ESRF	**Experiment title:** **Color identification of precious wall paintings from Oscar Schlemmer**	**Experiment number**: HG-145
Beamline: BM20	**Date of experiment**: from: 19. 01. to: 26.01. 2021	**Date of report**: 25. 02. 2021
Shifts: 21	**Local contact(s)**: Christoph Hennig	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

It was originally planned that 3 users are present during the experiment. Due to the COVID-19 restrictions the users were not able to participate.

Report:

This is a joint research project to identify the colors of recently re-discovered wall paintings from Bauhaus artist Oscar Schlemmer. The restauration strategy and a dublication of these precious objects require a identification via phase analysis of the used coloring minerals.

Several investigations, as hyperspectral surface diagnostics, UV-fluorescence measurements and IR-studies on the entire walls, are combined to recognize the original color scheme. These measurements are now strongly supported by the sucessful identification of several colors by the measurements with XRF and PXRD at BM20/ESRF.

Fig. 1 shows a historical photograph. The position for samples provided for measurements at the ESRF were identified form coordinates defined by optical overlaying the equalized historical photograph over the color residuals, shown at Fig. 2.

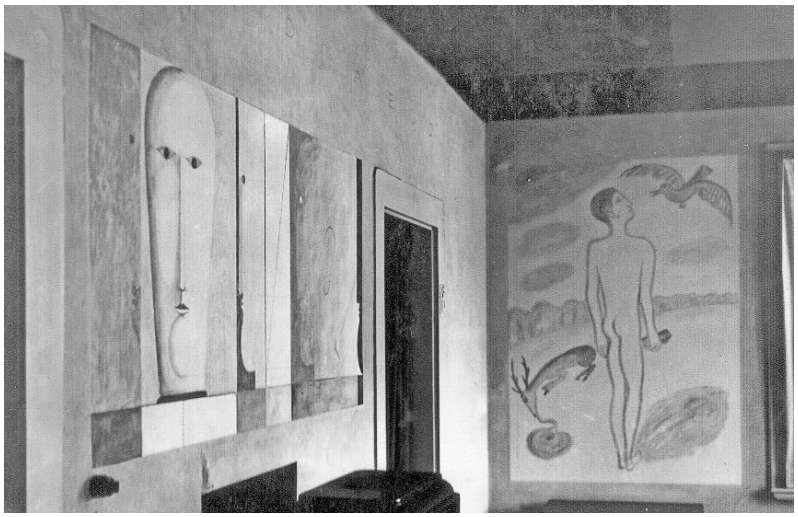

Fig. 1 *Historical photograph of the room with the wall paintings. Left side of the left picture "Fries with heads" from O. Schlemmer and rght side "Back nude with deer and bird" from W. Gilles.*

A critical issue is the preparation of the samples excluding material modification from preparation process. Several tests resulted finally for most of the samples in a preparation using epoxy glue and MiTeGen loops. This sample confinement allowed a conventional rotation of the color fragment samples during the XRD measurement to improve the counting statistics despite the microscopic sample dimensions of 10-30µm.

The epoxy glue was tested with XRF and PXRD with regard to its influence on the measured signals. XRF on pure epoxy glue indicated the absence of heavy metals. The epoxy glue is furthermore free from crystalline residuals and induces only a featureless background scattering. This background was measured independently on pure epoxy glue and was subtracted from the XRD data of the embedded color fragments.

Fig. 2. *The picture on the right side shows the todays status of the wall painting "Fries with heads" with sampling points. The picture on the right side shows an optical overlay with the dimentional equalized historical photograph. The read triangle depict the sample coordinates selected as example in Fig. 3.*

The strategy to analyse the XRD data was to refine the prevailing signals from the wall plaster and painting ground with Rietveld analysis and to subtract their contributions successively from the data set. This process revealed the weak diffraction signals of several pigments. XRF measurements were performed and revealed in some cases heavy metals. This information supported significantly the phase identification in a subsequent search of the ICDD database.

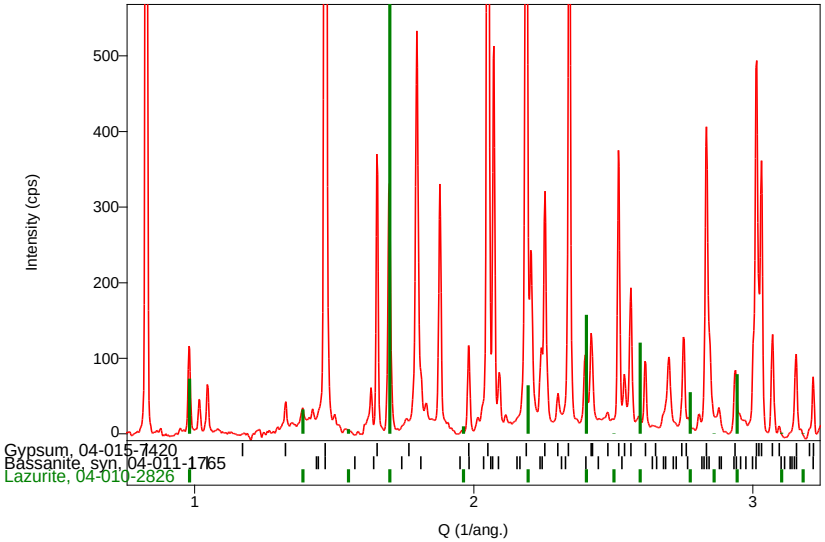

Fig. 3. *Powder diffraction data of sample bhs-09, 2.1.08-G, Bild 1 "Fries with heads", Schlemmer 1, Zone 3, Basis, color: blue. The majority of the peaks from the color material are hidden below strong peaks from wall plaster, as gypsum and bassanite in this example. The coloring mineral is Lazurite.*

Fig. 3 shows the powder XRD pattern and the related phase identification of from example of the different blue pigment fragments with re approximate composition Lazurit-c $Na_8Ca(SiO_4)_6S_{0.86}(SO_4)_{1.14.}$ The XRF measurements indicated in some blue color fragments significant traces of cobalt, in others not. Lazurit was always identified in the blue fragments. This is a hint that Schlemmer modified the blue color of the rather light appearing Lazurite partly with the darker appearing cobalt based blue. It is well known from Schlemmers personal notes that he experimented with the visual color apperance. We assume to identify more color mixtures with the progress of this study.