Spectrophotometric analysis of the interiors of seventeenth century churches in Arbanassi

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ABSTRACT

This paper presents the use of a new method of assessment and comparison of the appearance of colour in an art historical context, using some seventeenth century churches in Bulgaria as a case-study. The method also allows initial identification of the main colour agent of the pigments used. It contains the results of the identification of the colour red. This research provides a possible basis for further investigation into the use of colour in seventeenth century Bulgaria, in a way that overcomes the limitations of colour reproduction in print. In addition, a faithful and unambiguous record of the existing colours will make it possible to create the non-metameric subtractive mixtures that are needed for the restoration of the frescoes.

Keywords: Arbanassi, art history, spectrophotometry, colour appearance, pigment identification.

1 INTRODUCTION

The town of Arbanassi, situated in the middle of Bulgaria, contains seven churches built in the seventeenth century. The interiors of four of these are completely covered with frescoes which were executed between 1612 and 1681 and have been proved by scholars to be preserved in their original state [1]. During the late 1970s and the 1980s the frescoes of all of the examined churches were cleaned.

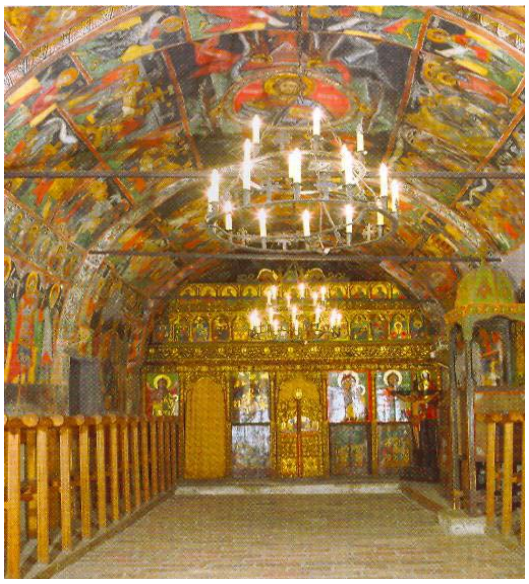

Illustration 1 Church of the Nativity of Christ, Arbanassi, Bulgaria: Nave.

The aim of this research was to record and compare the colours used in these four churches and to perform an initial comparison of the dominant colorants used. The research was prompted by the significance of colour in the construction not only of the decorative system employed in the churches of Arbanassi, but also in the construction of any decorative composition. Colour also has an impact on the way an interior space as a whole is experienced.

Previous research on the site has been limited to the traditional and meticulous (but subjective) assessment and verbal description of the colours used in the church interiors [2-3]. However, this methodology has significant limitations due to the complexity of the processes by which the intricate interaction between light, the eye and the brain result in the experience and recognition of colour [4-5]. The mechanism of recognition does not permit colour to be identified, assessed and communicated with great precision because each observer may see and interpret colour somewhat differently. Moreover, very often the descriptions sought to assess the psychological effect of particular colours on the basis of the meanings which the writer supposed that the investigated composition had been intended to convey. Even though such an approach acknowledges the importance of colour, it still leaves the actual appearance of colour as a peripheral issue. By contrast, the use of analytical methods can provide an unambiguous description which makes it possible to identify, record and then compare the use of colour. One such method is

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spectrophotometry which is non-invasive and does not cause damage to the painted layer of the examined surfaces.

2 EXPERIMENTAL

In this research a hand-held Minolta CM-2600d spectrophotometer was employed, using target mask CM-A146 (8mm measurement area). All data were processed in the Konica-Minolta colour imaging laboratory at the University of Leeds. The instrument is easy to use, precise and highly portable making it possible to obtain comprehensible reference data in the simplest way. One of the types of data which the instrument can provide is spectral reflectance factors. The reflectance factors were obtained (at intervals of 10 nm in the visible spectrum) from averages of 16 measurements for each colour. These results were then converted to CIELAB values (using the 1964 CIE 10º observer and for the D65 illuminant). Before commencing the measurements, the spectrophotometer was calibrated using the white calibration plate CM-A145.

The fact that all the frescoes in the churches were painted at about the same time and were then subjected to much the same exposure to smoke from candles and from the burning of incense for about the same number of years and finally underwent the same cleaning procedure at about the same time, makes the churches suitable sites for the conduct of this research. In a comparative study such as this, the changes which have taken place over time can be ignored because the investigation is concerned not with changes in the appearance of colours since they were first applied, but with the differences between the appearances of the same hue as used in different churches.

Frescoes with a similar theme and composition from each of the churches were identified in order to create a further base for comparison of colour in the different churches. The surfaces of the frescoes have a comparatively smooth and even finish, which allows the instrument to lie flat over the point of measurement (thus preventing any external light from interfering with the reading of the instrument). Furthermore the measurements were taken from comparable points on the figures or pictorial compositions initially chosen. The areas chosen for examination were prepared prior to the measurements being taken. For this purpose a soft brush was used to remove dust and loose matter from the surface followed by the use of pair of very small bellows. This was done to avoid inaccuracies which might occur because of the presence of small particles when the measurements are performed.

3 RESULTS AND CONCLUSIONS

The dominant colours in the frescoes of the churches in Arbanassi are: red, blue, green, ochre, white, black or deep navy blue and gold (gold leaf). Because of the concise format of this paper we will limit our examination to the colour red.

Illustration 2 Church of the Nativity of Christ, Arbanassi, Bulgaria. Depiction of Christ Pantocrator on the ceiling above the altar. Above his head is the image of the Mother of God and he is surrounded by angels.

The choice of the hue was governed by the relatively high frequency of the use of reds in the iconographic tradition of the Eastern Church from very early days up to the seventeenth century [6-8]. According to some authors the colour red has particular symbolic meaning within a conventionally accepted visual code. Red is mainly associated with the Messiah, the Archangel Michael, royal figures, some martyrs and the Last Judgment. Most of the presumed symbolic associations of reds derive primarily from the theological link between blood and redemption which makes it a popular choice in the artistic palette of the iconographers [6, 8].

In the initial examination it appears that in every church the appearance of the colour red, at least in any particular chamber, is more or less constant, which could be explained by the way the frescoes were executed and the way paints were prepared [8-9]. This involved painting a large area – sometimes the entire chamber – in one day. Although there were several artists working at the same time, paints were mixed by the artist who headed that particular studio [9-10]. Assessed subjectively, the appearance of the reds seems to be divided between bright red in the churches of the Archangels Michael and Gabriel (brightest) and St Atanass and deep red in the churches of the Nativity of Christ (darkest) and St Dimitr. Initial examination of the images revealed negligible differences between the bright reds, but a very considerable perceived difference between the dark reds. Furthermore there seems to be a sharp

difference between the lightest and the darkest red. Given the impossibility of retaining a memory of the sensory experience of a colour, any valid comparison of the appearance of the colour red used in the four churches must be made by external, objective means. Such a comparison is needed for the study of the use of colour. The CIE data, presented in Tables 1 and 2 make that comparison possible.

Table 1 CIELAB values for red in four church samples.

Church	L*	a*	b*
Nativity of Christ	18.38	11.74	14.14
St Dimitr	17.22	14.12	9.86
Archangels M&G	31.59	26.83	16.67
St Atanass	32.44	27.05	17.91

Table 2 CIE chroma and hue angle values for four church samples.

Church	C^*_{ab}	h_{ab}
Nativity of Christ	18.38	50.30
St Dimitr	17.22	30.93
Archangels M&G	31.59	31.85
St Atanass	32.44	33.51

However, the CIE data relate to the sensory experience of the observer and do not give an indication of the way in which that colour effect has been achieved, namely about the colorant used to impart colour to the artistic material.

Figure 1 shows the original reflectance spectra of the four church samples. These curves can provide important clues about pigment identification. The reflectance spectra obtained from each of the churches were compared with spectra measured from samples of a range of pigments obtained from suppliers. These particular pigments were chosen because analytical chemical research done on samples from fresco fragments collected from various churches in Bulgaria at different stages of their restoration has already demonstrated their use. Research also shows that the main range of pigments did not change until the beginning of the eighteenth century and, even then, did not increase significantly before the beginning of the nineteenth century. All of them can be categorised chemically as inorganic [11-12]. Issues such as paint thickness, pigment loading, and, of course, light fading all make a direct comparison of the spectral data difficult. It is useful, therefore, to compare the spectral data in terms of the ratio of Kubelka-Munk absorption and scattering coefficients (K/S) which can be obtained – for opaque samples – from the reflectance P using the expression $K/S = (1-P)^2/2P$ [13]. Figure 2 shows the K/S plot for the four church samples and pigment standards.

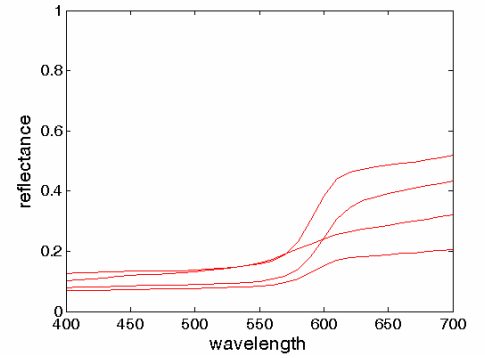

Figure 1 Reflectance spectra for four church samples.

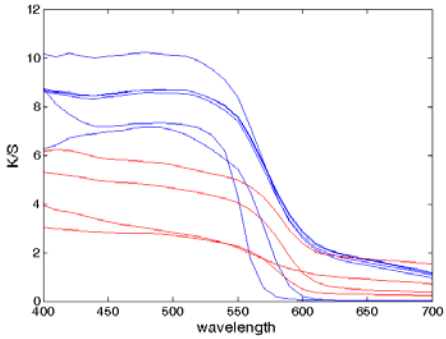

Figure 2 K/S plots for church samples (red lines) and pigment standards (blue lines).

The advantage of the K/S representation is that the shape of the K/S spectral curve is relatively invariant to pigment concentration since K/S can be considered to be approximately linearly related to concentration.

Table 3 The possible dominant pigment for four church samples.

Church	Possible pigment
Nativity of Christ	Fe_2O_3 + 1% MgO_2
St Dimitr	Fe_2O_3 + 1% MgO_2
Archangels M&G	Fe_2O_3 + small quantity of Al/Mg/Si
St Atanass	Fe_2O_3 + small quantity of Al/Mg/Si

The standard pigments with which the measured samples were compared were: Pb_3O_4; HgS; Fe_2O_3; Fe_2O_3 + small quantity of Al/Mg/Si; Fe_2O_3 + 15-20% MgO_2; Fe_2O_3 + 1% MgO_2. A Nelder-Mead simplex optimization was used to find the best match (independent of pigment concentration) for each sample K/S curve with the standard pigment curves [14]. This analysis revealed the possible identification of pigments as shown in Table 3.

The differences between the composition of the pigment samples appear to be constant and in all probability can be explained by differences in the initial sources of the particular sample. Such a finding is of value to further research attempting to identify the geographical origins of the pigments. That in turn may help answer the long-standing question: where did the artists who painted the Arbanassi churches come from? Some scholars have argued that they might have been local artists, trained at Mount Athos. Others have suggested that they came from the mainland Greek province of the Ottoman Empire. A third group of scholars have argued that the artists of Arbanassi were based on Mount Athos.

This research provides a possible basis for further investigation into the use of colour in seventeenth century Bulgaria, in a way that overcomes the limitations of colour reproduction in print. In addition, a faithful and unambiguous record of the existing colours will make it possible to create the non-metameric subtractive mixtures that are needed for the restoration of the frescoes.

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