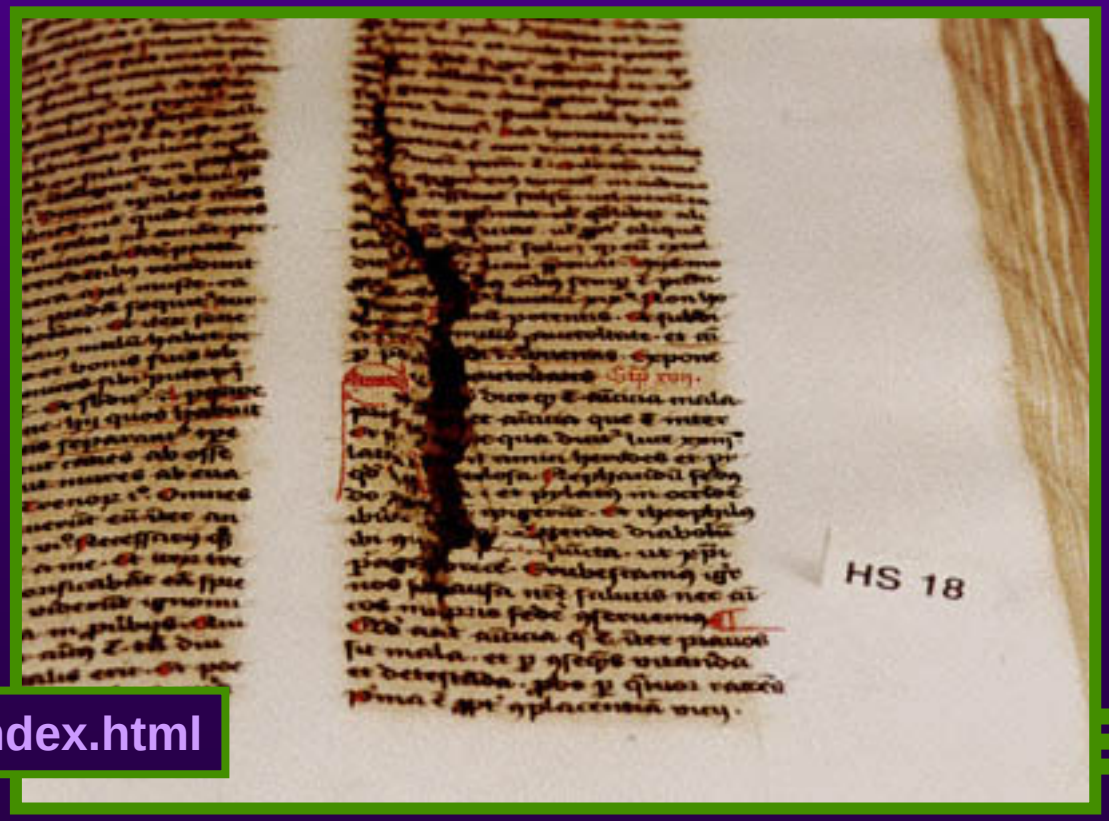
Oxidize the sulfide with a solution of hydrogen peroxide in ether

VARNISHES and POLYMERS

- Increasing variety
  - hard to identify
  - long term stability poorly understood
- Unsaturated compounds
  - role of ozone, radicals, light
  - colour changes
- Film base -
  - archival relevance
  - cellulose nitrate

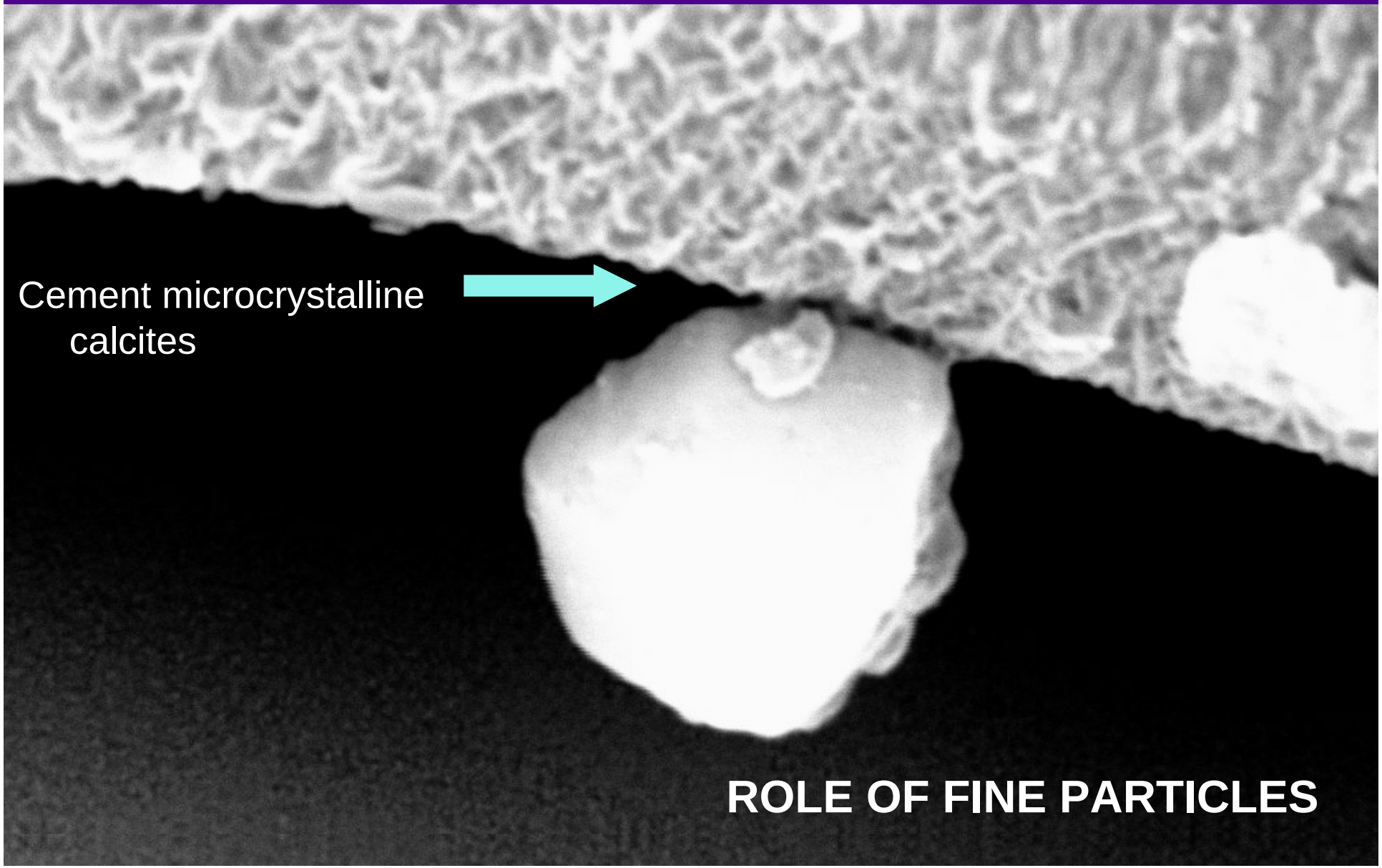
IRON GALL INK

- Firstly fluorescence in the immediate vicinity of the ink writing under UV-light is noticeable



http://www.knaw.nl/ecpa/ink/index.html

CHEMICAL CEMENTATION

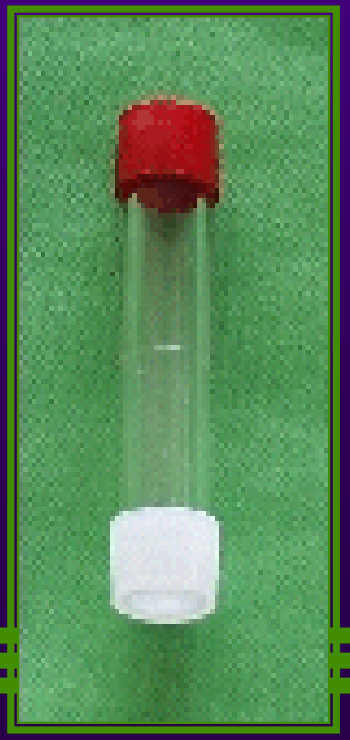


MONITORING SIMPLE / ROBUST

long response times
low sensitivity
low selectivity,
drift...

- Passive devices
- Solid state
- Glass/dye dosimeters
- Fluorescent dosimeters
- Corrosion layers

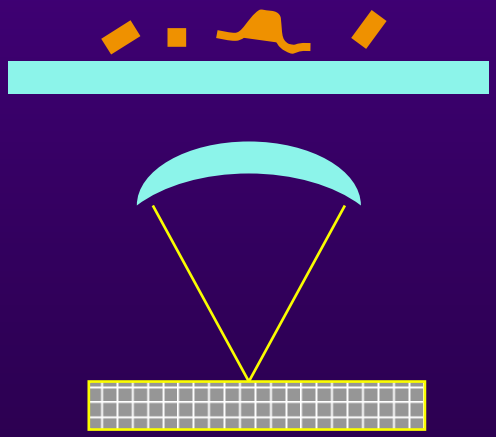
Detailed analysis:
time-consuming interpretation



…beyond the Oddy test!

DUST

- Dust shed from visitors recognised as a major problem for open display



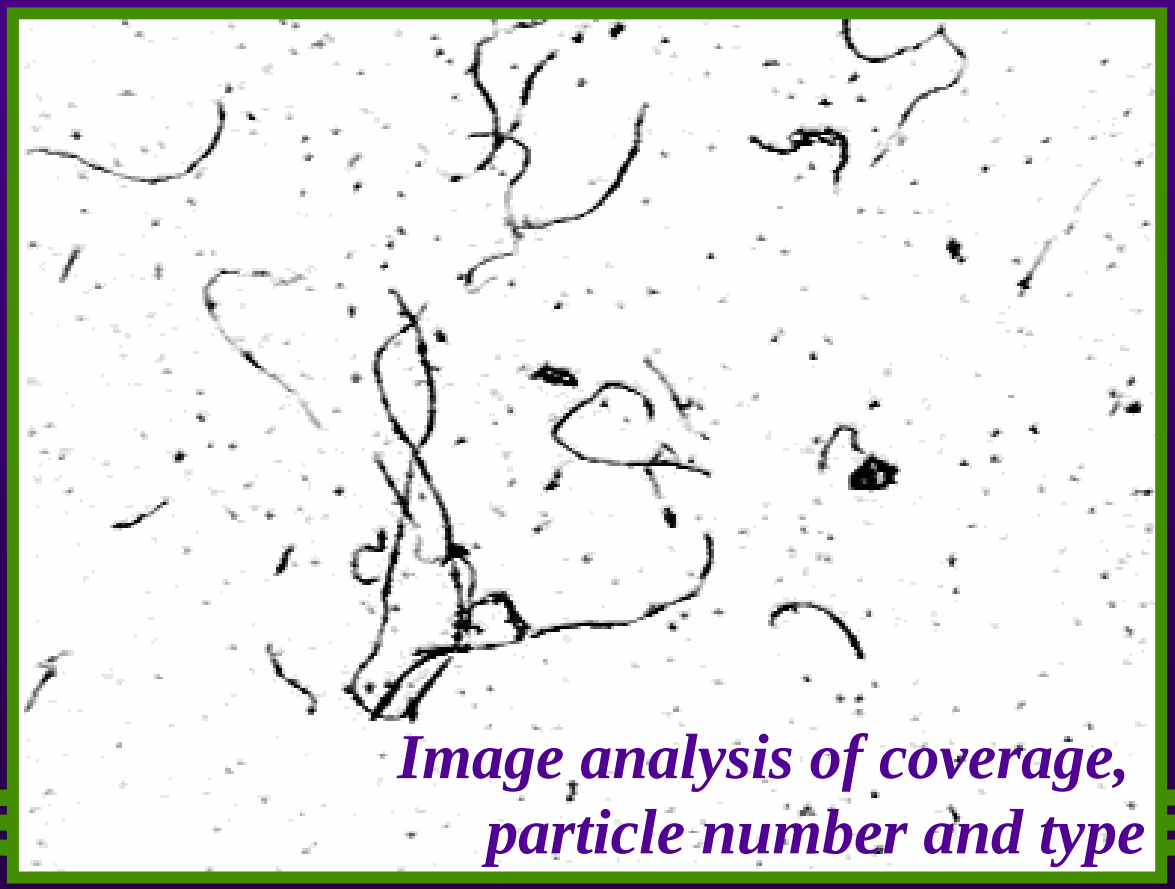
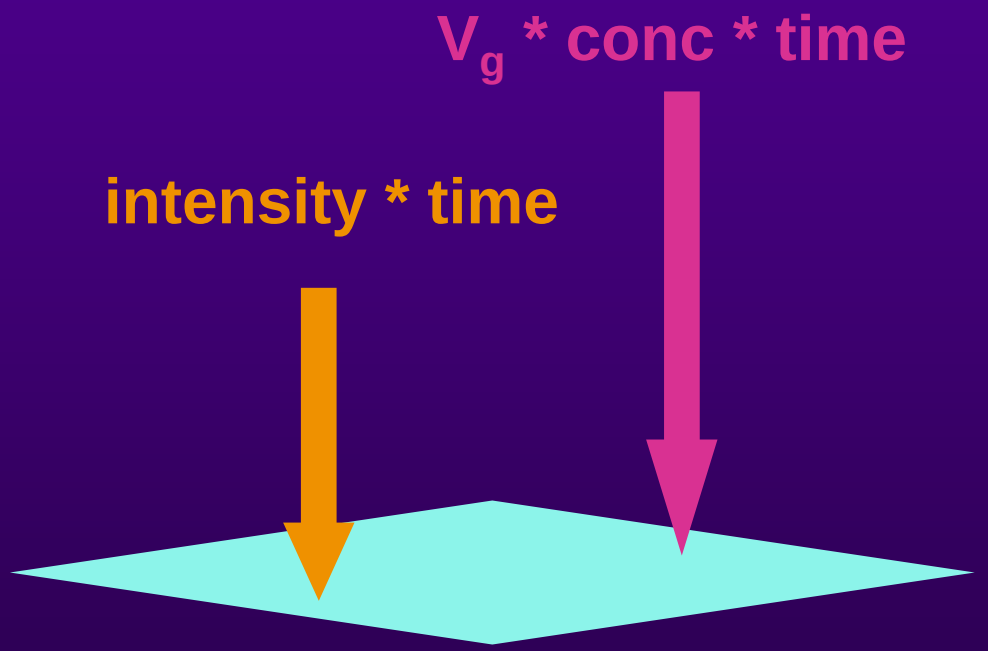


Image analysis of coverage, particle number and type

MODELLING: THERMODYNAMIC or *IMPACT*

- Interest in modelleing as a tool…



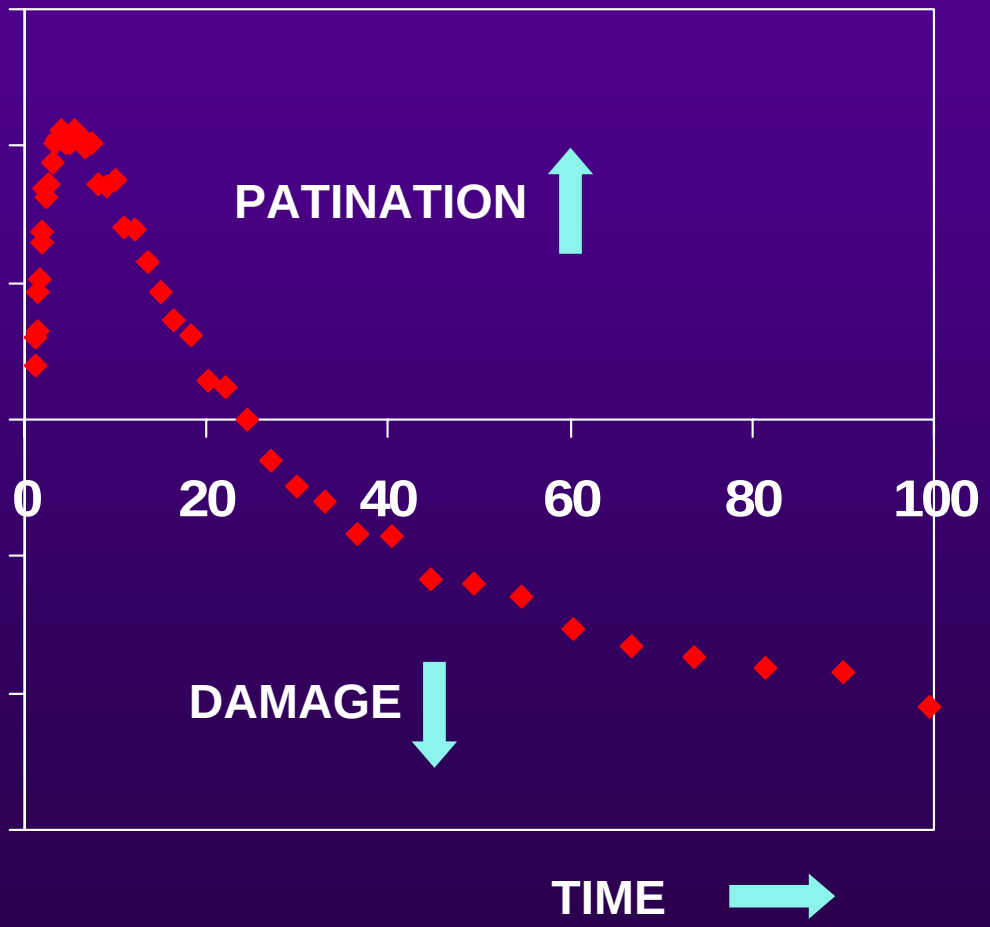
MUSEUM EPIDEMIOLOGY

- Total response of collection
- Pitt Rivers Museum!

PATINA AESTHETICS

- Damage recognition
- Surface changes over time may not all be negative

Kari Kivisalo



KEY POLICY ISSUES

- Increasing access
- Open display
- Preventive conservation
- Integration of research into policy


THE END