ANALYSIS OF ROMAN WALL PAINTINGS FOUND IN VERONA

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Summary - The present paper deals with the analysis of roman wall paintings fragments recovered from twelve buildings of Verona, Italy. The analytical techniques used were Optical Microscopy, Scanning Electron Microscopy (SEM) equipped with an EDS microanalysis detector, Xray powder diffraction (XRD) Fourier Transform infrared spectroscopy (FTIR) and Raman Spectroscopy. The wall preparation generally consisted of three layer: the pictorial layer, an *intonachino* layer of hydrated lime and a plaster one made of slaked lime and sand. The pigments found in the studied *domus* are different reflecting the taste and culture of *X^a Regio of Italy* but also the economical possibilities of the *dominus* and the building period.

INTRODUCTION

The analysis of materials and pigments used in roman wall paintings gives useful information to define the gamut of pigments available on a regional and local scale and to understand the techniques of colour preparation and application[1-8].
In addition, through the study of provenance of the pigments, it is possible to discover the communication and trade exchange lines[1,2].

The aim of this contribution is the study of wall's decoration of twelve *domus* in Verona, built between the second half of the first Century B.C. and the imperial age.

The studied buildings are: the *domus* of Borgo Tascherio alley, the *domus* of Vescovado square, the *domus* of Garibaldi street the *domus* of Rensi alley – Oberdan street; the *domus* of Nogara Square, S. Cosimo Street, Tazzoli Street and Valdonega of the Julius-Claudian period; the d*omus* of S. Alessio Street, Palazzo Forti, the Hypogeum of Cantore Street and the *villa* of Agnello alley built in the II^a and III^a century A.D..

This kind of investigation has already been carried out for *domus* of Vicenza[9-11], Pordenone, (Torre) Montegrotto Terme (Padova) and Trieste[12].

The techniques used to study pigments, *intonachino* and plasters were Optical Microscopy, Scanning Electron Microscopy (SEM) equipped with an Energy dispersing microanalysis detector (EDS), X ray powder diffraction (XRD), Fourier Transform infrared Spectroscopy (FTIR) and Raman Spectroscopy.

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EXPERIMENTAL

The sampling was made by the archaeological team, which collected the samples representative of the variety and differences of colour in each site. The dimension of the fragments analyzed, ranged from 2 square centimetres to 20 square centimetres, but it was hard to have a precise idea of the dimensions of the whole work of painting, because all the walls were found as fragments covered by mould and rubble.

Optical microscopy

The samples were observed by means of an optical microscope Wild-Leitz M8 with a 19.2x to 256x zoom. The samples were illuminated using a movable fibre glass system. This technique was used specially in the examination of the grains, crushed calcite or other tiny stones inside the mortar.

Scanning Electron Microscopy (SEM)

SEM images were taken using a Jeol (Tokyo, Japan) JSM 5600 LV equipped with an Oxford Instruments 6587 EDS microanalysis detector. The images were taken under low vacuum conditions where samples did not show charging effects; in this way, it was possible to avoid the coating of the samples with a high conductance thin film (gold or graphite films).

EDS microanalysis was made to obtain information on the elemental composition of the sample.

X Ray Diffraction (XRD)

Powder X ray diffraction was used to identify the different crystalline phases present in pigments. A Philips X'Pert vertical goniometry with Bragg-Brentano geometry, connected to a highly stabilised generator, was used for XRD analysis. Cu-Kα Ni-filtered radiation, a graphite Review Copy monochromator on the diffracted beam and a proportional counter with pulse height discriminator were used. Measurements in a 5-60° range were taken with a step size of 0.05° and 2 seconds per point.

Infrared Spectroscopy (FTIR)

Absorption spectra in the IR region were collected using a FT-IR Perkin Elmer Spectrum One spectrometer. Thirty-two signal-averaged scans were acquired on the samples. Few milligrams of each sample were diluted in KBr (IR grade, Merck) pellet, of a diameter of about 13 millimetres.

Raman Spectroscopy

Raman spectra of the pigments were collected using a Nicolet Nexus E.S.P. FT-IR spectrometer equipped with a Raman module. To obtain spectra of good quality, 2000 scans were performed with 4 cm^{-1} resolution, necessary to effect a satisfactory signal-to-noise ratio; each specimen required about 8 minutes to acquire the data. The excitation in the near infrared was made by using a Nd/YVO4 laser with a power of 0.56 W and the scattered radiation was collected with a In GaAs detector.

RESULTS AND DISCUSSION

Borgo Tascherio alley.

The colours of the analyzed samples, the number of samples and the identified pigments are reported in Table 1. In parenthesis are indicated the white pigments diffused from *intonachino* (a

fresco) or coming from the lime milk used to apply the pigments in a dry way (a secco). The latter procedure seems to be used in most cases for white strips and bands superimposed to an underliyng colour.

TABLE 1.

Colour	Number of samples	Identified pigments
Red, light red, brick red	6	Red ochre (calcite)
Green	3	Celadonite, glauconite (calcite)
White	4	Calcite
Black	1	Coal black (calcite)

The red colours are all red ochre as demonstrated by the presence of iron and silicates in EDS and FTIR spectra.

The green colours are made of celadonite and glauconite. The white colours are of calcite with IR bands at 1430, 872 and 710 cm^{-1} [13]. The black sample does not show significant FTIR bands except the bands of calcite. The black colour disappears when the sample is heated in muffle oven at temperatures of about 450°C, confirming the presence of carbon, (*coal black*) as pigment.

The colours used and the rare ornaments recovered bring forward the idea that the *dominus* of this *domus* probably was not an important and rich townsman, in fact are absent rich pigments as Egyptian Blue (*Caeruleum*) and cinnabar (*minium*)[17]. Also the floors made of earthenware fragments and lime slaked, bring forward the idea that this building was made during the roman republic[14].

The wall samples have an *intonachino* layer of 2-3 mm in thickness and a plaster layer of 2-4 cm made with slaked lime and sand or lime and small rounded river stones.

Vescovado Square

In Table 2 the data of the samples coming from this *domus* are reported.

The samples brick red in colour and the violet ones show IR bands of hematite at 540 cm^{-1} while the orange samples show spectra typical of red ochre with the presence of silicate bands; yellow pigments are yellow ochre; lead oxide (PbO) or arsenic sulphides (*auripigmentum*) are not present.

The green bands present in different samples exhibit IR spectra where are evident silicate bands at about 1000 cm^{-1} and the sharp bands of the terminal OH groups of celadonite and glauconite at 3527, 3554 and 3600 cm^{-1}.

The ivory – white sample resulted made of calcite. The sample named “decorative pattern” shows a leaves drawing, yellow on a red background, separated by a white line from a yellow field.

The yellow colour is yellow ochre, the white line shows IR band at 1445, 885 and 730 cm^{-1} typical of dolomite[13].

The EDS spectrum of the red background is reported in Fig. 1 and shows the presence of lead compounds together with iron compounds. This pigments has been realised with mixed pigments of red ochre and *cerussa usta* (Pb_3O_4).

This association of compounds is rather rare in roman wall painting of North-East of Italy; it can be noted, in addition, the presence of appreciable quantities of phosphorus.

The floor of the rooms are mosaic flooring white and black and indicate the good level of the *domus*, surely more rich than the *domus* of Borgo Thascherio.

The preparation of the walls is accurate and made of three layers, the pictorial one, the *intonachino* layer of 1-2 mm in thickness and finally a lime – slaked layer with fine sand.

TABLE 2.

Colour	Sample numbers	Identified pigments
Brick red	4	Red ochre – hematite (calcite)
Violet	1	Hematite (calcite)
Orange red	2	Red ochre – Hematite (calcite)
Yellow	4	Yellow ochre (calcite)
Green	2	Celadonite – glauconite (calcite)
Jvory white	1	Calcite
Decorative pattern yellow white line red	1	 Yellow ochre (calcite and dolomite) Dolomite and calcite Lead oxides – iron oxide (calcite and dolomite)

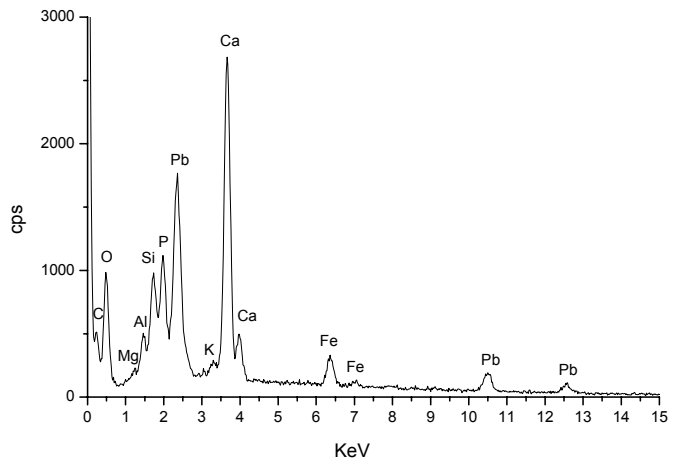

FIGURE 1. - EDS of a red sample containing lead from Vescovado Square

Rensi Alley – Oberdan street

In Table 3 the data of the wall painting coming from the *domus* of Rensi alley-Oberdan street, built out of the city, are reported.

The floors of this domus were in earthenware fragments and lime-slaked and mosaic flooring.

In Table 3 in parenthesis are reported results of the analyses.

The red colours, more or less brilliant, the light reds and the brick reds are made of red ochre and hematite.

TABLE 3.

Colour	Samples numbers	Identified pigments
Red	5	Red ochre – Hematite (calcite)
Violet	1	Hematite (calcite)
Yellow	1	Yellow ochre (calcite)
Green	1	Glauconite – celadonite (calcite)
White	3	Calcite
Grey	4	Black coal (calcite)
White stripes and bands on grey	4	Calcite and aragonite

Once again the violet pigment superimposed to a yellow ochre, is made from pure hematite, while the yellow gave IR spectra not much different from the calcite. The characterizing small bands appear at about 800 and 900 cm^{-1} [12,16].

The green samples show EDS and FTIR spectra indicating the presence of a green hearth, glauconite and celadonite.

The grey samples of a ceiling have been painted by using black coal, while the Raman spectrum of the lime-slaked used for the cane mesh ceiling (*incannucciato)* shows sharp peaks of calcium carbonate at 1085, 712 and 279 cm^{-1} and a rounded peak at 784 cm^{-1} attributed to the lime not yet completely converted to calcite.

White lines and white stripes are frequent in the samples of this *domus*, and are superimposed to a background colour (Fig. 2).

Lines and stripes consist of calcite and aragonite.

In the FTIR spectrum of a white strip are evident the calcite bands at 1430, 875 and 710 cm^{-1} and the bands at 1485, 1080, 853 and 699 cm^{-1} due to aragonite, present in about the same amount of calcite.

FIGURE 2. - Samples with white bands on a grey-black background of Rensi alley.

The presence of aragonite in the superimposed white stripes is due to the intentional use of a specific material ("*creta calcarea*") with new characteristics respect to calcite and probably imported from the Aegean isles or from Egypt [17]. These white pigments with aragonite have been successful in the roman wall painting of the imperial period, probably for their use in the "a secco" painting.

The studied fragments are made of three layers: a pictorial layer, an *intonachino* layer tick about 3-4 mm and hence a lime slaked layer with sand. Sometime a fourth layer is present, made of lime slaked and river small stones.

The Rensi alley *domus* do not exhibit paintings made with precious pigments, but the great variety of the colours and the good taste, defines this *domu*s of good level, decorated probably between the end of the first century B.C. and the first half of the first century A.D..

Garibaldi Street.

In Table 4 the data referring to the *domus* of Garibaldi Street are reported.

TABLE 4.

Colour	Sample numbers	Identified pigments
Red	3	Red ochre – hematite (calcite)
Green	5	Celadonite, glauconite (calcite)
Blue	3	Egyptian blue (calcite)
White stripe on green	1	Calcite, aragonite

The fragments show an *intonachino* layer of about 3 mm and a layer of lime slaked and fine sand of 3 cm.

The red samples of Table 4 are made of red ochre and hematite and green samples are realized with celadonite and glauconite in analogy with the samples already described.

The blue samples appear here for the first time, and show IR bands at 1156, 1058 and 1009 cm^{-1} indicating that this pigment is Egyptian blue, (*caeruleum*)[17,18].

The EDS spectrum shows with evidence silicon, calcium and copper peaks, constituents of the synthetic pigment Egyptian blue ($CaCuSi_4O_{10}$). It is important to note that *caeruleum* is one of the *colores floridi*, the expensive colours which characterized domus of high level.

The white stripe superimposed to a green of Table 4 shows FTIR spectra in which the bands of calcite appear again together with the bands of aragonite at 1480, 1080, 853 and 699 cm^{-1}.

The floors of the rooms are mainly mosaic flooring demonstrating that in Garibaldi Street existed a *domus* of high level, decorated probably during the first half of the first century A.D..

Nogara Square.

In Table 5 the colors, the number of samples, and the found pigments are reported.

The inspection of Table 5 shows a variety of pigments and "nuance" of colours unknown to the *domus* above described.

The green colours are similar to those already described and made from celadonite and glauconite. The yellow ochre contains kaolinite or clay as evident by the appearance of IR bands at 3615 and 3692 cm^{-1}.

The red colours are mainly constituted of red ochre and hematite with the exception of an bright red in which (together with hematite) also *cerussa usta* (lead red oxides) is present. The EDS spectrum of this sample shows the main peaks of lead at 2.4, 10.5 and 12.6 KeV.

A similar mixture was found also in the *domus* of Vescovado Square. The grey colour was made with coal black, while the white lines separating different colours are of calcite and dolomite in agreement with the *domus* of Vescovado Square. Sometime also aragonite is present as in the case of the grey colour.

The floors are mainly mosaic works indicating the good level of the *domus* of Nogara Square.

The walls were treated with an *intonachino* rather thin of about 1-2 mm of thickness while the plaster was made of slaked-lime, sand and small river stones.

TABLE 5.

Colour	Number of samples	Identified pigments
Red violet	2	Hematite, red ochre (calcite)
Brick red	2	Red ochre, hematite (calcite)
Yellow	2	Yellow ochre, Kaolinite (calcite and dolomite)
Green light	1	Green earth (calcite)
Grass green	1	Green earth (calcite)
Tricolour sample Green Brick red White line	1	 Green earth (calcite) Red ochre, hematite (calcite) Calcite, dolomite
Grey White line	1	Coal black (aragonite, calcite) Calcite, dolomite
Band ochre White line Bright Red	1	Yellow ochre kaolinite (calcite) Aragonite, dolomite, calcite Hematite, lead oxides (calcite)

S. Cosimo Street

In Table 6 the data of this *domus,* built inside the city wall, are reported.

The floors recovered are mosaic works and also *opus sectile,* marble floors, and paintings of III Pompeian style.

TABLE 6.

Colour	Number of samples	Identified pigments
Bright red	1	Cinnabar (calcite, aragonite)
Wine violet	1	Hematite, (calcite)
Orange red	1	Red ochre (calcite)
Ochre	2	Yellow ochre (calcite)
Green	2	Celadonite, glauconite (calcite)
Black	1	Coal black (Calcite, traces of aragonite)
Blue	2	Egyptian blue (*Caeruleum*) (calcite, aragonite)

TABLE 6 (Continued)

Samples decorated to dummy marble	1	
Black-green		Glauconite-celadonite, phosphates (calcite)
Brown red		Hematite, phosphates (calcite)

The wall plaster were formed of three layers, under the painting, a thick *intonachino* layer of 4-5 mm followed by a layer of slaked-lime and fine sand of about 0.5 cm in thickness, to which sometime followed a fourth layer made with slaked lime and small river rounded stones.

As it can be seen from Table 6, the gamut of colours is different and complete and both Egyptian Blue and the precious cinnabar are present (*colores floridi)*.
In Fig 3 a SEM image of the bright red is reported; the cinnabar crystals appear very bright.

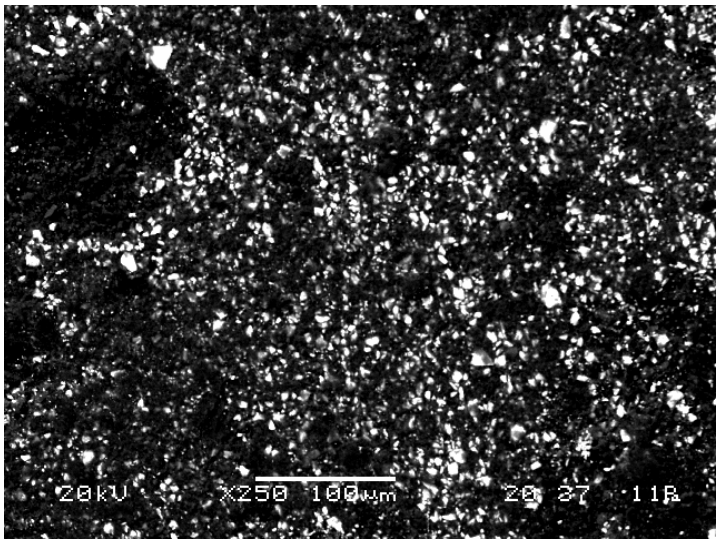

FIGURE 3. – SEM image of a red bright from S. Cosimo

The EDS spectrum of cinnabar shows the three peaks of mercury and the one of sulphur. The corresponding FTIR Spectrum shows the presence of aragonite together with calcite.

The wine violet colour is constituted of pure hematite while the orange-red is a red ochre and the green colours are made from celadonite and glauconite. The grey sample coming from this *domus* is made from coal black and is mixed or diluted with a little of aragonite as well as calcite.

The blue samples are all constituted of Egyptian blue *caeruleum*; together with calcite also aragonite is present. This is the first case in which *colores floridi* are diluted or mixed with white pigment make up of aragonite and calcite.

Two samples are decorated to dummy marble with black stains on green and brown stains on red in imitation of serpentine and alabaster.

In Fig. 4 the EDS Spectrum of the brown-black colour on red is reported; it can be observed, that a sharp peak of phosphorous appears. This peak could be attributed to a residue of binders, but it can be observed that the IR bands at 2916 and 2841 cm^{-1}, due to the C-H band, have the same intensity of the others samples. In the presence of organic compounds (coming for example from

phospholipids), these bands should be more evident; probably the phosphorous is due to inorganic phosphates present in bone black pigment mixed to green and brown..

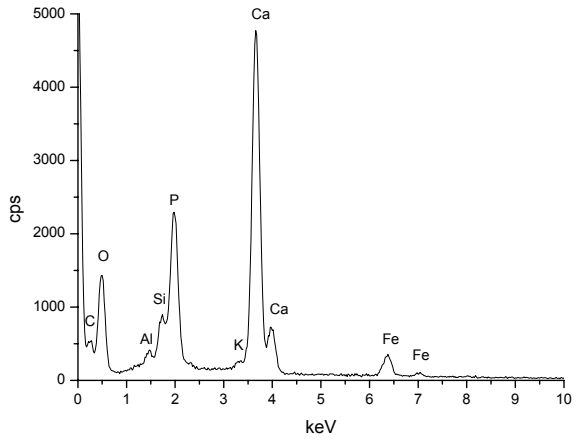

FIGURE 4. - EDS of a brown red from S. Cosimo

Tazzoli Street

In Table 7 the results obtained in the analyses of the samples coming from the *domus* of Tazzoli Street, are reported.

The floors of these *domus* were mosaic works with *tessera* white and black or scabbing white and pink.

TABLE 7.

Colour	Number of samples	Identified pigments
Brick red	2	Hematite (calcite)
Vine violet	1	Hematite (Calcite)
Ochre yellow	1	Yellow Ochre, Caolinite (calcite)
Green	2	Glauconite, celadonite (calcite)
Bright green	2	Celadonite, glauconite (calcite, aragonite)
Black	1	Coal black (calcite)
Red bands with white	2	Hematite (Calcite)
Tri-colours; violet bands Red band White line	1	 Hematite (calcite) Hematite, cinnabar (dolomite, calcite) Dolomite and calcite
Tri-colours; Red band White line Undercoat ochre	1	 Cinnabar (calcite) Calcite and dolomite Ochre yellow (calcite)

From the inspection of Table 7 it can be deduced that the *domus* of Tazzoli street was of a good level but surely not very rich. The *caeruleum* (Egyptian Blue) is absent while the cinnabar is present in limited areas; in a sample the cinnabar is mixed with hematite.

In Fig. 5 the EDS spectrum of this sample is reported and the peaks of iron and mercury are evident.

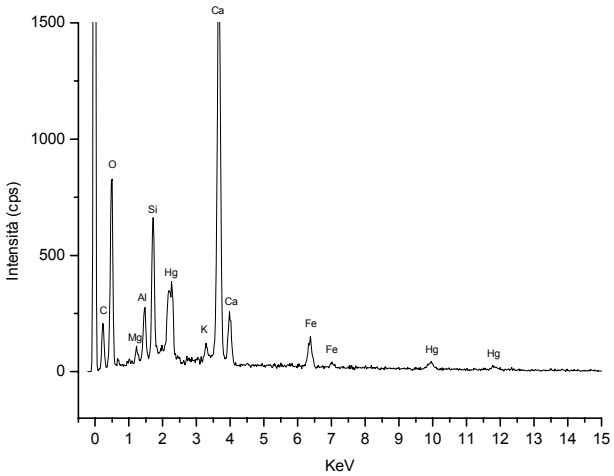

FIGURE 5. - EDS of a red from Tazzoli

The white areas as well as the lines are of calcite and calcite and dolomite.

The use of this particular white colour of calcite and dolomite was observed also in the domus of Nogara and Vescovado squares.

The aragonite is present in a decoration bright green of leaves made as lances. The black colour is coal-black.

This *domus* is largely decorated with green colours of different "nuances". The frequent use of lines to separate bands or colour areas, leave you to think to the II and III Pompeian style. This *domus* can be hence attributed to the end of first century B.C. or to the first century A.D.[14].

Valdonega

In Table 8 are reported the results of the analyses carried out on micro samples taken from the three rooms of the *domus* (O*ecus corinthius*, intermediate room, last room) characterized by splendid polychrome floors in mosaic works and columns of the Julius Claudian period.

TABLE 8

Colour	Room	Identified pigments
Red	Oecus	Hematite, (calcite, aragonite)
Red	Intermediate room	Hematite chalk, (calcite)
Yellow	Oecus	Yellow ochre (calcite)
Green	Last room	Celadonite, glauconite chalk, (calcite)
Black	Intermediate room	Coal black chalk, (calcite)
Beige	Last room	Calcite, chalk
White	Oecus	Chalk, aragonite, (calcite)
Blue	Last room	Egyptian blue, (aragonite, calcite)

From the examination of table 8 comes out that, despite of the sumptuousness of architecture and of the mosaic works, cinnabar was not employed in the red colours but simply hematite.

The EDS spectrum of the yellow colour taken for the more important room (*Oecus corinhtius*) shows two small peaks of iron, typical of the hydrate oxides of iron of the yellow, and a sharp peak of sulphur is present.

The green sample taken from the last room is constituted of silicates of magnesium, iron and potassium (green earth).

The white colour taken from the *oecus corinthius* shows the presence of aragonite mixed with calcite. The black colour was realized with coal black, while the blue colour of the last room is an Egyptian Blue and bright crystals are visible in the SEM image.

The EDS spectrum of this colour shows the copper peaks together with the peaks of calcium and of silicon. The Egyptian Blue is the *floridus color* used in this *domus* which shows garden paintings with animals, typical of the period of Tiberius imperator.

It must be noted that chalk has been recovered in the samples taken from the walls not treated with protecting. The calcium sulphate was formed most likely by reaction of sulphur oxides on calcium carbonate of the walls; the sulphate formation can be attributed hence to the pollution due to the traffic and to the city heating.

Sant'Alessio street.

In Table 9 the colours, the number of samples, and the found pigments are reported.

TABLE 9

Colour	Number of samples	Identified pigments
Red amaranth	4	Hematite (Calcite, dolomite)
Yellow	3	Yellow ochre (Calcite, dolomite, aragonite)
Green	5	Celadonite, glauconite (Calcite, aragonite)
White line	3	Calcite, dolomite, aragonite
Black	1	Coal black (Calcite, dolomite)

The inspection of Table 9 puts in evidence that in this domus abound reds, green and yellow colours, but are absent the precious pigments. It can be observed that aragonite is present in *austeri* colours yellow, green and whites, often with calcite and dolomite. This is a particular feature of this domus and the EDS spectrum of this samples exhibits the peaks of calcium and also a significant magnesium peak, due to the dolomite [Ca, $Mg(CO_3)_2$].

The preparation of the wall of the domus of S. Alessio Street is of good workmanship: an *intonachino* several millimetres tick, followed by slaked - lime with fine sand and sometime by a fourth layer of slaked – lime with river rounded small stones.

Forti Palace

In Table 10 are reported the characteristic data of this *domus*, built in the Centrum of the city.

From the FTIR data it can observed that in the preparation of these walls a great quantity of silicates was used. In this domus are not present rich pigments and aragonite is used only for the white lines, as already observed for the *domus* of Garibaldi and Rensi-Oberdan Street.

The preparation of the walls seems to be rather poor because the *intonachino* layer is of one millimetre, followed by a slaked – lime layer with sand of about 5 mm and hence a plaster with small river stones 1-2 cm tick.

TABLE 10

Colour	Number of samples	Identified pigments
Red	3	Red ochre (Calcite)
Yellow	2	Yellow ochre, Kaolinite (Calcite)
Pink under yellow	1	Red ochre (Calcite)
Green	2	Celadonite, glauconite (Calcite)
White line	2	Aragonite, calcite
Black	1	Black coal (Calcite)
Pink under black	1	Red ochre (Calcite)

Hypogeum of Cantore Street

The hypogeum is arranged in the second half of the second century of the Common Era[19].

In Table 11 the results of the analyses performed on the fragments of wall paintings are reported.

The spacious room show walls painted with figure drawing of goods. Well visible again is a Mercury Standing and dressed of a red mantle. On the wall facing the Mercury, a god sitting is painted.

TABLE 11

Colour	Number of samples	Identified pigments
Wine Red	3	Hematite (Calcite)
Bright Red	2	Hematite, red ochre (Calcite)
Red and red and yellow bands	4	Hematite (aragonite, calcite)
Yellow ochre Yellow and red bands	4	Yellow ochre (Calcite) Kaolinite, yellow ochre (Calcite, aragonite)
Green	2	Celadonite, glauconite (Calcite)
Green on red wine and light green	3	Celadonite, glauconite (Calcite, aragonite)
Grey	4	Black coal (Calcite)
White	2	Calcite and trace of aragonite
Blue	2	Egyptian blue (Calcite)

As it can be noted from table 11, in the wall painting of Hypogeum only *caeruleum* is present as expensive pigment. Aragonite has been used very often also for *austeri colores*, yellow ochre or green.

In the case of the green colours, aragonite has intentionally employed to make clear the colour by using a *creta calcarea* of special characteristics[13-17].

In the FTIR spectrum of Fig. 6 are reported the calcite bands and those of aragonite and the large number of silicate bands; the green is in fact a silicate. It can be noted here that the matching of aragonite and *austeri colores* as yellow, red and green is a novelty with respect to the preceding century.

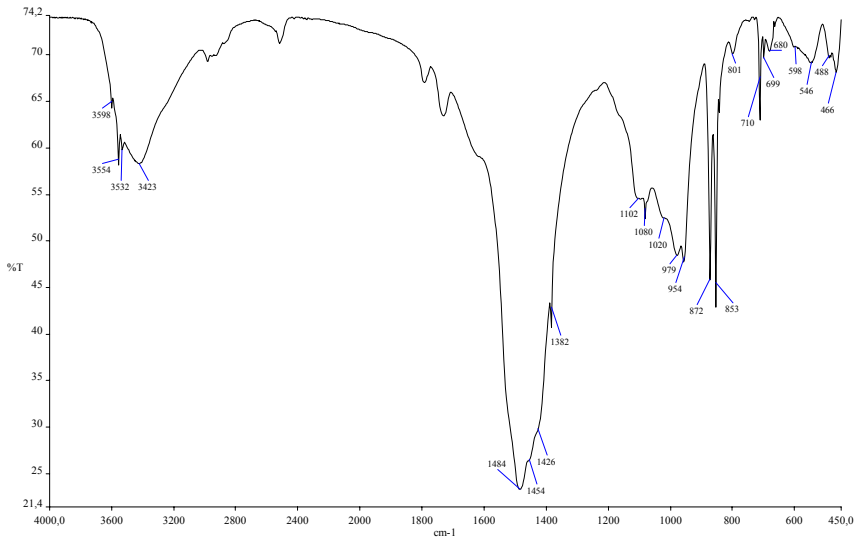

FIGURE 6. - FTIR spectrum of a green sample from Ipogeo

Agnello Alley

In Table 12 the results of the analyses carried out on the samples coming from this *villa* are reported

TABLE 12

Colour	Number of samples	Identified pigments
Red brilliant	2	Cinnabar, (calcite, aragonite)
Red vine	2	Hematite, red ochre (calcite)
Brick red	3	Red ochre (calcite)
Yellow	2	Yellow ochre, goethite (Calcite)
Green	2	Celadonite, glauconite (calcite)
Green - blue	4	Egyptian blue, celadonite, glauconite (calcite, aragonite)
Blue	3	Egyptian blue, (aragonite, calcite)
Black	1	Coal black (Calcite)
White	1	Calcite
Brown band	1	Red ochre, cinnabar (Calcite)
Decorated sample White flower Red flower	3	 Calcite, aragonite Hematite, (aragonite, calcite)

As it can be observed, in this rich *villa* all the colours, *austeri* and *floridi* have been used, but not colours based on arsenic or lead while *cinnabar* has been largely used, alone on mixed with hematite.

According to A. Barbet[1], the use of mixtures of hematite and cinnabar increases with the increase of *Roman Empire*. In the fifth century of the Common Era the supplying of cinnabar changed from Almaden (Spain) to Greece and Turkey.

In this rich *villa* the variety of decorations and of colours are represented in Fig. 7 where all the gradation of colour of green, blue. pink and brown have been used with precious pigments.

FIGURE 7. - Wall fragment with floral painting from Agnello Alley

The floors of this villa are very rich (*opus sectile*) and also the walls have a marble lining. The preparation of the wall surface was perfect, with an *intonachino* layer tick about 5 mm, followed by slaked-lime with fine sand and hence a further layer of slaked-lime and small river stones.

CONCLUSIONS

The high number of samples found in the different *domus* studied, indicate that wall painting was largely used as an important factor for the ornament. The preparation of the plaster was similar in the *domus* examined with a *tectorium* of three or four layers.

The colours used change with the role of the *domus*; the expensive pigments appear only on the *domus* of Garibaldi street, S. Cosimo, Tazzoli, Valdonega, Hypogeum and Agnello Alley.

Some singularity appears in the domus of Vescovado square, Tazzoli street and S. Alessio where a “dolomite white” has been used while a red colour made from lead oxide and iron compounds appears in the *domus* of Vescovado and Nogara Square.

The use of colours with a basis of lead is rare in the North Italy and demonstrate that different painters with different taste and technological knowledge alternated to decorate the *domus* of the X^a *Regio* of Italy. Finally is evident the parallelism existing between the colour richness and the floors quality.

From the analysis of the four *domus* decorated in the Julius Claudian period, comes out the more frequent use of *floridi colores* as cinnabar and Egyptian Blue with respect to the older *domus*. More frequent is again the use of whites based on aragonite. The *domus* of S. Cosimo street and Valdonega should be the houses of very important personages of great economical possibilities.

The Julius Claudian period is characterized by the diffusion of the taste and splendour of the aristocratic houses of Rome. The *domus* of S. Alessio Street, the *villa* of Agnello Alley and the Hypogeum, gave information about technologies and taste of *II and III century A.D*: different pigments do not appear, unlike "Gallia" and "Helvetia"[20,21] but the use of white special pigments containing aragonite increases in a significant way, up to cover also *austeri colores* as yellow and red ochre.

This circumstance should mean that is growing the technique of the "dry – way" painting (a *secco*) through the use of lime milk obtained from a *creta calcarea*. By this method the colours are put on the dry wall, making free the painter to operate also out of the precise time until the wall was *fresco*. From the present results, obtained with instrumental techniques of limited sensitivity, no evidence come out for the use of organic binders not even in the dry-way finishing, but more sensitive techniques as GC-MS should be used to exclude this hypothesis.

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