Why? How? What?

Historical buildings are important landmarks of the history, architecture and culture of a region or community.

The need for conservation occurs due to intrinsic physical and chemical properties of the monuments and their interactions with the environment.

The **study of old mortars and renders**, based on a methodology that combines mineralogical, microstructural, chemical, physical and mechanical characterisation has an important role on the preservation of architectonical cultural heritage, allowing a **deep knowledge about**:

- **Binder** (aerial or hydraulic lime, gypsum, clay,…)
- **Aggregates** (type of sands and their provenance)
- **Additives** (naturak or artificial pozollans, straw, fibers, etc)
- **Mortars composition** (binder/aggregates ratio)
- **State of conservation / degradation products**
- **Physical properties** (mechanical resitance, porosity)
- **Past interventions**
- **Pigments in painted layers**
- **Insight on technical knowledge**

This information is essential for the development of **integrated conservation methodologies** as well as for the **design of new aesthetic and functional compatible mortars**.

Drying at 40 °C

Stereo-zoom microscope (7.5- 120x)

Sample disaggregation and preparation for characterisation

chemical analysis → soluble fraction → AAS → Soluble salts (Cl⁻, SO_4^{2-}, ...) Binder Hydraulic

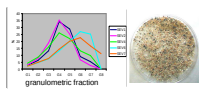
insoluble residue → Aggregates composition Particle size distribution

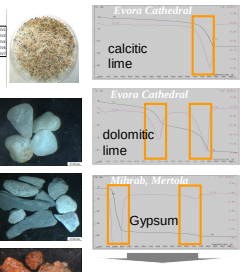
XRD → Mineralogical composition

TG-DTA → Binder compositon and classification

SEM-EDX → Mortar composition and morphology Degradation diagnosis

optical microscopy → Nature, color and morphology of the aggregates



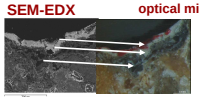


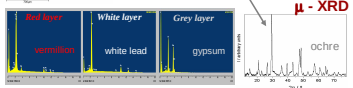
aggregates / binder ratio

Spatial interrelationships of mortar components

Aggregate/binder interfacial reactions

…sometimes, painted layers

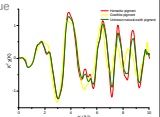




Synchrotron radiation

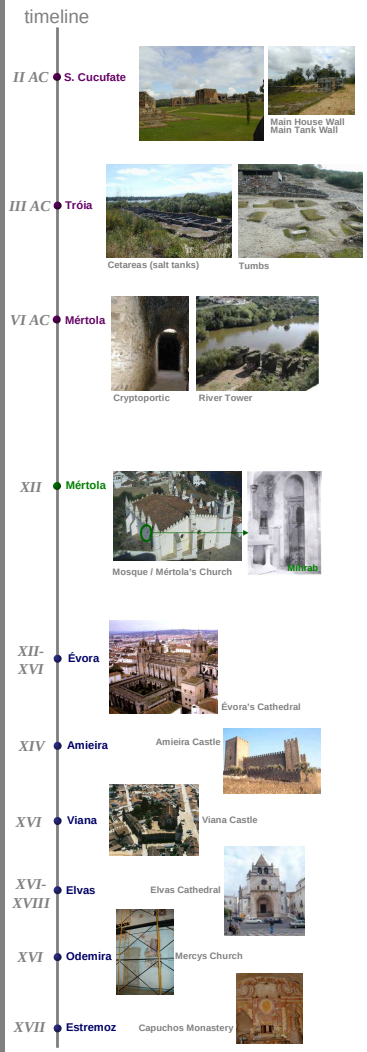
Some times the colouring agent is **scarce** or is **not crystalline**. In these cases a elements-specific technique as **XAS** is essential.

Thin-sections studies require **μ-XAS/XRF** techniques.



Earth natural pigment Fe K-edge EXAFS $k^2\chi(k)$ functions.

timeline



roman mortars

Our studies showed that the **Romans** in the Iberian Peninsula were highly skilled, and possessed a **sophisticated technological knowledge** (even after the fall of Imperial Rome). **However, this knowledge was lost after their occupation**.

The aggregates used were always local sands (either crushed rocks or river sands) and the binder used was in all cases aerial lime.

The use of **artificial pozzolans** (powder and crushed ceramics) rendered the mortars **mechanical resistance** and **water tight properties** (hydraulic properties) due to the formation of pozzolanic reactions and the formation of new materials. Their **crystalline and compositional nature its not well known** and **synchrotron μ-XRF/XRD** experiments are planned. The preferential position of the neo-formation compounds at the binder/aggregates (pozzolans) interface is apparent from 2D optical microscopy studies but must be evaluated by 3D X-ray microtomography.

muslim mortars

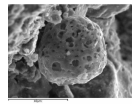
Previous information reported that the **Mihrab mortars** were lime mortars. **Surprisingly** our studies showed that the Mihrab mortars are **gypsum mortars** with very **fine crushed bricks** as aggregates and very smaal amounts of sand.
This type of mortars is common in Northern Africa but is the first time that is reported in Portugal.

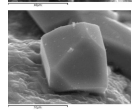
christian mortars

All mortars are **more friable than Roman mortars.** Mortars from XVII century upward have higher resistance than older mortars showing a cumulative empirical knowledge. In some cases, artificial and natural pozzolans were added .

All mortars are aerial lime mortars. The type of binder is in some cases calcitic lime while in other cases is dolomitic lime.

The mortars from the inside of **Evora's Cathedral** show the presence of **abnormal amounts of chlorine** and the presence of **carbon black particles**. These results may indicate that **fire** was produced inside the church and **sodium chlorine** was added during the making of the mortars to **accelerate the mortars hardening.**





searching for the past in ancient mortars and renders

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