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Technical Note

Chemical–mineralogical characterisation as useful tool in the assessment of the decay of the Mesola Castle (Ferrara, Italy)

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ABSTRACT

The Mesola Castle and its Portico (16th century) rises on the right side branch of the River Po Delta in the eastern part of Ferrara province (Italy). Bricks, mortars and plasters from the Castle's Portico were characterised by optical microscopy, X-ray fluorescence, X-ray diffraction and scanning electron microscopy/energy-dispersive X-ray spectrometers. This masonry is affected by efflorescence and sub-efflorescence, and mineralogical analysis, together with scanning electron microscopy observations, assisted to define the damaging products. Structures built in coastal environments are subject to sea weathering which cause substantial damages mainly due to the presence of salts. These could attack the building materials: (a) by penetrating from the ground through dampness; (b) carried by the wind in the form of salt spray; (c) due to occasional or recurrent flooding; (d) caused by the use of marine water during the preparation of mortar. For these reasons an integrated study approach involving chemical–mineralogical analysis and assessment of the environmental conditions is a useful tool to better define the causes of building materials deterioration.

1. Introduction

The Mesola Castle rises on the right side branch of the Delta Po River, 50 km east of the city of Ferrara (Italy), near the coastal line (Fig. 1). The Castle was built during the 16th century (between 1578 and 1583) by the dukes of the Este Family. It was used as a holiday residence and on its south side it was protected by a 12 km long wall, including the Mesola woods area. The Portico that surrounded the Castle, was used as living quarter for the court's personnel. The Castle and the Portico underwent several restoration and modification events, not all registered by historians, and during the last one, a continuous strata of cement mortar was applied on the entire Portico wall.

Salt weathering is currently affecting the Portico's masonry (mortars, bricks, and plasters) with efflorescence and sub-efflorescence. Salts are one of the main causes of deterioration in the porous building materials [1], involving not only the regions located near the sea, but in part also the continental regions. The preservation of ancient architectural heritage is extremely important and has to involve a wide range of specialists and their competencies. Therefore, historical understanding is not just the characterisation and preservation of artifacts, but also the investigation of the knowledge and skills used to produce them. This study is a multidisciplinary approach aiming to link the chemical–mineralogical features of mortars, bricks and plasters and the damaging products affecting them, to the changes in environmental conditions of the area. Establishing such a link will greatly assist public administration operatives and researchers to suggest suitable treatments and suitable new materials for maintenance and restoration.

2. Chemical and mineralogical characterisation

A localised and very complex stratigraphy characterise the Portico masonry due to many interventions, and in parts of it is possible to recognise the overlapping of different plaster mortar layers (Fig. 2). These layers appear all around the Portico, with a discontinuous trend, from the ground nearly to the top, placed directly on the brick wall or over ancient plaster mortar layers during the several restoration events. Crystallisation of soluble salts, such as efflorescence and sub-efflorescence, has caused superficial exfoliations (Table 1).

Chemical composition (both in major and in trace elements) of some bricks, mortars and plasters (Table 2) was determined by X-ray fluorescence (XRF) using an ARL ADAVNT.XP spectrometer [2]. Loss on ignition (LOI) was measured by weighting before and after 12 h of calcination at 1050 °C. Moreover, mineralogical determinations of some bricks, mortars, plasters and the efflorescence were carried out through X-ray powder diffraction (XRD) using a Philips PW1860/00 diffractometer, with a graphite filtered and a Cu Kα radiation (1.54 Å) in a two angular range 5–75°, with a 5 s/step (0.02° 2Θ). On selected samples both of building materials

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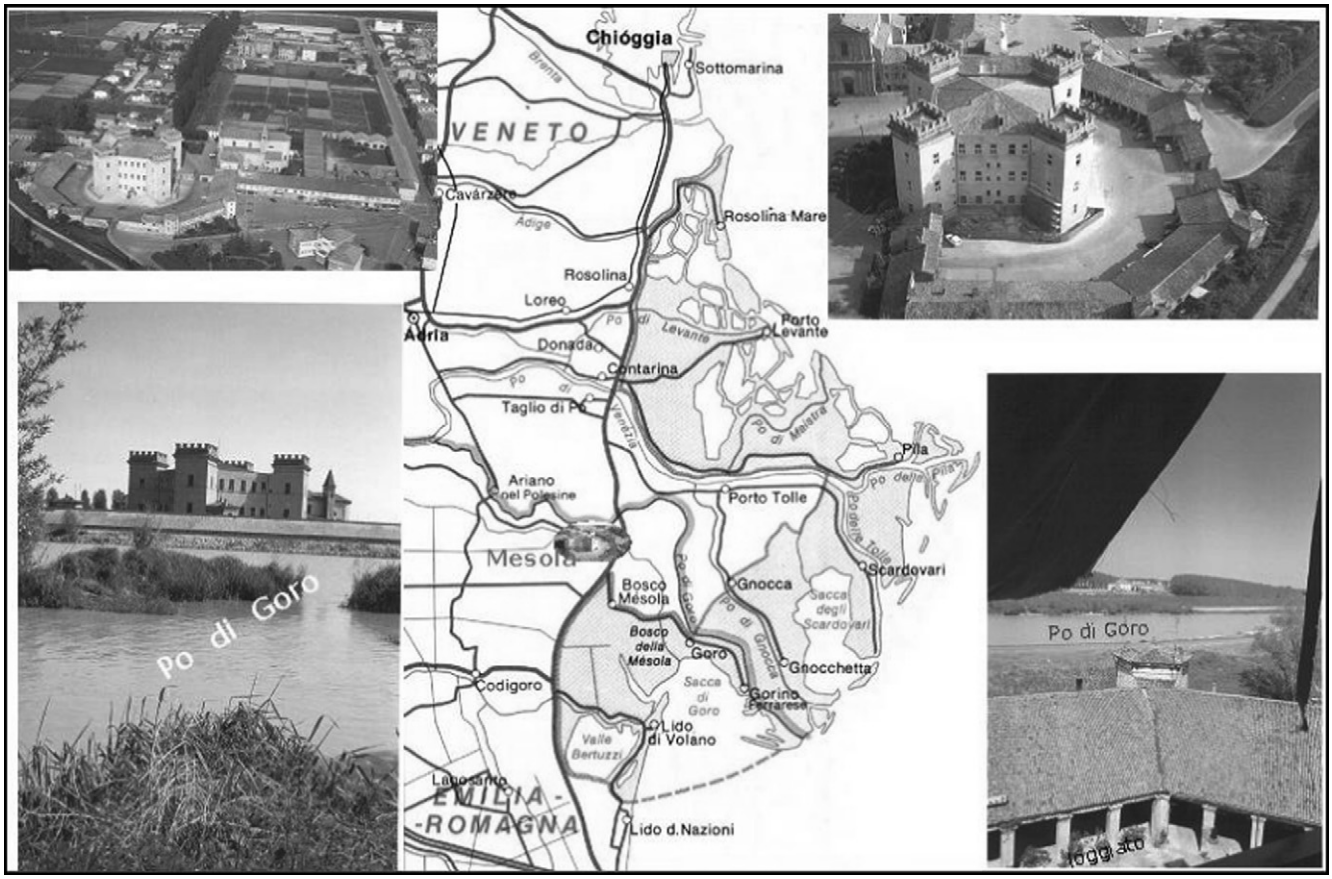

Fig. 1. Sketch map of the River Po Delta area.

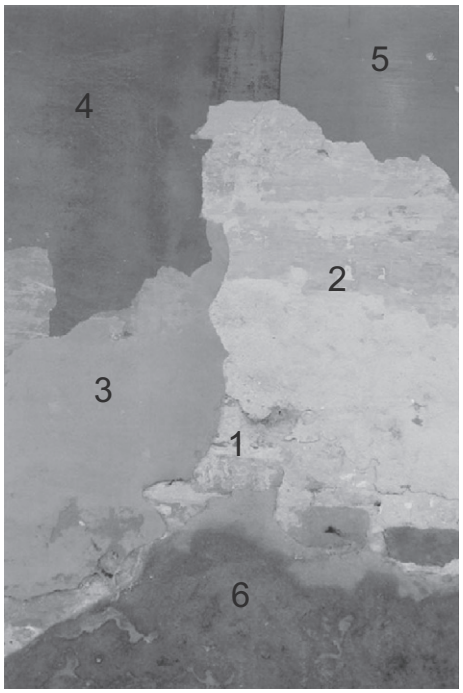

Fig. 2. Visible plaster mortar layers overlapped due to several restoration events.

and damaging products were performed observations with scanning electron microscope (SEM) coupled with EDS microanalyses at the Electron Microscope Centre of Ferrara University, in order to identify micro-textural features between them.

Table 1
Sample identification.

Sample ID	Description
MES1	Efflorescence on bricks
MES2	Brick
MES3	Mortar
MES5	Mortar
MES6	Brick
MES8	Efflorescence on bricks
MES9	Brick
MES10	Plaster
MES11	Plaster
MKS12	Plaster
MES13	Efflorescence on mortar
MES15	Brick
MES17	Mortar
MES18	Efflorescence on bricks
MES19	Modern brick

2.1. Bricks

At a mesoscale observation the brick samples appear to be constituted by very fine particles mix and is very difficult to recognise the inert materials. Optical microscopic observations, have shown that bricks have a homogeneous texture with an optically semi-isotropic matrix, a very weak sandy skeleton (<5%), mostly composed by quartz, plagioclase and biotite. Natural clay inclusions, present only in one sample (MES15), are named "clay pellets" by