

COLL
ECTION
CARE

NEW CHALLENGES IN PREVENTIVE CONSERVATION,
PREDICTIVE ANALYSIS AND ENVIRONMENTAL MONITORING

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UNIVERSITAT POLITÈCNICA DE VALÈNCIA (Valencia, Spain)



Mechanical properties of tempera paints

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Approaches to determine acceptable climate variability

1. Understanding the mechanical behavior of objects in response to climate variations

2. The Acclimatization Concept

3. Tracing the climate-induced damage directly – a precise assessment of the specific site

Mechanical models – the worst-case approach

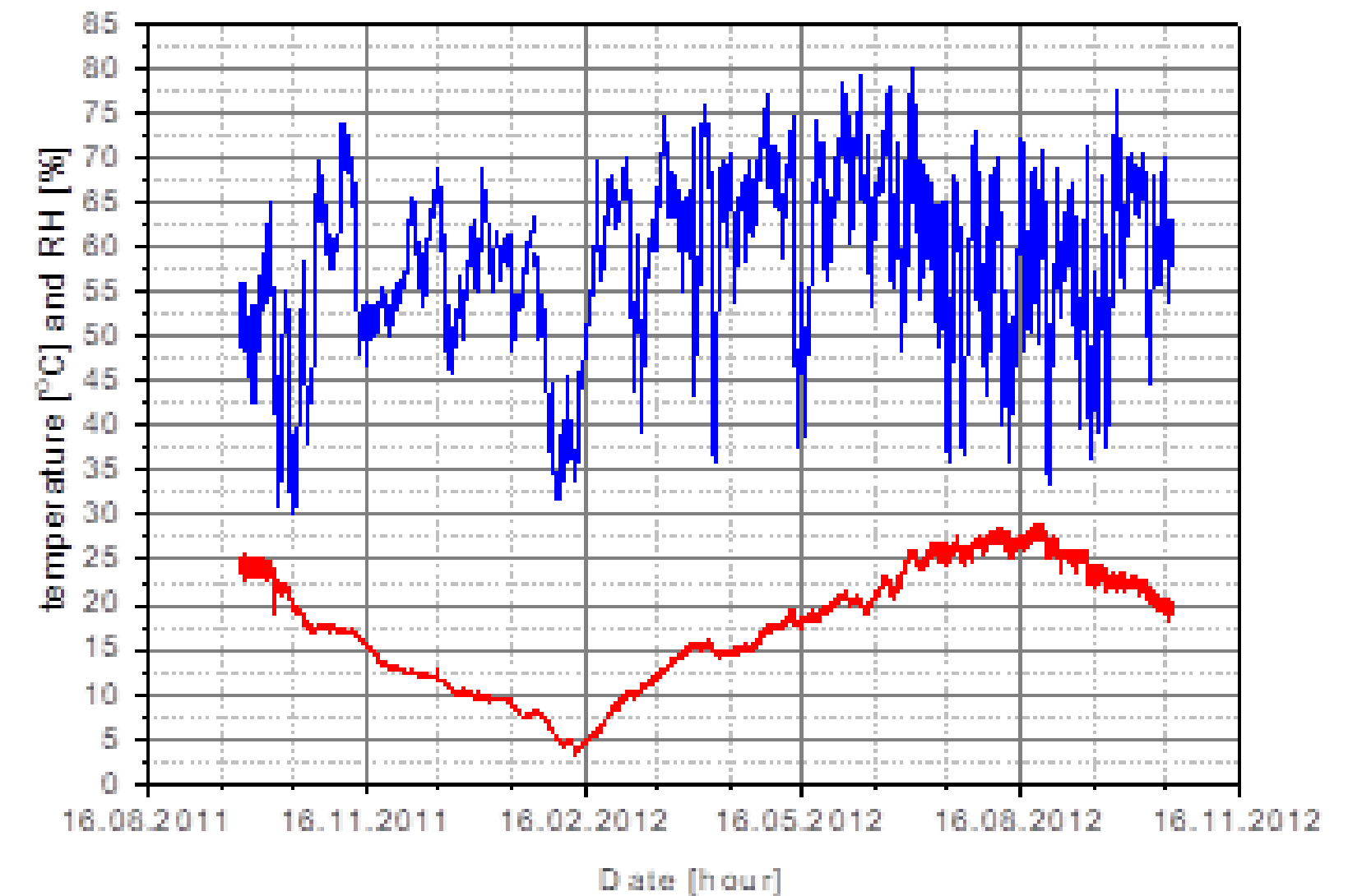
Assumptions:

1. fully elastic model

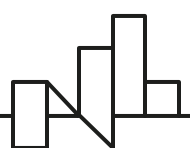
2. yield strain as damage criterion

3. undamaged object

+/- 10%RH



Church Santa Maria Gloriosa dei Frari, Venice



Craquelure - how it is formed and what is its influence on the vulnerability of objects to variations in T and RH

craquelure - objects are commonly cracked

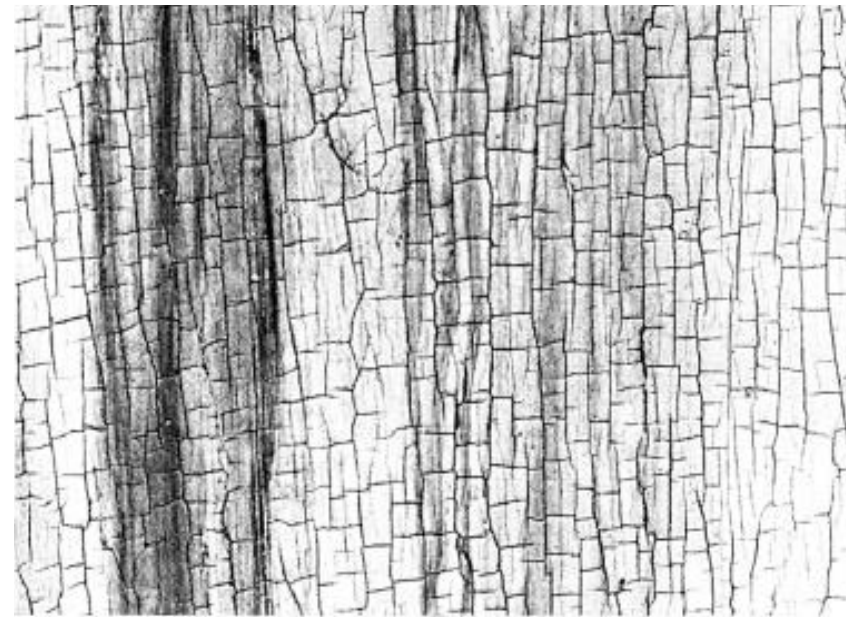


Figure 12 Example of a craquelure pattern showing an ORDERED network; Flemish; Master of St Giles, 'Saint Giles'. Horizontal dimension 4.5cm.

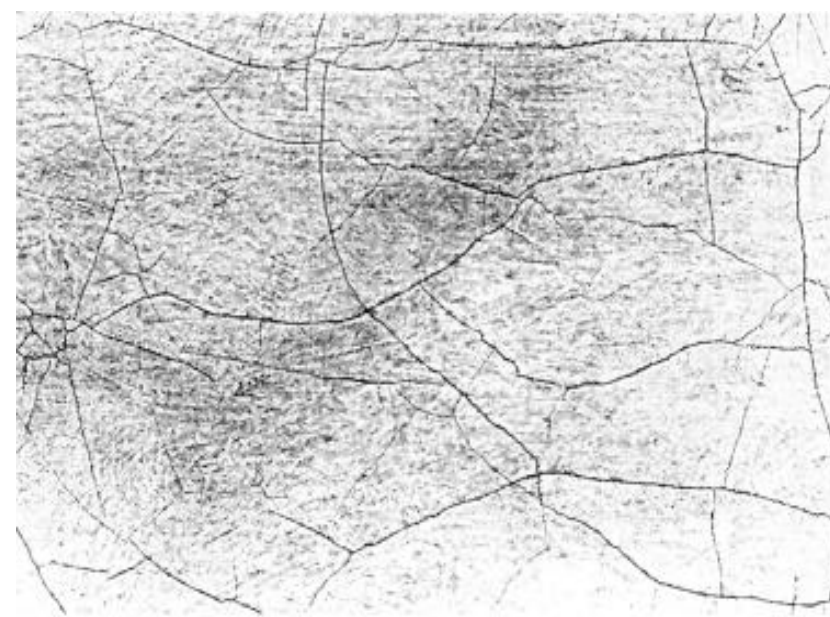


Figure 13 Example of a craquelure pattern showing a RANDOM network; French; Francois Boucher, 'Diana bathing'. Horizontal dimension 7cm.



Figure 2 Example of a craquelure pattern showing cracks PARALLEL to the wood grain; Flemish; Hieronymus Bosch, 'Christ Mocked'. Horizontal dimension 4.5cm.

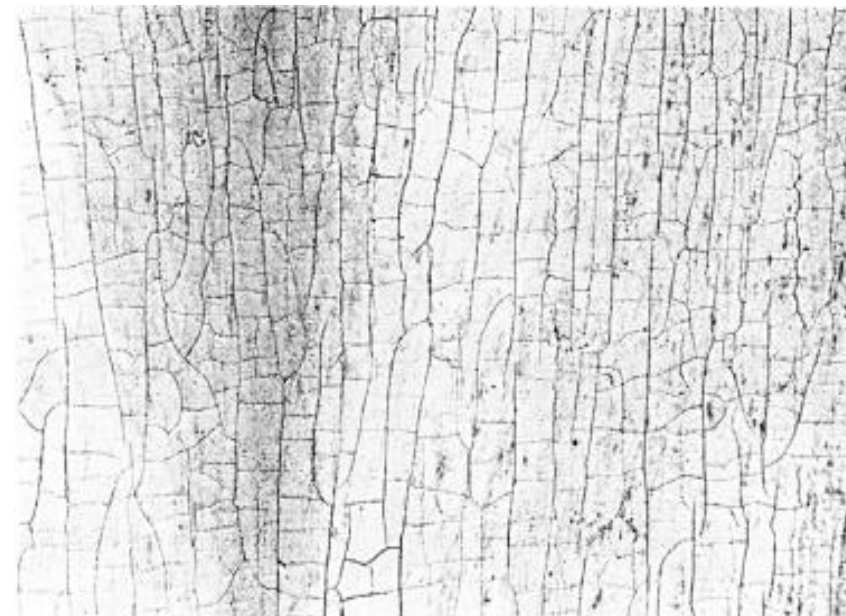


Figure 15 Typical craquelure pattern from a Flemish fifteenth/sixteenth-century painting on panel; Robert Campin, 'Virgin and Child before a fire-screen'. Horizontal dimension 4.5cm.

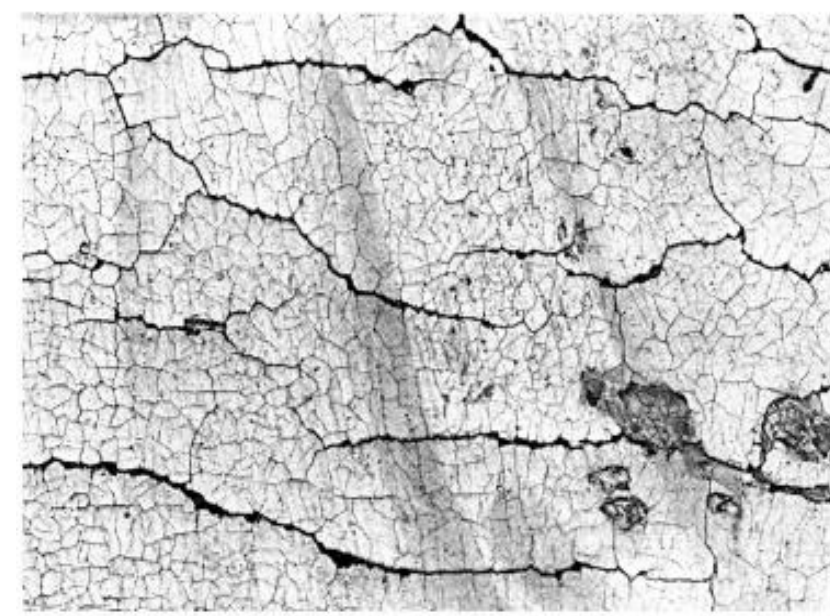
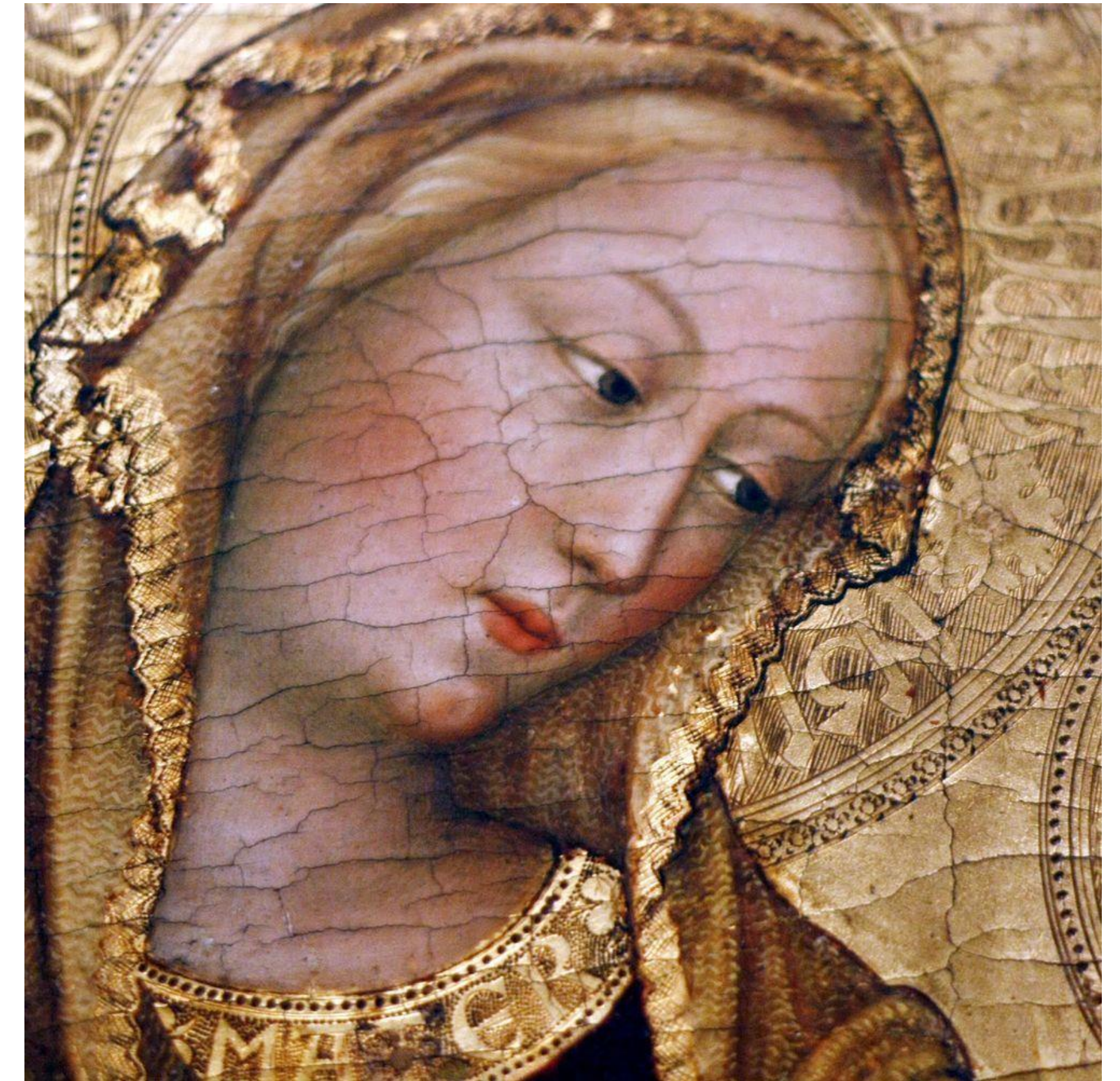


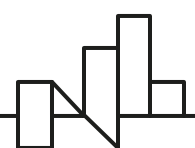
Figure 14 Typical craquelure pattern from an Italian fourteenth/fifteenth-century painting on panel; Lorenzo Monaco, 'The Coronation of the Virgin'. Horizontal dimension 4.5cm.



Figure 3 Example of a craquelure pattern showing cracks PERPENDICULAR to the wood grain; Italian; Paolo Uccello, 'The Battle of San Romano'. Horizontal dimension 4.5cm.



'Madonna and Child Enthroned', c. 1420, Gentile da Fabriano, the National Gallery in Washington

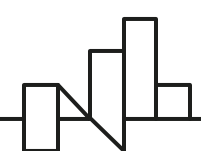


Model of paintings with craquelure patterns for evidence-based environmental control in museums – CRAQUELURE

The project aims to develop a **3D physical model of paintings with existing craquelure patterns** and through this decisively contribute to the **development of evidence-based environmental specifications** for paintings.

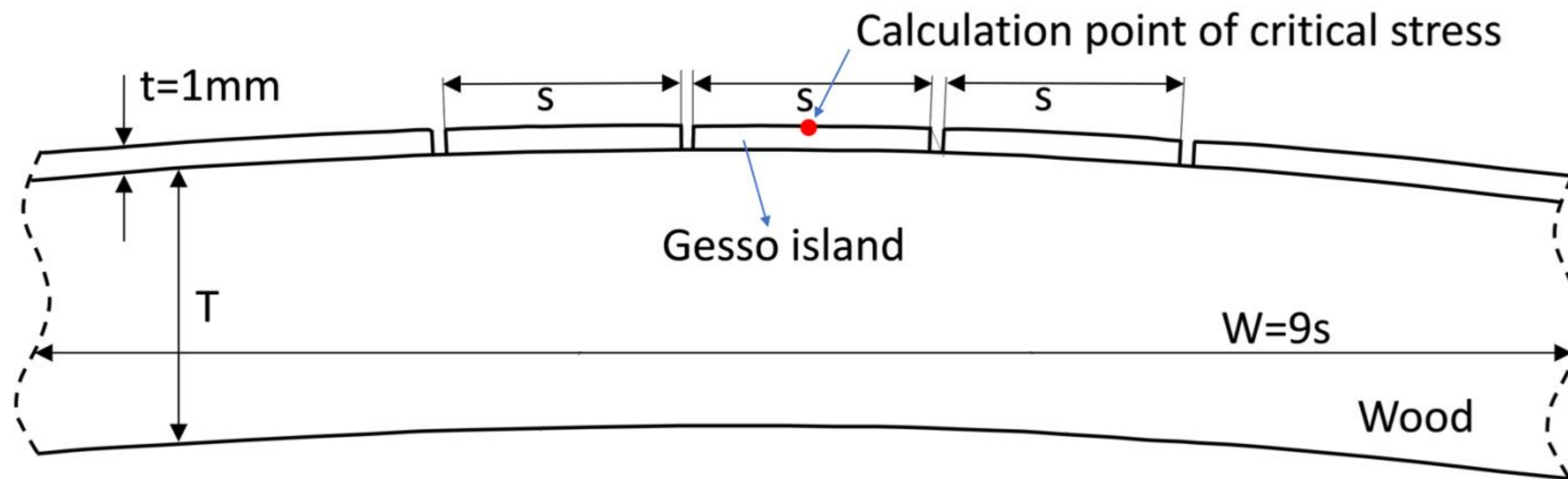
Strategic objectives will include:

1. Building a database of for historical materials used in pictorial layers
2. Developing a 3D model of painting with of fractured pictorial layers, especially to understand the mechanisms and processes involved in craquelure pattern formation and growth
3. Determining of a safe range of RH variations for paintings with craquelures



Mechanical modelling of painting

Understanding the mechanical behavior of objects in response to climate variations.



Bratasz, Ł., Akoglu, K.G. & Kékicheff, P. Fracture saturation in paintings....(2020)



Virgin and Child' by unknown author (XV century) from St. Mary's Basilica in Krakow

Mechanical modelling of painting

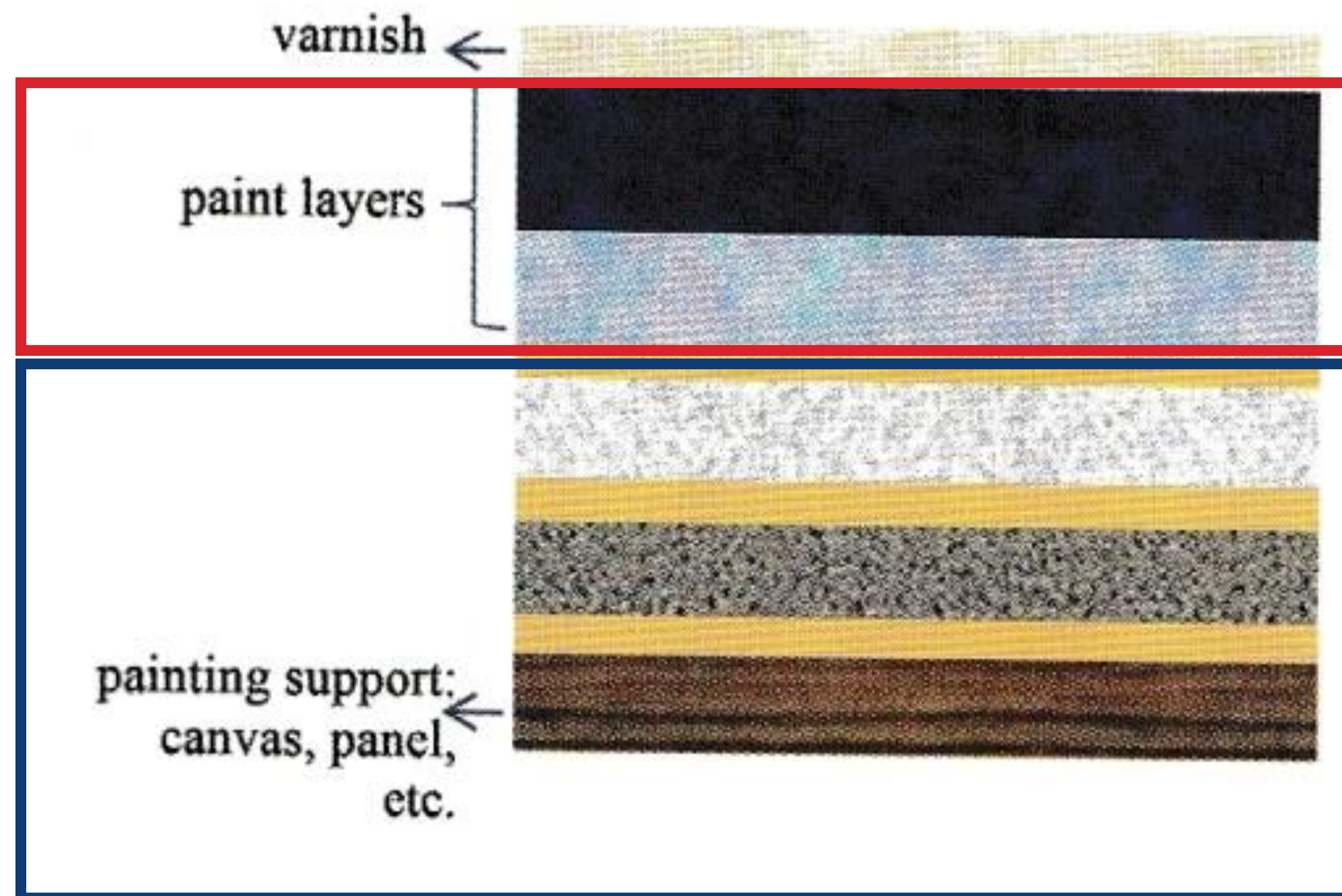
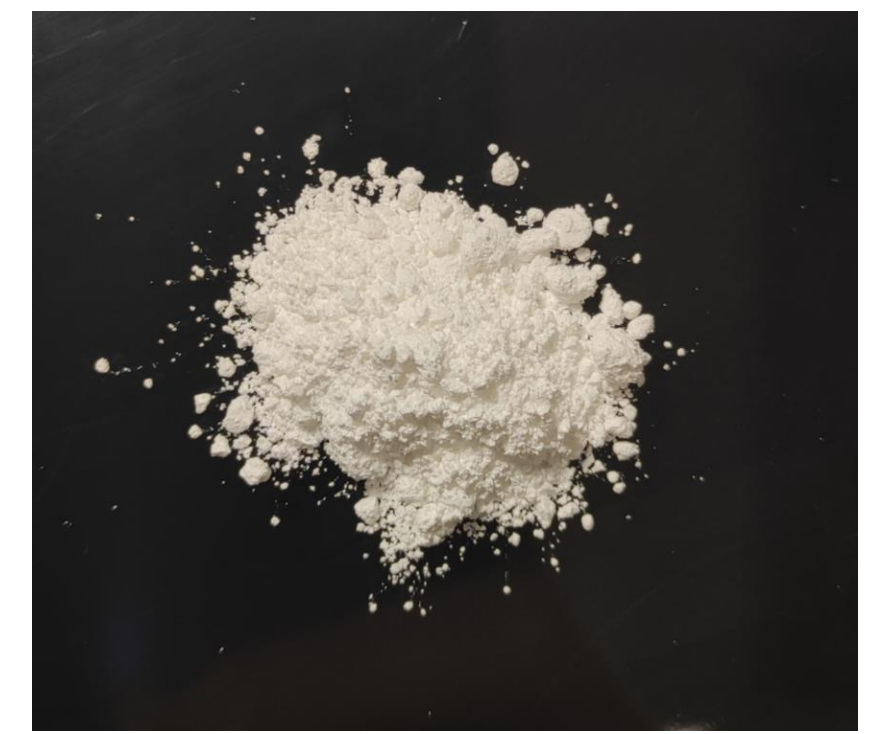
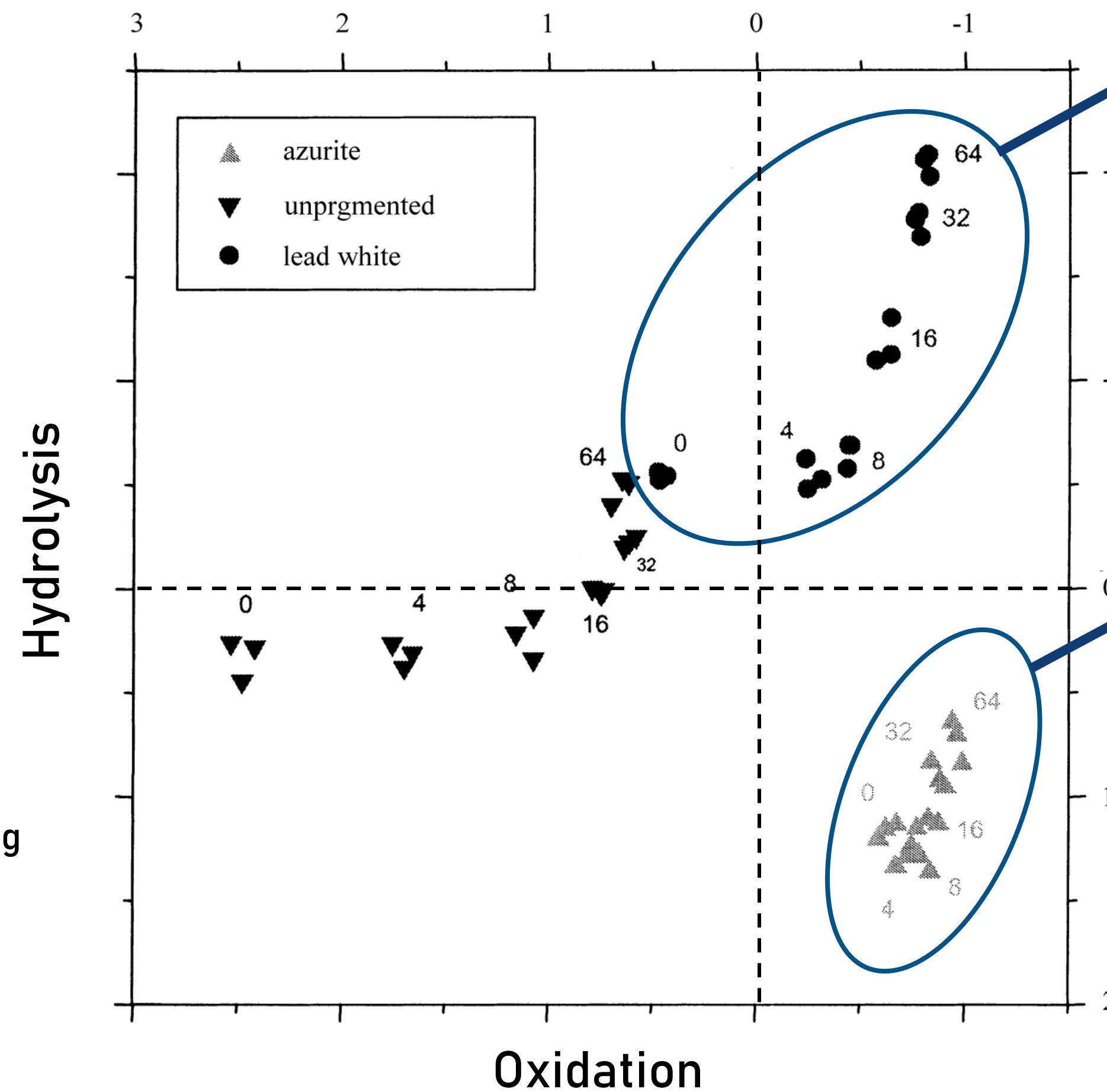


Table 2 Summary table of the types of paints and testing parameters varied in the studies that used uniaxial tensile testing to investigate mechanical properties

Reference	Oil	Alkyd	Acrylic	Filler, ground, support
Mecklenburg, 1991 [29]	✓			
Erlebacher, 1992 [30]		✓	✓	
Mecklenburg, 1994 [31]			✓	
Whitmore, 1995 [32]			✓	
Tumosa, 1999 [28]	✓			
Mecklenburg, 2001 [33]	✓			
Carr, 2003 [34]	✓			
Mirone, 2004 [35]		✓		
Meckelburg, 2004 [36]	✓			
Hagan, 2004 [37]			✓	
Erhardt, 2005 [38]	✓			
Tumosa, 2005 [39]	✓			
Young, 2007 [40]	✓	✓	✓	
Hagan, 2007 [15]		✓	✓	
Young, 2008 [41]	✓	✓	✓	
Fuesers, 2008 [42]	✓	✓		

Selected pigments

Two ageing phenomena of tempera paint

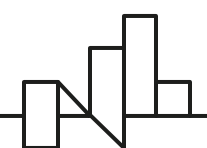


lead white
 $2\text{PbCO}_3 \cdot \text{Pb}(\text{OH})_2$



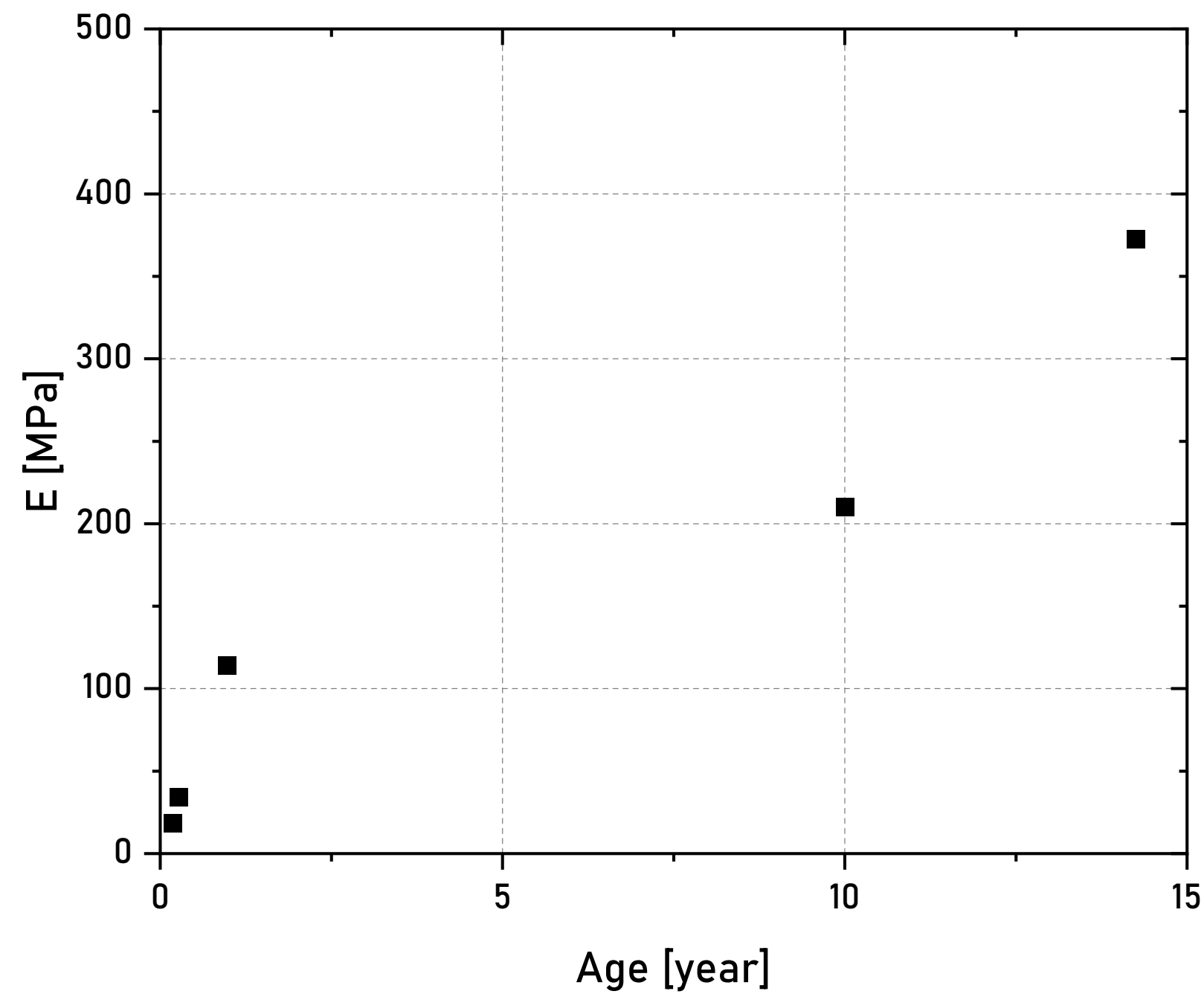
azurite
 $2\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$

Fig. 9. Map of scores on the first two discriminant functions for light ageing series of unpigmented, lead white pigmented and azurite pigmented tempera.

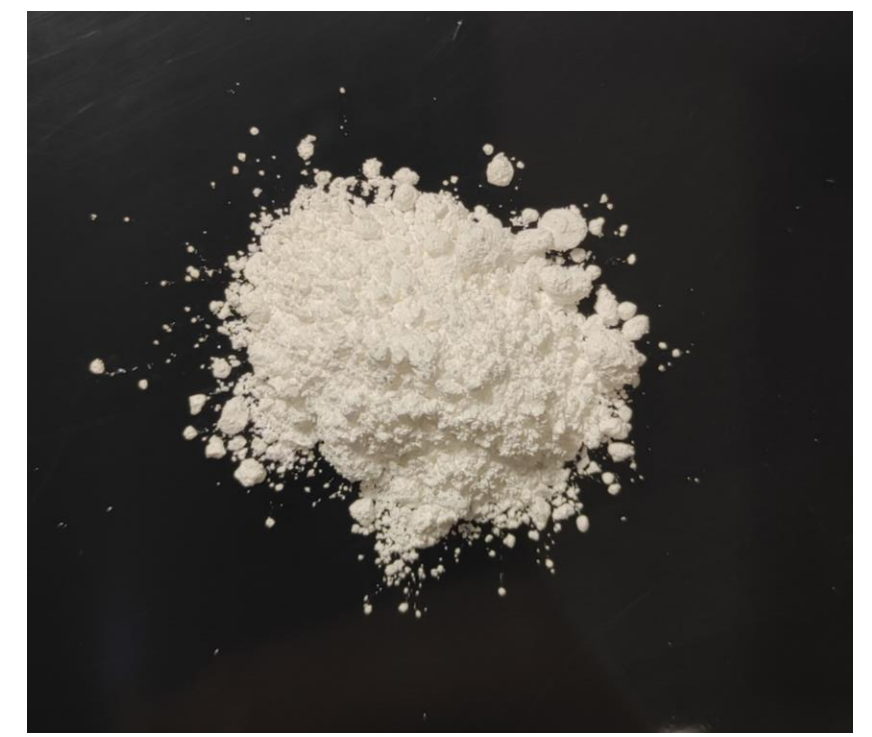
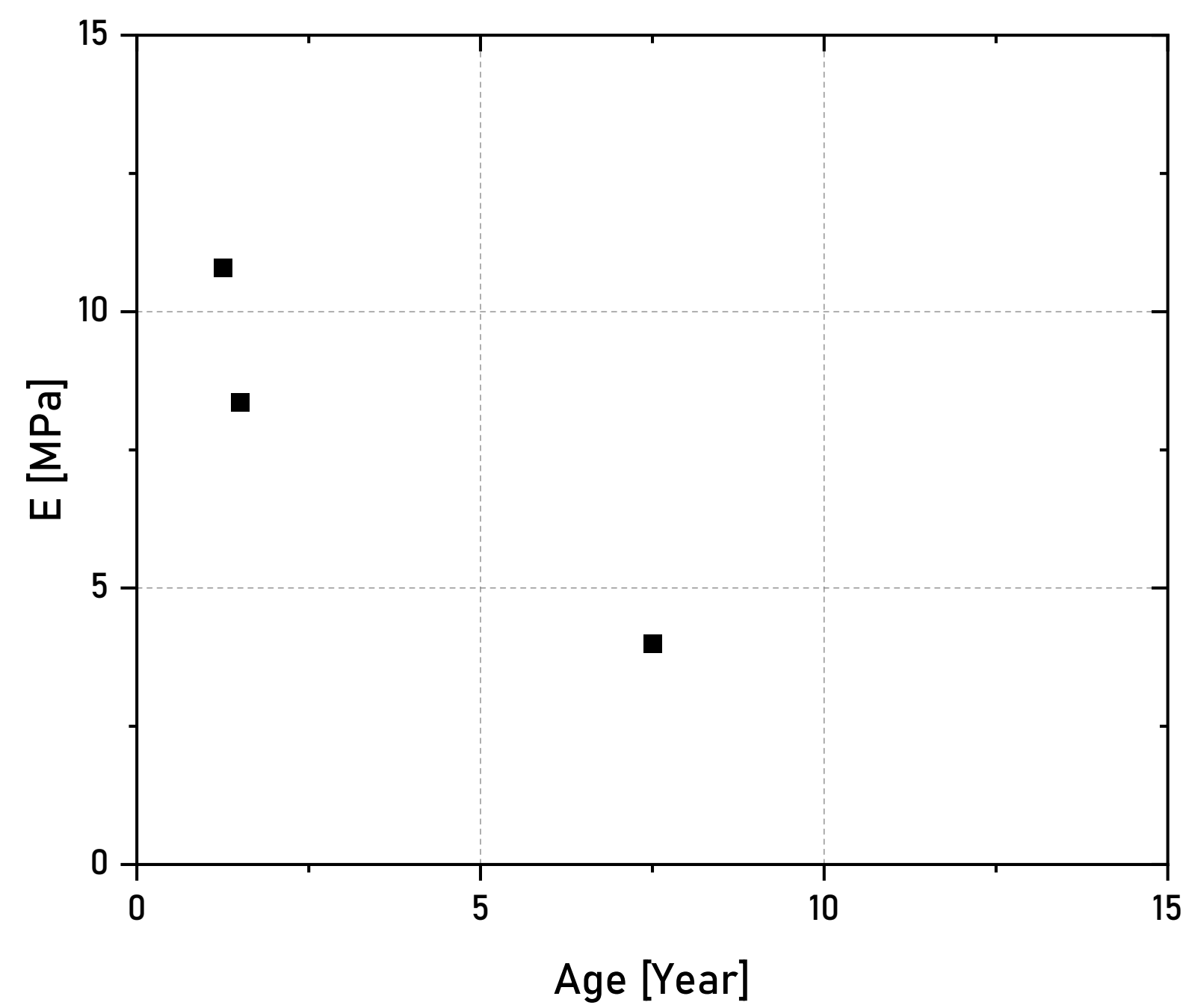


Selected pigments

E Modulus of lead white oil paint



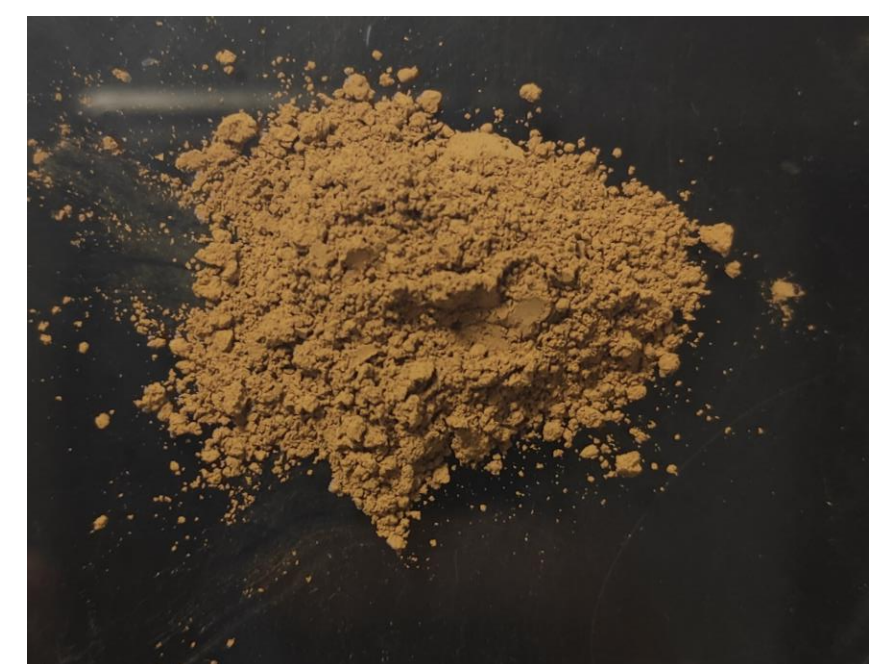
E Modulus of red iron oxide oil paint



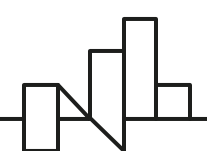
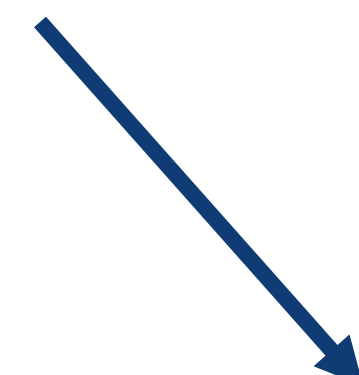
lead white
 $2\text{PbCO}_3 \cdot \text{Pb}(\text{OH})_2$



azurite
 $2\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$



yellow ochre
 $\text{FeO}(\text{OH})$



Paint preparation

Samples that can be both:
realistically produced and
representative of the historical techniques

Egg tempera samples were prepared according to the traditional procedure of C. Cennini's book *El libro del arte* ca.1400.

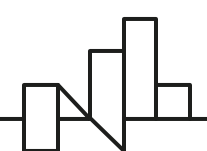
Binder: egg yolk and water (1:1)

Pigments: lead white (PVC 60%)

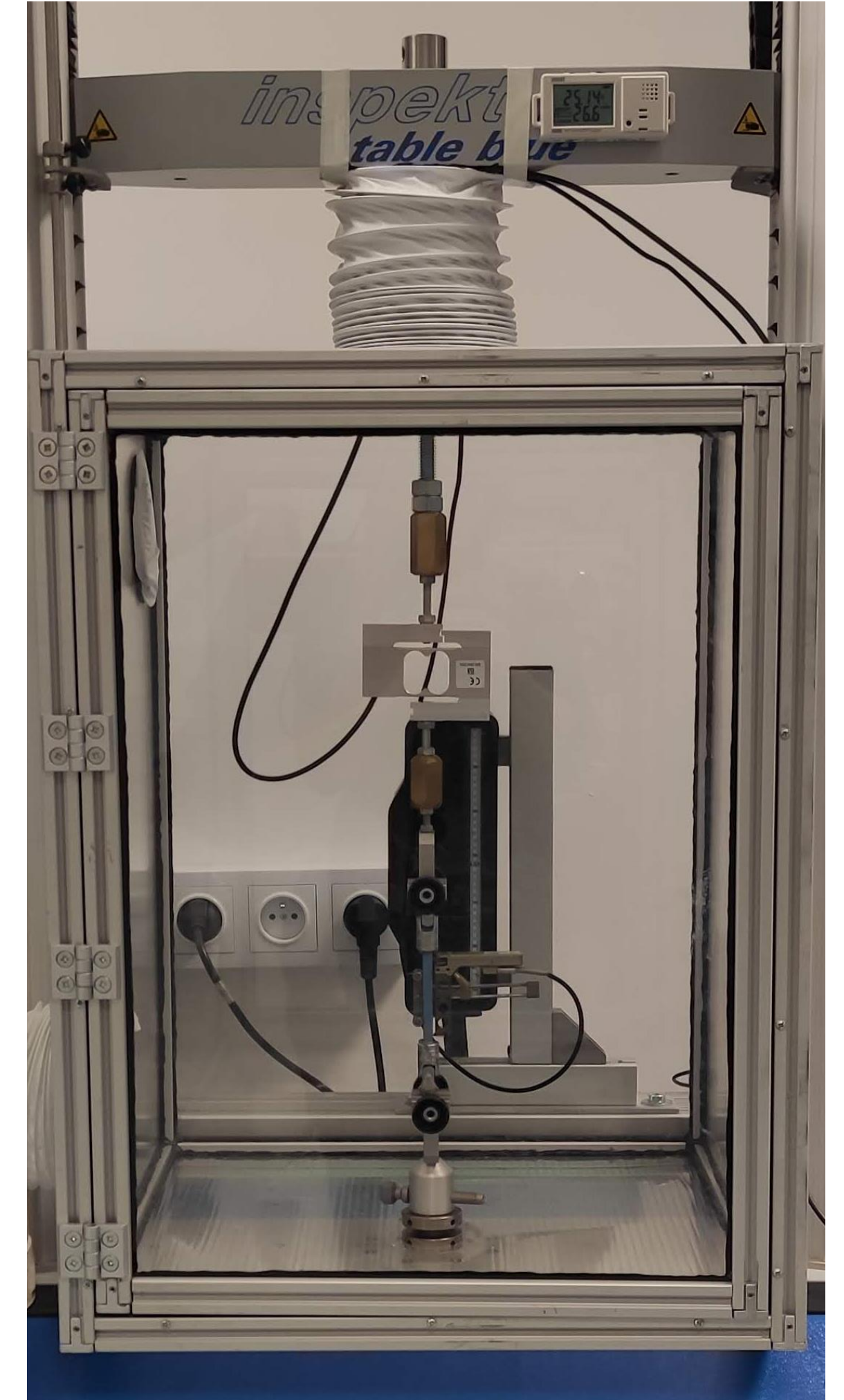
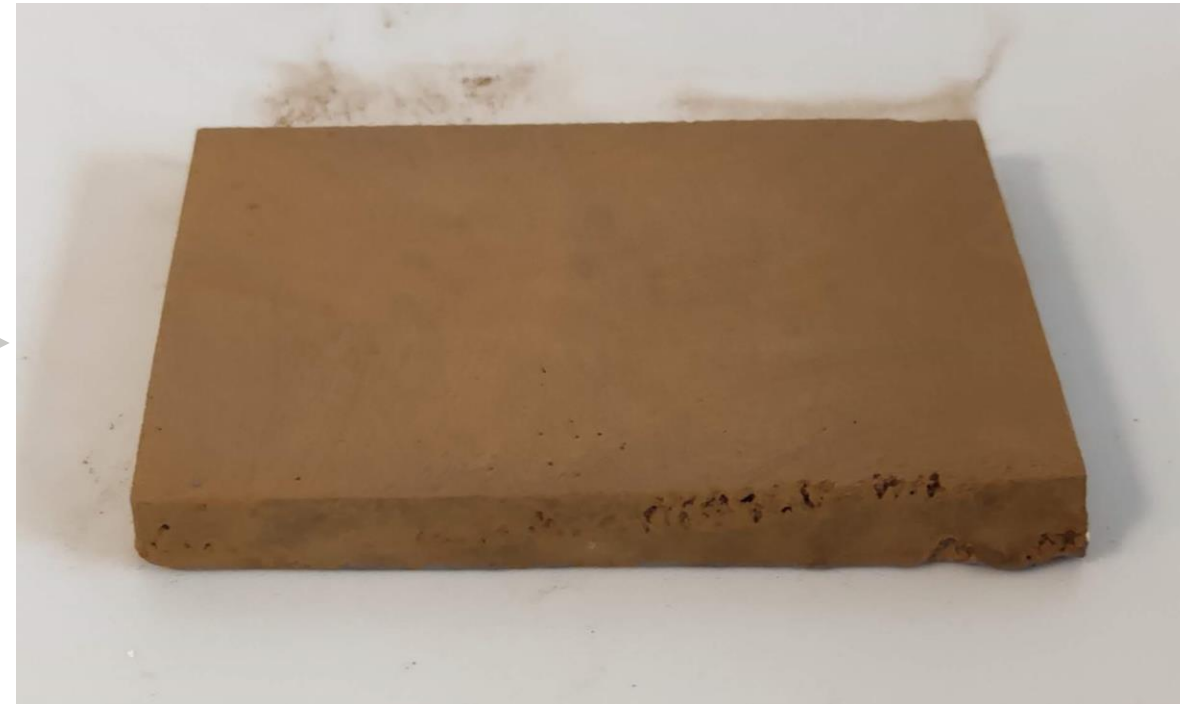
azurite (PVC 76%)

yellow ochre (PVC 73%)

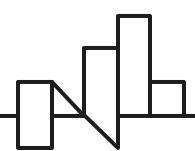
Curing: stored in room and dark conditions 6 months



Sample preparation and testing method

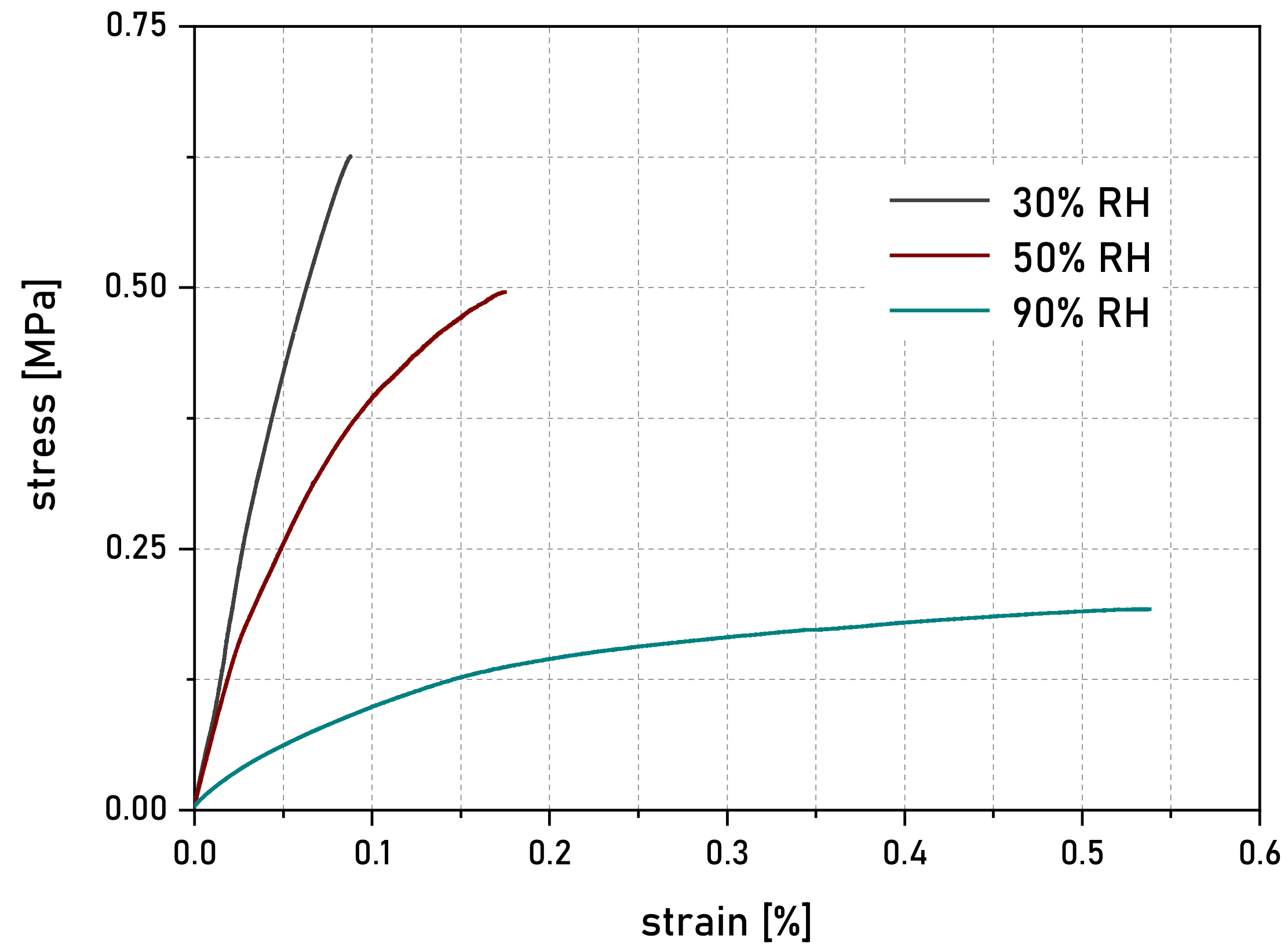


6 mm x 6 mm x 80 mm

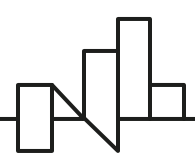
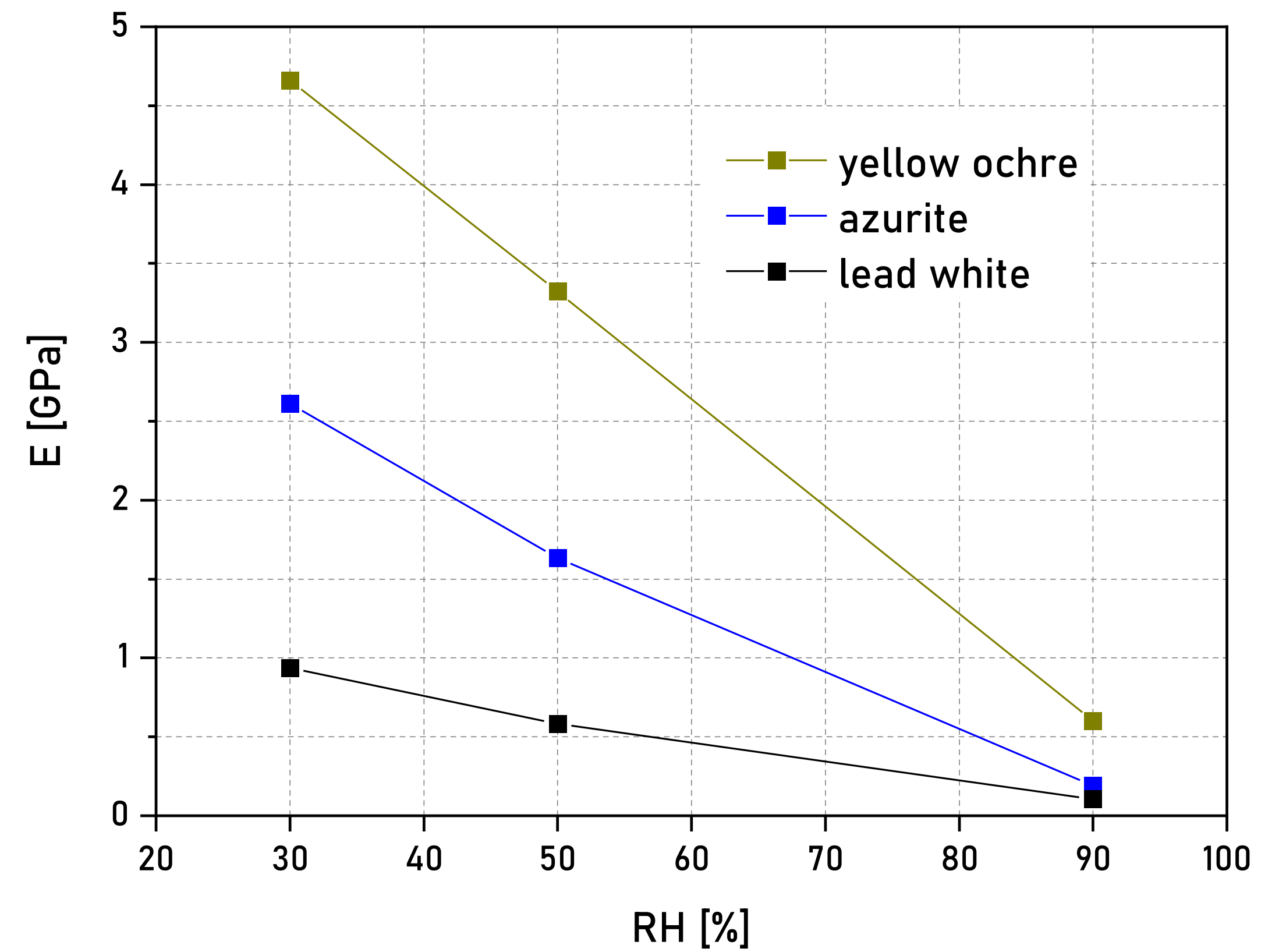


Tensile test - modulus of elasticity

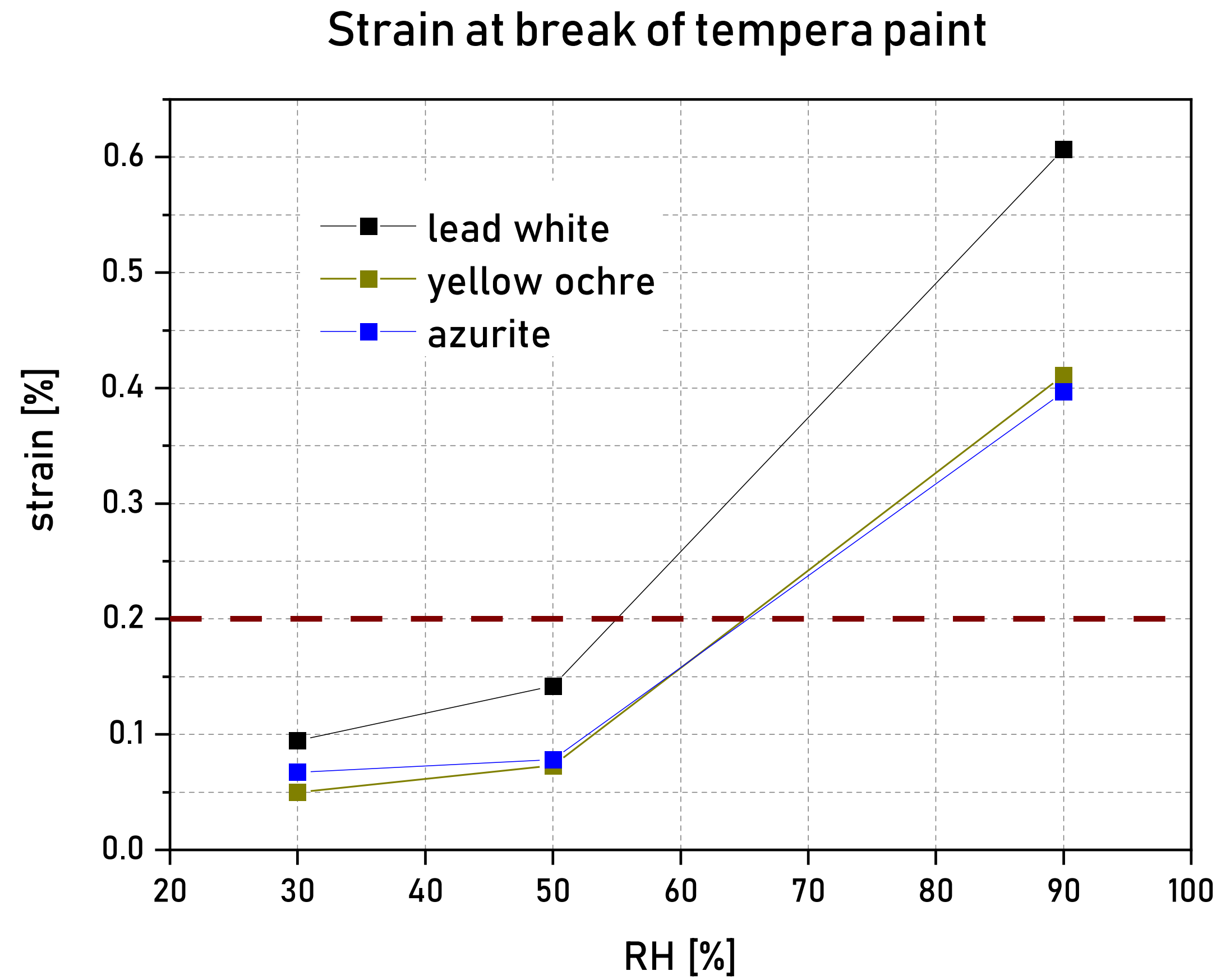
Stress-strain curve for lead white tempera



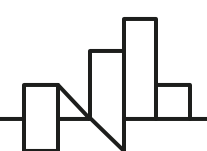
Modulus of elasticity of tempera paint



Tensile test – strain at break

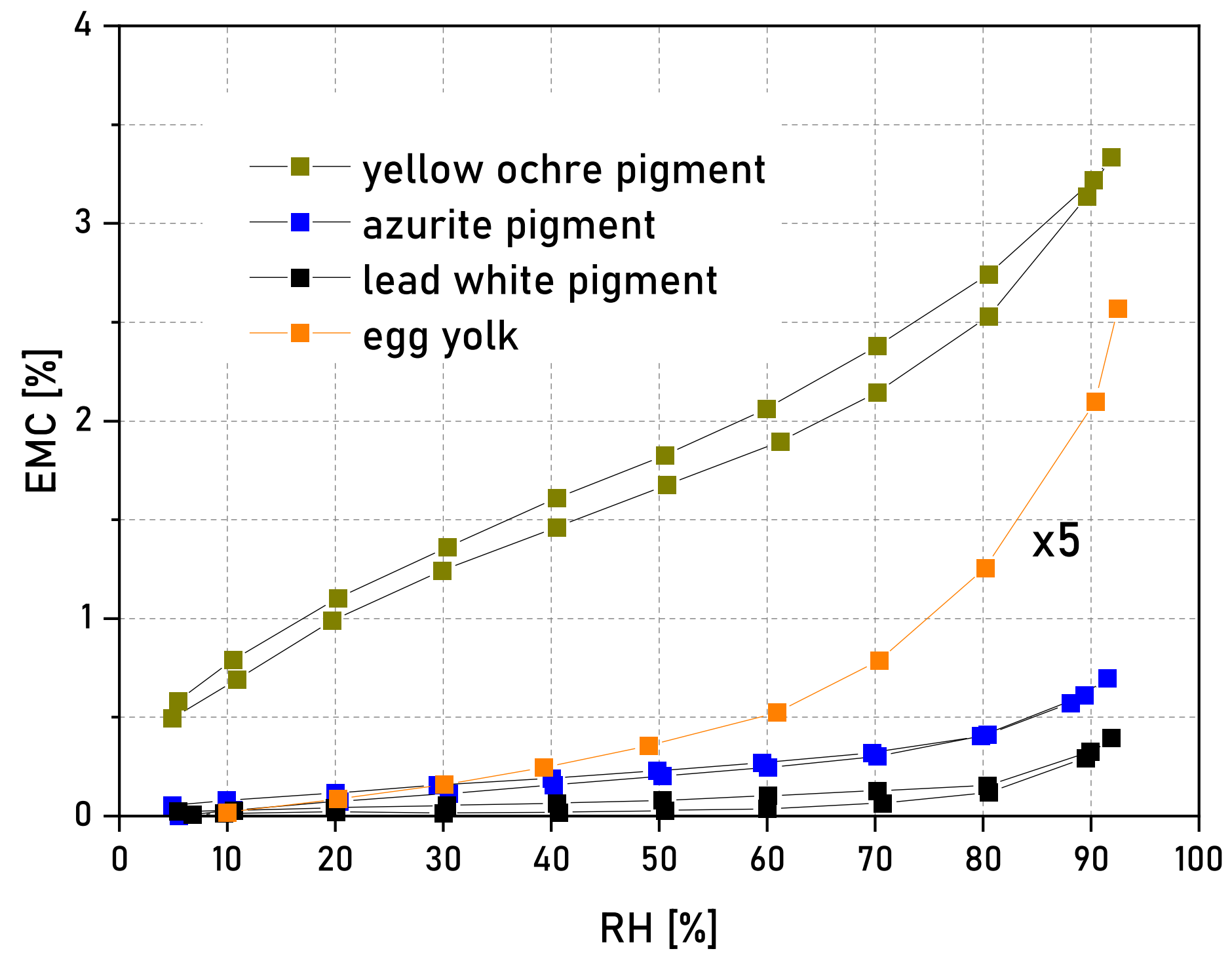


critical strain of gesso

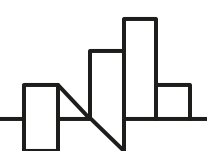
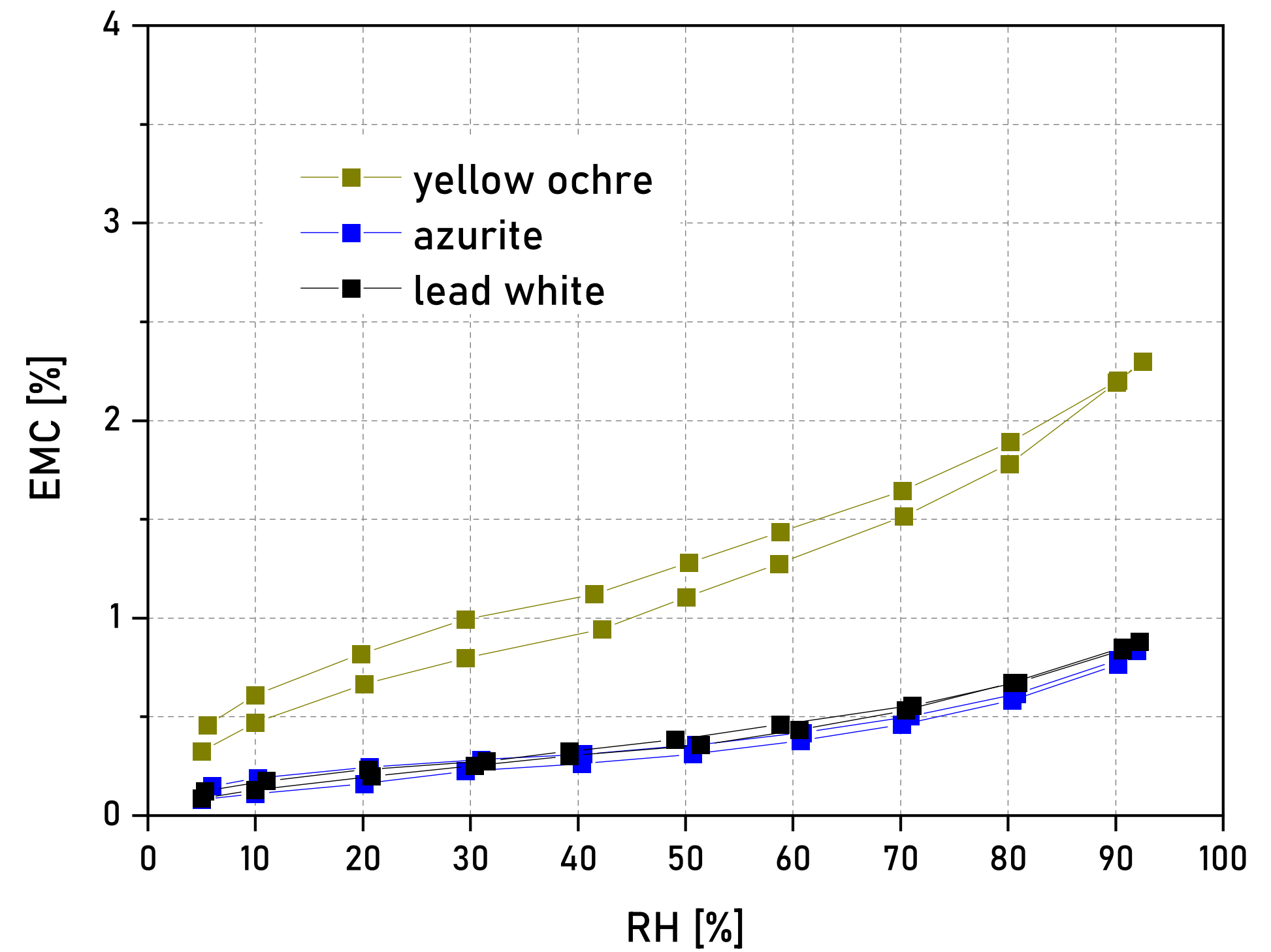


Moisture sorption isotherm

Sorption isotherm of components of tempera paint



Sorption isotherm of tempera paint



Thank you



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