NUMBER OF PARTNER:	Academy of Fine Arts in Warsaw
COUNTRY:	Poland
LIST OF OBJECTS:	

1. Information on analytical tests carried out on selected objects

The analysis of materials taken from murals included the identification of mortar, pigments and binders. Numerous instrumental methods and basic classical microchemical methods were used.

Mortar identification

Mortar identification was carried out using the X-ray Diffraction method. Measurements were taken in Bragg-Brentano geometry, using the SmartLab diffractometer from Rigaku, equipped with a Cu anode and a D/tex Ultra 250 detector.

Visual examination and additional microchemical tests of mortar samples were carried out using the Nikon SMZ1000 stereomicroscope, and a flexible fiber optic illuminator.

Organic binder identification

Fourier Transform Infrared Spectroscopy is an instrumental technique used for organic binder analysis. As it identifies only different types of chemical bonds (functional groups), it allows to determine the class of the analysed organic compound. The FTIR analysis of samples was performed with a Thermo Fisher Scientific Nicolet iS 10 camera using the reflective technique of multiple weakened reflection (ATR - Attenuated Total Reflectance). To conduct a precise analysis of the obtained spectra, a series of FTIR - ATR analyses of reference substances were carried out.

To confirm the results, reaction to an alkaline solution (4M NaOH) and reaction to Lugol's solution (aqueous solution of iodine with potassium iodide) was analysed.

Pigment identification

To identify the pigments, fillers and dyes contained in the mural paints, the following analyses were carried out:

I. Microchemical analysis including: reflected light observation with the use of a Nikon SMZ1000 stereomicroscope; observation of water and/or DMF smears in transmitted light, Nikon Eclipse E200; sensitivity to acid (98% HNO_3 and 3M HCl) and alkali (4M NaOH); specific cation microchemical reaction tests.

II. Instrumental analysis:

- Scanning Electron Microscopy with Energy Dispersive X-ray Spectroscopy (SEM-EDS) for an elemental analysis of samples.

Electron images and elemental composition analysis were obtained using a scanning electron microscope (JEOL IT500 LA) with an integrated EDS X-ray spectrometer.

- X-Ray Fluorescence Spectrometry (XRF) for in situ elemental analysis.

Elemental analysis was carried out using a portable XRF analyzer Tracer 5i, Bruker. XRF analysis provided the qualitative result – a list of elements from the coloured outer layer and also from the layers underneath.

- Raman spectroscopy for pigments and organic dye identification.

Raman spectroscopy is a non-destructive, reliable and sensitive method, based on inelastic light scattering at the chemical bonds of a sample. It allows to quickly identify materials and their molecular composition.
Pigments and organic dyes were identified using an inVia Qontor confocal Raman microscope (Renishaw) equipped with two lasers: 532 nm and 785 nm.

Stratigraphic cross-sections
Samples were obtained from the polychromed wall decoration by scraping minute pieces containing all paint layers with a clean and dry scalpel. They were taken from different significant parts of the decoration. Then they were embedded with a particular orientation in a transparent acrylic resin (Meliodent Rapid Repair, Heraus Kulzer), ground and polished with sand paper up to a grit size of 2000 parallel to painting layers. Highly polished layers are required for good-quality microphotographs and proper layer recognition. Such samples were used for analysis using a stereomicroscope.
Microscopic photographs were taken using a Nikon ECLIPSE Ci-L biological microscope and a Nikon D5300 digital camera connected to it.

2. What characteristic features in the technique have been found in analytical studies (dominant groups of materials and techniques)?

Based on the conducted tests, the substrate for the used murals (mortar) and paints (pigments and binders) was identified for 8 out of 24 murals.
The same lime mortar with quartz filler was used for all murals, and then whitened with a layer of acrylic paint containing calcium carbonate and titanium white.
Among the tested paints were mainly blacks, reds and blues. The most commonly identified pigments in the used paints were: titanium white, calcium carbonate, fillers based on silicon and aluminium compounds, less often barite white. Iron black and soot was most common in black, ultramarine and organic dye in the form of phthalocyanine blue were in blue, while synthetic red dyes mainly in the form of azo compounds were present in reds.
The majority of the used paints had an organic binder in the form of acrylic resin. In some cases, paints based on polyester resin, polyvinyl acetate or a mixture of acrylic and phthalic resins were used.

3. What other research (apart from those indicated by the WP3 leader) have been helpful?

On one of the murals by Mikołaj Chylak, a piece of fabric was used as part of the composition. The condition of the submitted sample (presence and type of layers) prevented fiber identification in accordance with the recommended methodology. To identify the type of fibers, the sample was subjected to pre-treatment to allow fiber preparation. Then a preparation was made – a longitudinal view in glycerin, on the basis of which the material used was determined.

4. Information on the causes of deterioration of selected works of art.

Cracks and other plaster damage caused by the subsiding of wall foundations were noticed in all the murals.
The main factor damaging the murals are atmospheric factors, especially variable temperature and humidity (annual, daily and seasonal). Atmospheric precipitation is particularly important. Paint layers were washed out in many areas, thus affecting the aesthetics of the work. Moisture caused the

development of mould and hence dark discolouration on the surface of many murals. In addition, moisture combined with heating from the sun (periodic humidification and drying of the object) is probably the cause of the white colour peeling off on many objects.
The paintings' resistance to external factors also results from technical and technological errors of their execution – the use of too much paint binder or the use of old (expired) paints in which the binder has precipitated and the use of organic pigments which change colour when exposed to light. These are the main causes of the peeling and powdering of the paint layer, numerous washes and colour changes. Important factors degrading the murals also include all subsequent interventions, for example resulting from the renovation of the building, such as the installation of a air conditioning or the replacement of gutters, the reconstruction of the street, the modernization of the space around the building (construction of new buildings). In addition, murals are very often covered by graffiti and stickers.
Poor conservation and restoration can greatly accelerate the degradation of murals. An example is the conservation of the Utz mural, where poor fixation of the paint layer has completely changed its character. Additionally, poor under-plaster injections and fillers were used. In addition, the entire mural has been repainted.
All murals are heavily covered with dirt due to air pollution. The murals are located near traffic routes and birds and other animals.

5. **The most common causes of damage in the analyzed objects (eg resulting from technical and technological errors, climatic conditions in the region, social factors).**

- Poor technique and technology of execution
- Weather conditions:
    - Humidity factors (capillary moisture, water infiltration, rainwater)
    - Thermal factors (temperature fluctuations: annual, seasonal and daily)
    - Physico-chemical factors (air pollution)
- Biological factors (mould growth, birds)
- Subsequent interference
- Vandalism

6. **Added value due to the European dimension of the project.**

The project at this stage of its implementation allows to determine what techniques contemporary artists use to make murals and how they affect the durability of their works. Thanks to this, it will be possible to distinguish which binders and pigments are the most resistant to atmospheric factors, and thus to offer artists the most durable techniques of painting on facades. These studies resulted in closer cooperation between various specialists at the Faculty of Conservation and Restoration of Fine Arts at the Academy of Fine Arts in Warsaw – conservators from the NOVUM Laboratory for the Protection and Conservation of Modern and Contemporary Art, conservators and technologists from the Department of Conservation and Restoration of Wall Painting, and chemists from the Department of Specialist Research and Documentation Techniques. Activities carried out under the CAPUS program can to some extent contribute to the preservation of at least some murals in Warsaw.

7. Potential benefits of cooperation / division of competences between partners.

Comparison of the results of analytical tests and causes of damage sent by partners from different countries allows conclusions to be drawn about the durability of street art works. This database will also be a very important element in the implementation of the next stages of the project, e.g. WP4 and WP5, because it will be helpful in determining the appropriate methods and materials for the conservation of contemporary artworks exposed to external factors.

8. Derogation from the work plan.

None

9. Problems encountered and implemented or proposed solutions.

None

10. Specification of the main results (products and results) for artists, structures, sectors or systems that has generated your project so far. Description of impact on target groups (including participating institutions and interested parties). Suggestion (if possible) of qualitative and quantitative indicators.

Deliverable / results	Target groups / potential beneficiaries	Impact	Quantitative indicators	Qualitative indicators
Analytical characterization of the materials used and Degradation processes report	Partners	• Exchange of analytical protocols and methods used • Improved knowledge of other analytical techniques • Increase in knowledge on degradative processes as a result of the exchange of information with other partners	• Number of scientific papers in collaboration with consortium partners • Number of collaborative papers on degradation parterns	Internal survey on **collaborative publication**
Analytical characterization of the materials used and Degradation processes report	Researchers	• Increase knowledge on materials used by artist and methods • Increased knowledge on analytical methods and protocols	• Number of scientific papers on urban art topic •	Interaction on the social media channels

		• Increase in knowledge on degradative patterns and common factors for urban art		