Cracking it Open:

Addressing Mineral Instability within Museum Environments

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OR 3D
Digitise Dimension Design

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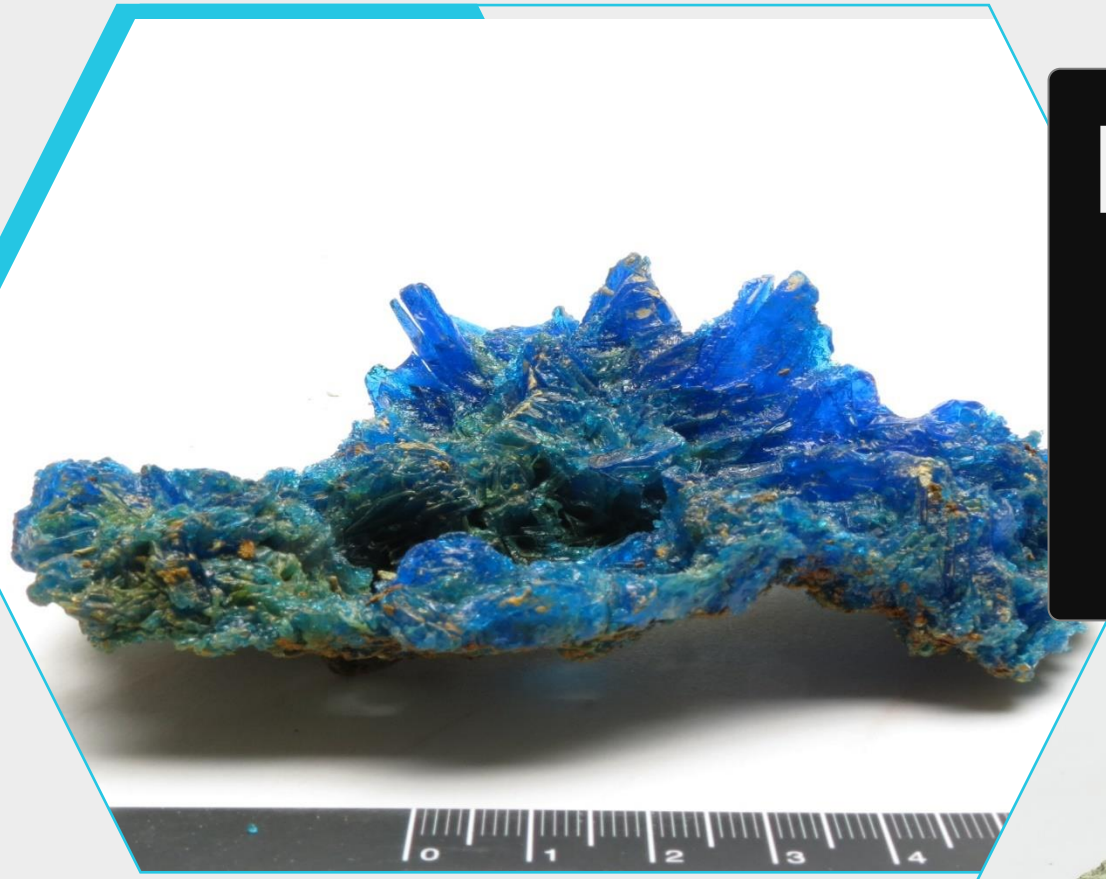


Minerals ≠ Stable Objects

1992 – 350 of 3,500 known minerals

Nov. 2018 – ? of 5,400 identified minerals

How many more are vulnerable?

Why are some minerals less stable than others?

Diversity

Metastabilty

Variable Conditions

Consequences of Inappropriate Conditions

Temperature

- Decrepitation
- Dissociation
- Fracture
- Increased reaction rate
- Polymorphism
- Pseudomorphism
- Sublimation
- Volatization

Relative Humidity (RH)

- Corrosion / oxidation
- Cracking
- Dehydration
- Deliquescence
- Efflorescence
- Hydration
- Swelling
- Water film formation

Pollutants

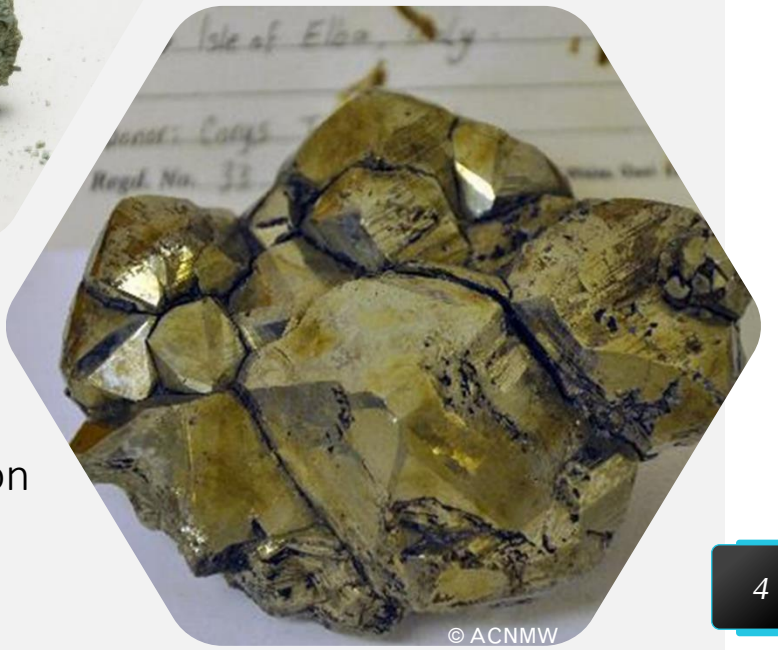
- Corrosion
- Efflorescence
- Moisture retention
- Surface reactions

Light

- Chemical & physical alterations
- Fading / darkening
- Loss of colour / fluorescence
- Surface reactions
- Other heat-related effects

Stresses

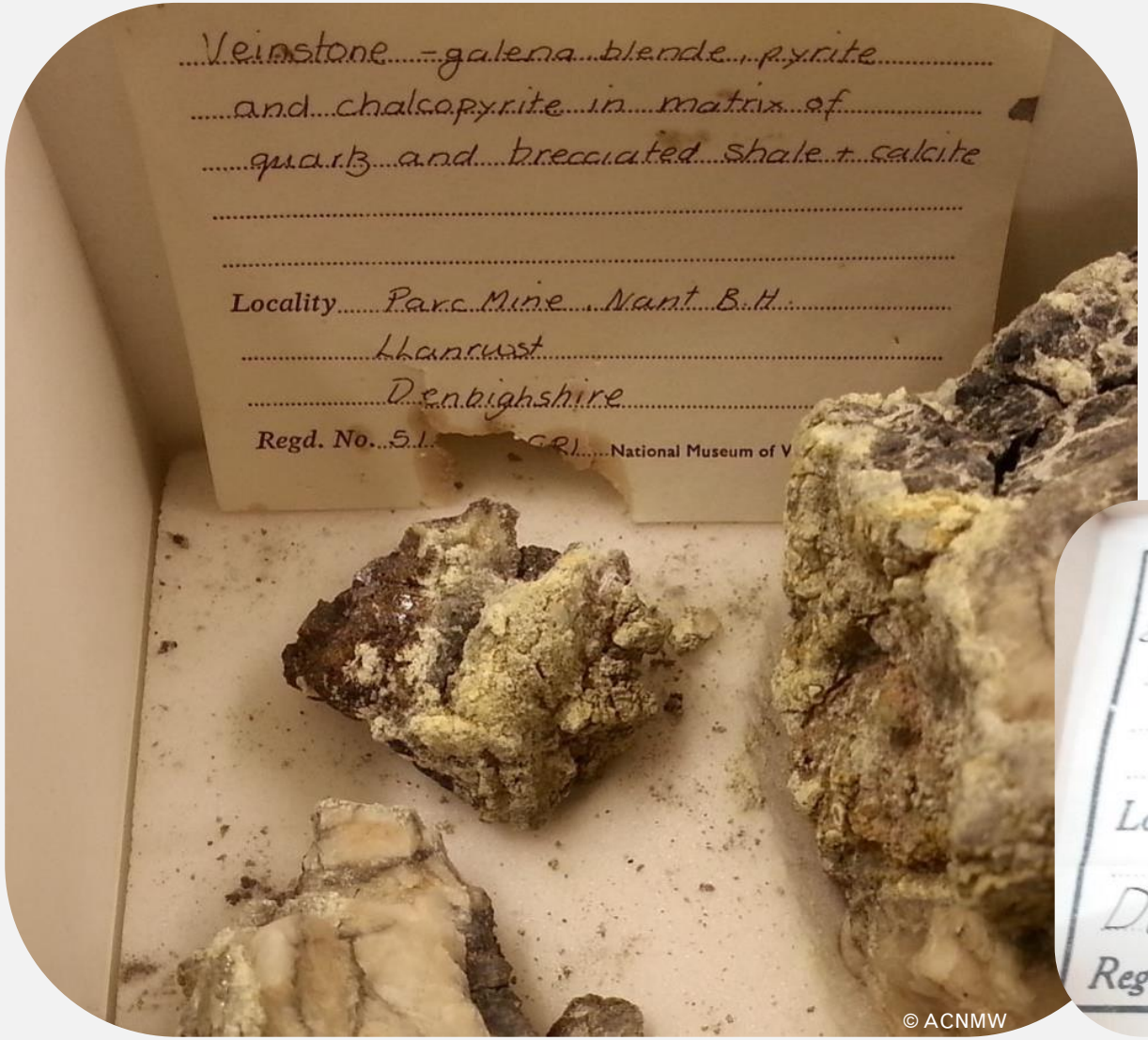
- Cracking
- Crumbling
- Decrepitation
- Dissociation
- Fracture



Pyrite & Marcasite

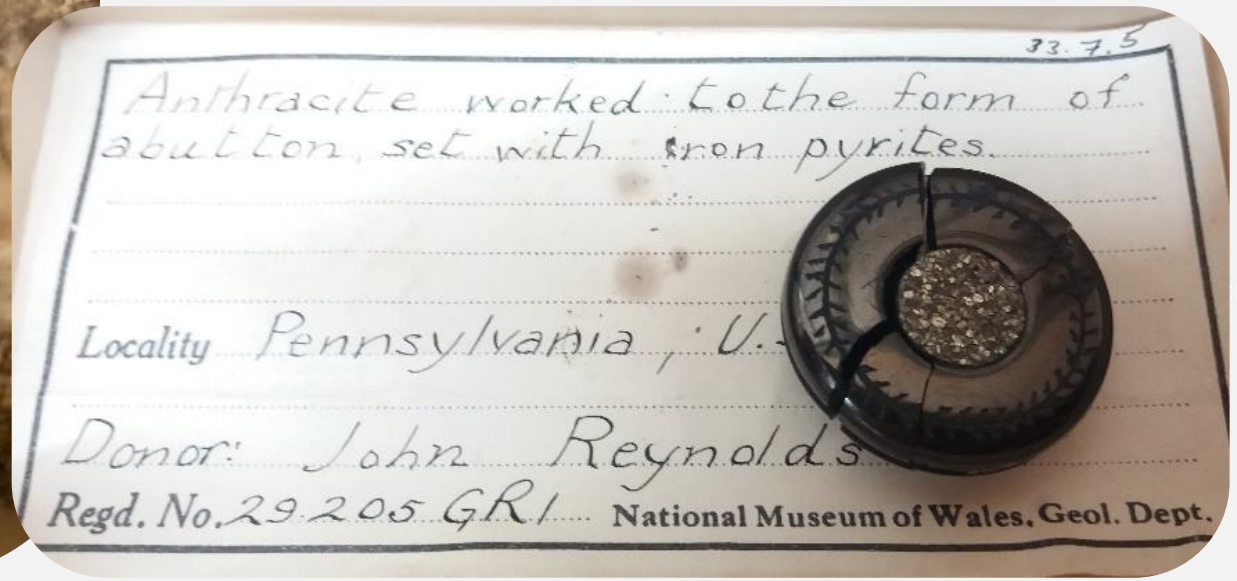
An infamous example

Pyrite & marcasite deterioration has long been a recorded issue

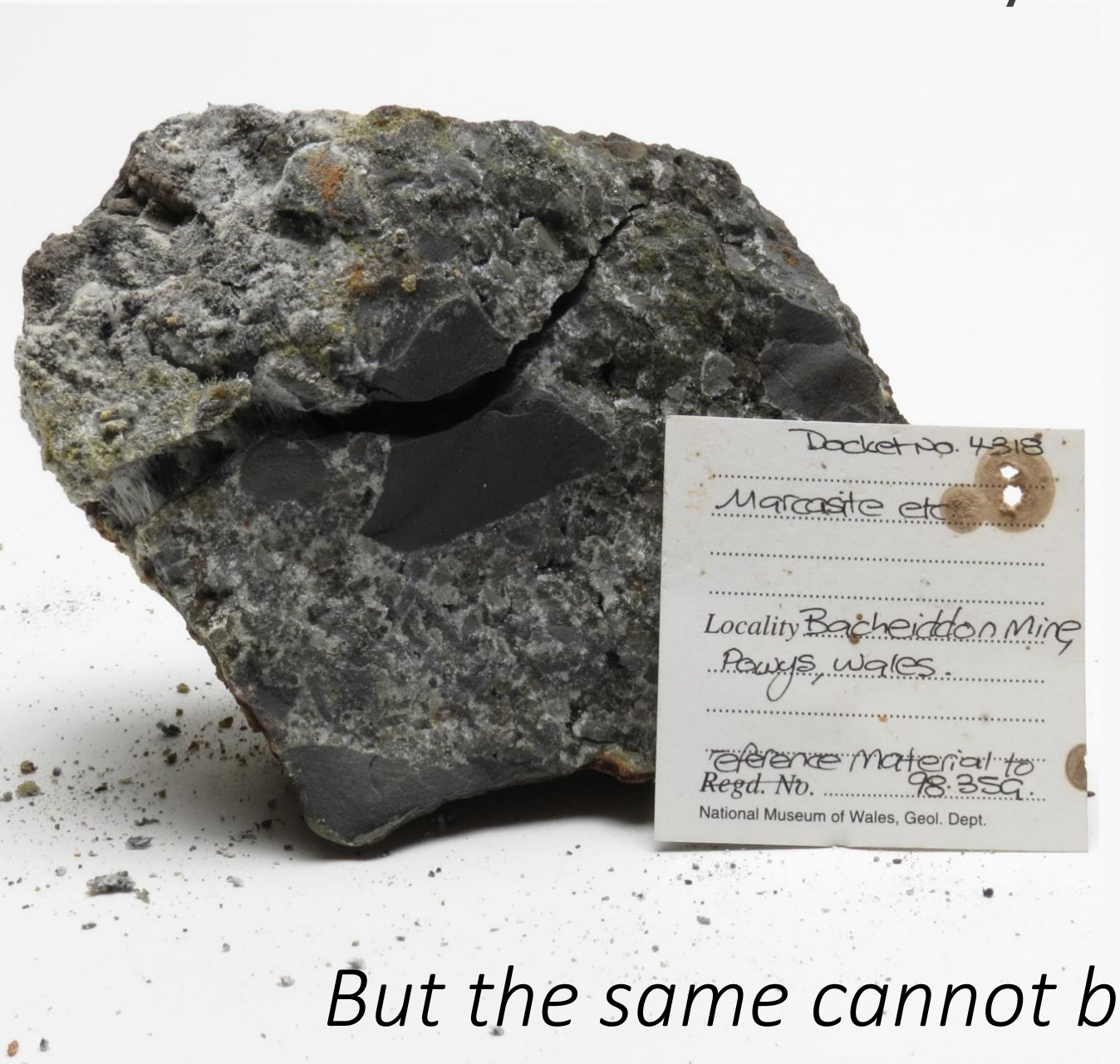


Why is it so problematic?

- Common in many rock-types
- Oxidizes ≥ 30% RH
- Releases sulphuric acid
- Alteration creates volumetric expansion



Its deterioration is actively being researched



- Aqueous
  - Marine
  - Mine
- Near aqueous
- Extra-terrestrial
- Museums
- Roles of agents of deterioration
  - pH
  - Surface moisture & oxygen
  - Bacteria
- Conservation methods
  - Microenvironments
  - Anoxic environments

But the same cannot be said for other minerals

The Research Project

Beginning to fill in the gaps

	A	B	C	D	E
1	**Acc Number**	**Specimen**	**Hey**	**Assoc. 1**	**Assoc. 2**
170	64.370.GR.7	gaylussite	11.1.14		
171	64.370.GR.8	gaylussite	11.1.14		
172	64.370.GR.9	gaylussite	11.1.14		
173	83.41G.M.4698	gaylussite	11.1.14		
174	84.19G.M.760	gibbsite	7.6.4	aluminite	gypsum
175	20.348.GR.133	goslarite	25.5.2		
176	28.5.GR.3 a	goslarite	25.5.2		
177	48.264.GR.446	goslarite	25.5.2		
178	83.41G.M.8995	goslarite	25.5.2		
179	2002.9G.M.5	gypsum	25.4.3	fibroferrite	
180	2003.1G.M.548	gypsum var. selenite	25.4.3	chalcanthite	
181	84.19G.M.772	ha³yne	17.10.4	chalcanthite	
182	80.213	halite	8.1.3		
183	90.314	halite	8.1.3		
184	13.140.GR.24	halite	8.1.3		
185	14.311.GR.28	halite	8.1.3		
186	15.132.GR.2	halite	8.1.3		
187	15.133.GR.7	halite	8.1.3		
188	15.156.GR.112	halite	8.1.3	lapilli	
189	15.156.GR.42	halite	8.1.3		
190	15.156.GR.45	halite	8.1.3		
191	15.156.GR.46	halite	8.1.3		
192	20.338.GR.39	halite	8.1.3		

- Melanterite & Chalcanthite = dehydrated
- Gaylussite = efflorescence
- Some sulphides = tarnished & cracking
- Halotrichite = friable & breaking

A Review of a Museum's Stores

Melanterite & Chalcanthite

Rare Welsh specimens – great concern for their stability

Melanterite

$FeSO_4 \cdot 7\,H_2O$

Cuprian Melanterite

$(Fe,Cu)SO_4 \cdot 7H_2O$

Fe

Form a solid solution series

Cu

Chalcanthite

$CuSO_4 \cdot 5H_2O$

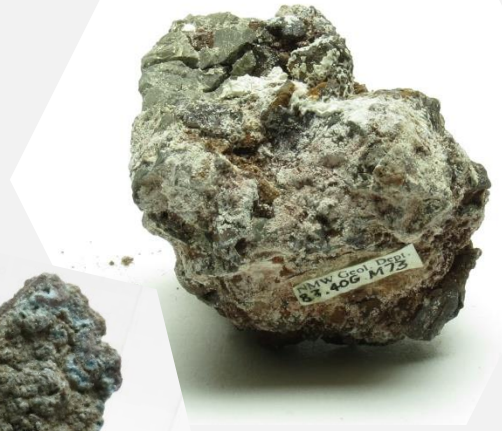
Ferrohexahydrate – $FeSO_4 \cdot 6H_2O$
Siderotil – $FeSO_4 \cdot 5H_2O$
Rozenite – $FeSO_4 \cdot 4H_2O$
Szomolnokite – $FeSO_4 \cdot H_2O$

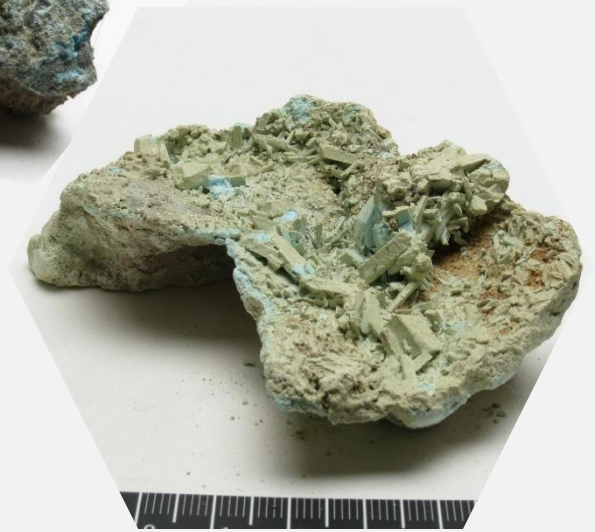
Dehydrate

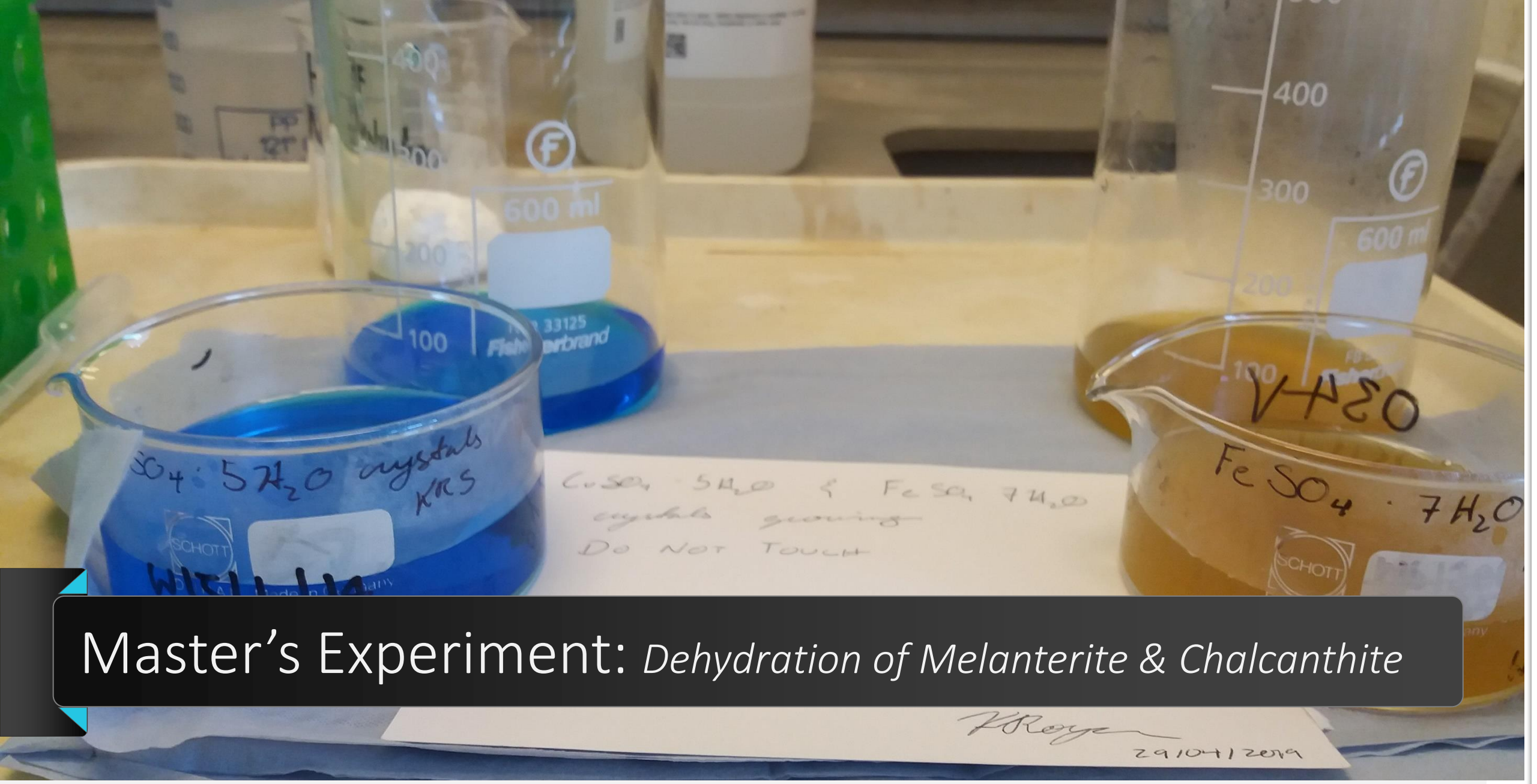
Fe

Cu

Bonattite – $CuSO_4 \cdot 3H_2O$
Poitevinite – $CuSO_4 \cdot H_2O$
Chalcocyanite – $CuSO_4$





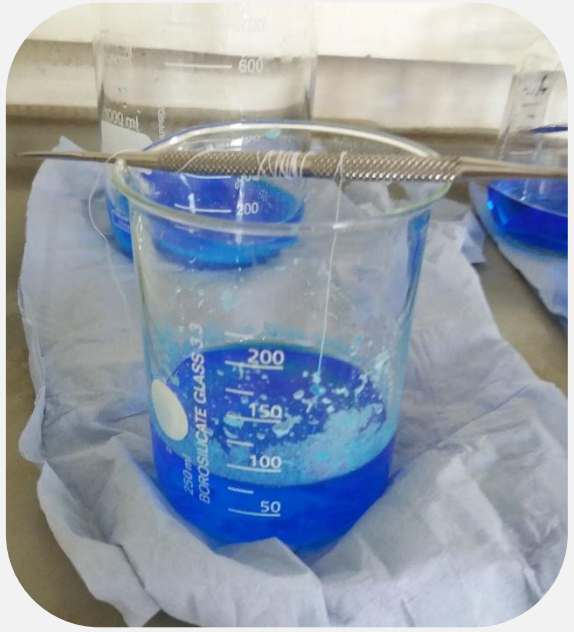


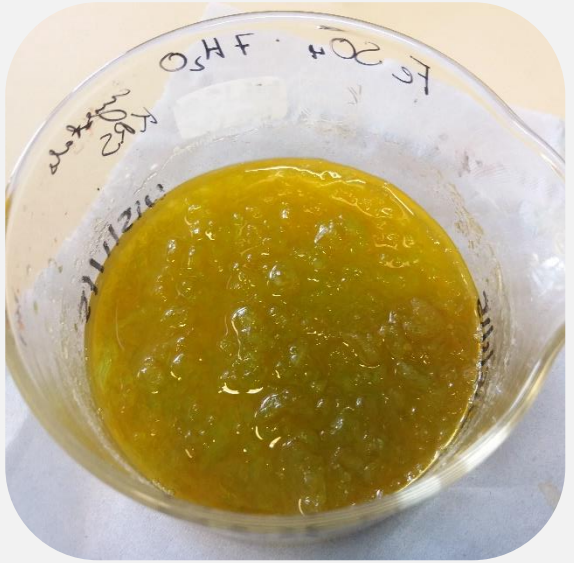
Master's Experiment: *Dehydration of Melanterite & Chalcanthite*

1. Crystal Growth

Chalcanthite: quick & easy

1. Create supersaturated solution with deionized water
2. Decant into container
3. Produce seed crystals
4. Add seed crystals to containers of supersaturated solution
5. Et voilà!





Melanterite: more difficult & longer, but not impossible

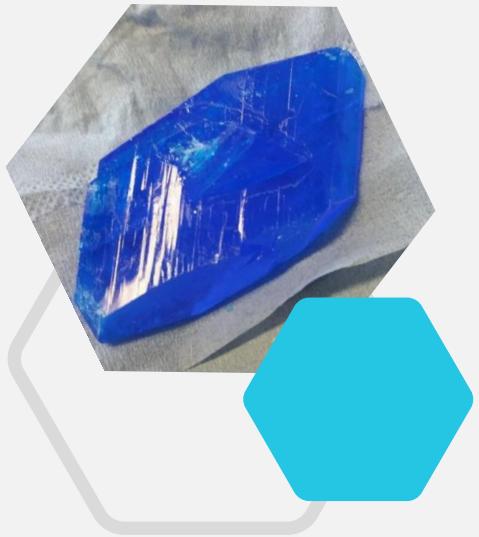
- Filter supersaturated solution upon creation & throughout crystal growth
- Add sulphuric acid to lower pH & reduce $Fe^{2+} \rightarrow Fe^{3+}$ conversion
- Cover to avoid oxidation
- Produce much smaller and finer seed crystals

2. Dehydration

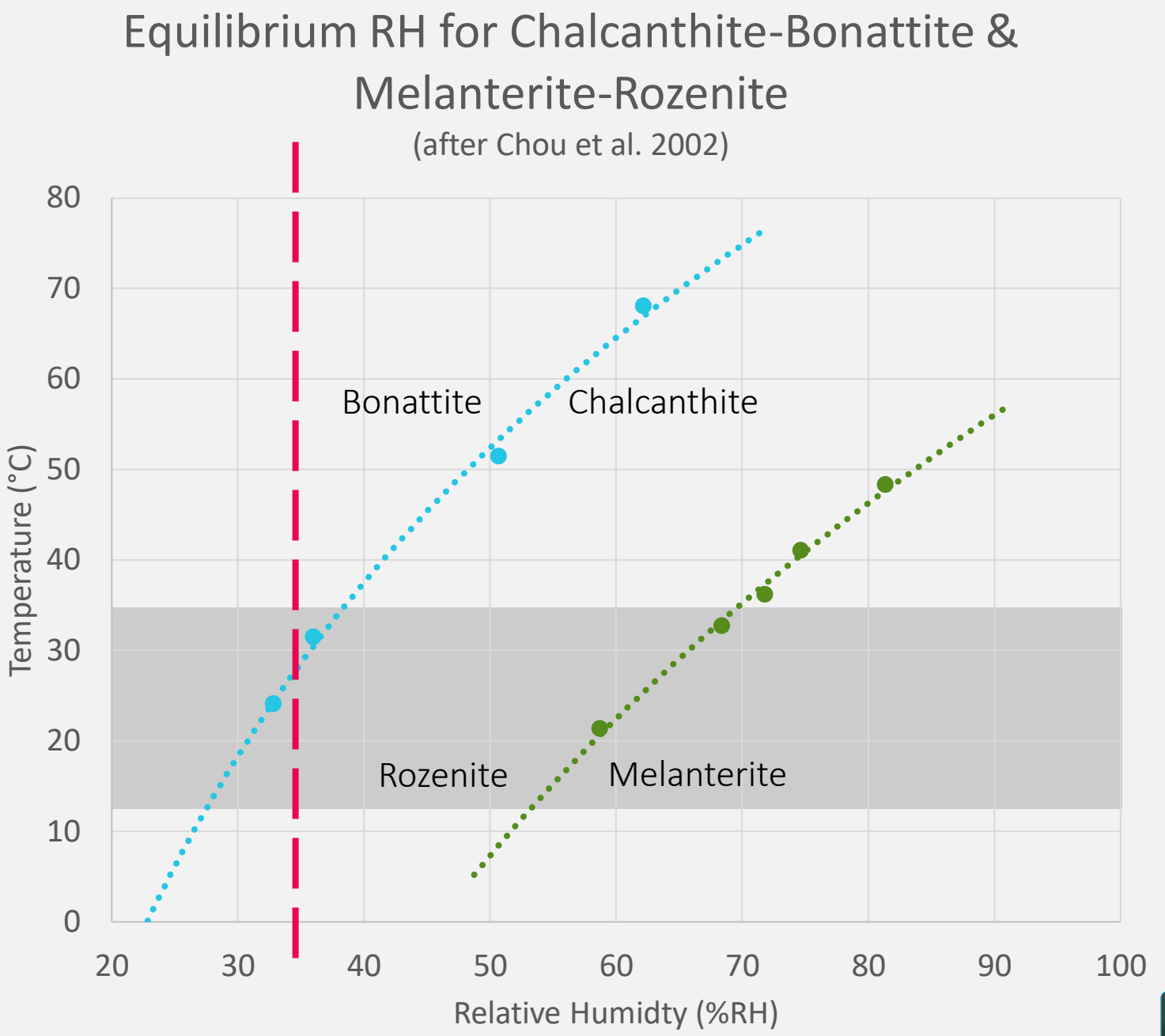
from Waller 1992 & Blount 1993

- Chalcanthite: ≥ 33%
- Bonattite: 22 ≤ x ≤ 30%RH
- Poitevinite: ≤ 22%RH

- Melanterite: ≥ 57%RH
- Rozenite: 30 ≤ x ≤ 57% RH
- Szomolnokite: 11 ≤ x ≤ 30%RH



Experiment:
30°C & 35% RH
for 6 weeks



XRD of Dehydration Products

Determine alteration products & anticipate experimental results

1. Chalcanthite => siderotil & szomolnokite
2. Pisanite => siderotil & szomolnokite
3. Melanterite => epsomite & hexahydrate

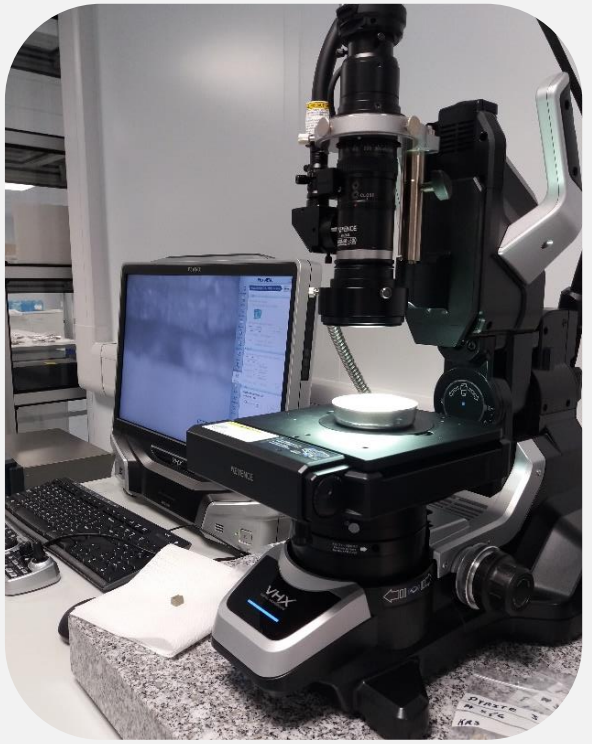
Specimens were misidentified when accessioned

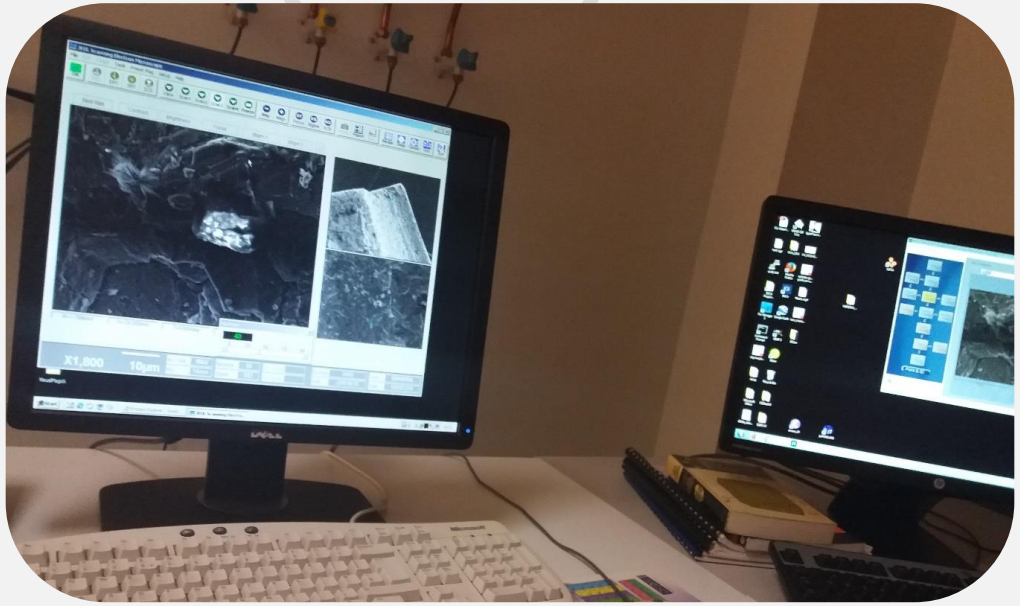
1. Cuprian melanterite
3. Epsomite

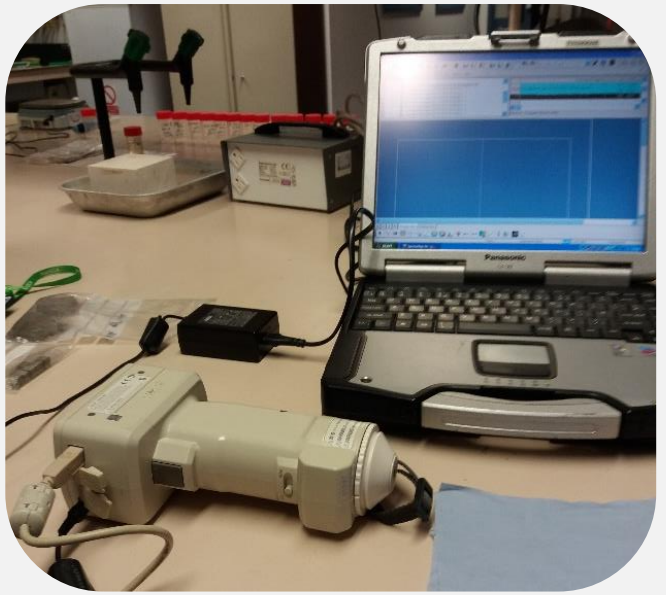
3. Analysis

Determine quantitative methods of identifying & monitoring change

- Weight gain
- Photography
- SEM – EDX
- XRD
- FT-IR
- Raman
- CT scans
- 3D microscopy
- Colorimetry







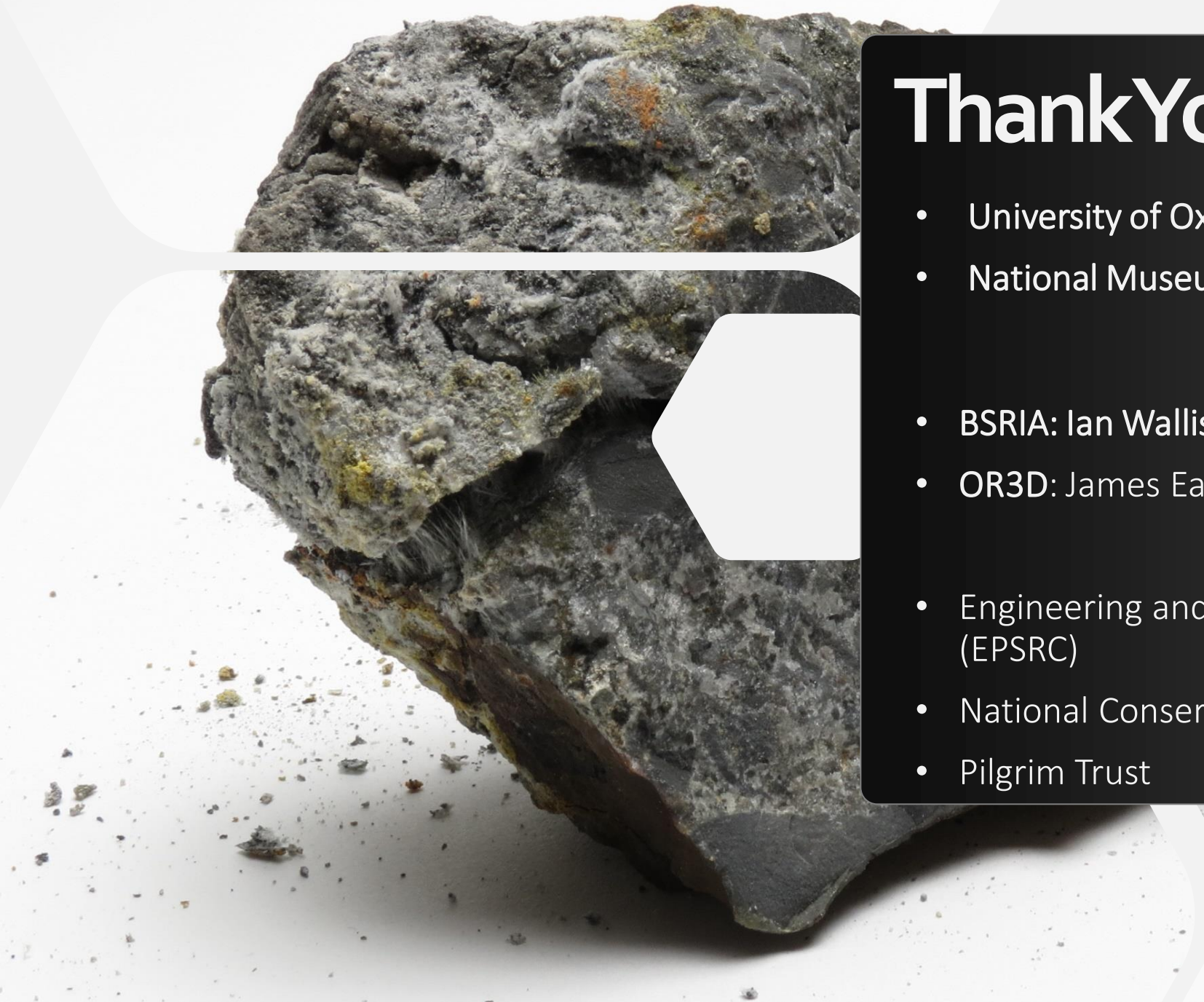
Areas of Further Research

Next few months

- More detailed review of mineral store
  - Visual identification of sensitive minerals
  - Narrow focus
- Rehydration study of melanterite & chalcanthite
- Additional analytical techniques
  - Specific gravity
  - Hardness
  - Polarized microscopy

Longer-term

- Defining & quantifying damage
  - Species specific?
- Utilizing digital technologies
  - 3D scanning / photogrammetry
  - AI
- Assessment of sample acquisition
- Further development of experimental design(s)
  - Allow for incorporation of pollutants & light



ThankYou

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