STUDY OF COLOURS IN ARABIC MANUSCRIPTS IN AL-ANDALUS

Dr. Teresa ESPEJO ARIAS
UNIVERSITY OF GRANADA (SPAIN)

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The Arabs settled in the Iberian Peninsula from the early 8th century until the end of the 15th century, bringing with them their own social, cultural and political framework.

This was a time of flourishing knowledge and tremendous scientific and cultural development for this people, in the territory known as al-Andalus. This development was directly related to large-scale production of books with particular characteristics in their structure and binding.

Christians, Jews and Arabs lived side by side for eight centuries; consequently there was a marked exchange of influences between the three cultures.

The Reconquest of this territory by the kingdoms of Castille and Aragon in successive centuries and, definitively, by the Catholic Kings, led to the destruction of the greater part of this legacy by the systematic burning of books and the imposition of symbols designed to demonstrate the Christian superiority and origins of the territory.

The population was also forced to convert to Catholicism, facing severe punishment should they resist. However, the population managed to maintain its culture and beliefs for many years by moving or hiding its libraries.

Every manuscript bears witness to the culture in which it originated. Therefore any research into the document would not be complete without an analysis of text and content, a study of the archaeology of the book and specification of the materials used. This data, to the extent that it can be compared with that of other similar examples, can be used to ascertain information about how the manuscript was made and the thought process of its authors.

In the making of these codices we can see important technical innovations in aspects such as paper manufacture and how they were bound. Studying the materials used – which are very different to those in Western documentary heritage – helps us to determine the most appropriate criteria and treatments to prevent further deterioration and guarantee their conservation.

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Undertaking comparative studies also enables us to date and name documents, and will highlight important features in the evolution of techniques used by calligraphers, scribes and binders.

This current line of work is included in the research project “New analytical technologies for the study of materials and production techniques in Al-Andalus Arabic manuscripts” (CTQ2005-0771/), financed by the Spanish Ministry of Education and Science.

In this project a coordinated, interdisciplinary team of researchers are working together with the primary aim of extending existing data on production techniques and the materials used in the making of this type of document, and the application of analytical techniques.

The contributors are the Departments of Painting, Optics and Chemical Analysis of the University of Granada, the Department of Translation and Interpreting of the University of Malaga, the Department of Painting/Restoration of the University of Seville, the Archive of the Real Chancillería de Granada, the Historic Archives of Andalucia and Granada regional councils, the Seville Materials Science Institute (CSIC - Seville) and independent researchers in document conservation.

MANUSCRIPTS STUDIED:

Up to now we have been working on the following collections:

Padres Escolapios Library of Granada.

This library houses a copy of the Koran dated as late 15th century. It has particular characteristics which are distinct from models of Arabic and Western binding, but it nevertheless has elements of both. At first we believed it to be an exception to the general model of binding. However after looking at other collections, and the discovery of documents with similar characteristics, we have come to believe that there existed in fact a specific binding model peculiar to Al-Andalus in its latter period. Now the document is restored and in a good state of conservation.

Collection of Arabic manuscripts from the Sacromonte Abbey, Granada.

This collection currently consists of 22 documents copied between the 11th and 12th centuries. Of these, only 17 are Andalusi, amongst which we note particularly manuscripts 16 and 20 for their codicilogical and binding model which presents identical characteristics to those of the Escolapios Koran. Generally speaking the collection is in a poor state of conservation. The many and varied types of damage make them impossible to consult properly. As we speak some of the items are being restored in the Institute for Historic Spanish Heritage in Madrid.

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Collection of Arabic manuscripts in the Malaga Provincial Historic Archive.

This contains only three andalusi documents: one Koran and two books *de oficio*. Belonging to an imam from a Mosque, they are dated between the late 15th and early 16th century. They were discovered in 2003 behind a wall and on top of a bed of straw, during restoration works at a Moorish house in the village of Cutar, in the province of Malaga, Southern Spain. Particularly notable is Book I, for the characteristics it shares with previous collections. Currently the necessary studies and analyses are being carried out prior to their restoration.

Collection of Arabic manuscripts in the School of Arabic Studies, Granada.

This is made up of 43 volumes of manuscripts (many being miscellaneous), of which only 21 are catalogued but the rest are soon to follow. The Treatise on Agriculture on Ibn Luyun stands out in particular (dated 1348, Almeria), as does the Grammar book of Al-Zubaydi. This latter item blends elements of Arabic binding with elements of Western binding. These characteristics make it a significant example of the transition from Arabic to Mudejar binding.

Al-Qarawiyin Library, Fez, Morocco.

Earlier this year the Spanish Ministry for Foreign Affairs and International Cooperation gave the go-ahead to a new project for Inter-University Cooperation and Scientific Research (A/7285/06). This project, between the University of Granada and the University of Sidi Mohammed Ben Abdellah in Fez (Morocco), has begun a study into the andalusi manuscripts conserved in the library and has started to establish the foundations of research criteria coordinated between Spain and Morocco. To date the research has focused on Manuscript 607, which is a treatise on Medicine from the 14th century, attributed to Ibn Al-jatib of Granada. From the analyses realised so far, the red derived from organic sources is notable.

National Library of France, Paris.

The cooperation offered by the National Centre for Scientific Research in Orleáns is enabling us to study some of the andalusi documents conserved in the National Library of France. Between March and June this year we had the opportunity to take samples from four documents, of which Moorish Korans from the 15th and 16th centuries stand out in particular. Our aim is to undertake a comparative study of the inks used, compared to the models studied in Spain.

RESEARCH METHODOLOGY AND APPLIED ANALYTICAL TECHNIQUES

Without doubt the first step towards a scientific study of any manuscript is meticulous examination and sample-taking. The greater the quantity and quality of

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data obtained, the better the information we will ascertain and the more relevant the conclusions we can derive from comparison with other documents.

Following protocols established by the research team, a database is being developed with the aim of recording:

- the bibliographical information of each manuscript;
- the characteristics and materials pertinent to each part of the book (such as the cover, the body of the book or how it has been assembled);
- any damage which determines its stage of conservation;
- and the treatments applied to conserve/restore it (if any).

The research process involves joint working between technicians specialised in archiving, Arabic experts, chemists and conservers/restorers. The idea is to create a tool, in the form of the database, which can be made available to other researchers via the internet.

In order to undertake physical and organoleptic examination of each of the elements under study, we use different measuring apparatus, capable of determining dimensions, weight, cover weight, marks, and characteristics of the medium used. To draw conclusions it has been essential to employ tracings, graphics and sketches, photography and sampling for analysis.

Chemical analysis of the materials used in production is also vital to the process. The data derived has enabled us to understand economic, social and cultural aspects of the era, as well as providing objective evidence regarding the ageing process of the materials concerned. In this way we can avoid the use of products or treatments in restoration which could change the chemical properties of the materials and thus cause damage or irreversible change.

Very few studies have been undertaken into the identification and analysis of paper, and those that do exist tend to be limited to establishing composition based solely on visual examination. This approach is serious flawed, particularly if we consider that one of the key changes in paper provoked by an excess of damp is the dissolving of stiffeners and glues. This dissolving, in turn, has an exfoliating effect on the paper, presenting as a cotton-like finish.

Therefore as well as microscopic study of lengthways and crossways cross-sections of fibres, we use spectroscopic methods. This enables us to distinguish between different types of fibres – for example cellulose, protein and synthetic – as there are different absorption bands which can be attributed to the different specific components. These include: cellulose; hemi-cellulose; pectin; and lignin.

The following techniques for the chemical analysis of inks and agglutinating agents have been applied:

- organoleptic (visual-tactile) analysis,
- macro and micro-photography with both traditional and digital cameras
- optic microscopy,

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- scanning electronic microscopy (SEM),
- energy dispersive X-ray (EDX),
- X-ray diffraction,
- infrared spectroscopy (FTIR),
- Raman spectroscopy,
- high performance liquid chromatography (HPLC)
- and capillary electrophoresis (CE).

In the last few years the use of Raman spectroscopy has rapidly extended across almost all scientific disciplines. This method, incorporating the microscope, is enabling us to carry out surface analyses at high resolution. The method causes no damage and is only slightly invasive.

The methodology used for the chemical analysis of organic colours in historical documents, texts and graphics is based on high performance liquid chromatography (HPLC) with diode array detection (DAD) and capillary electrophoresis (CE).

Capillary electrophoresis (CE) is a powerful technique for the separation, identification and quantification of a wide variety of inorganic and organic compounds. It can identify components such as proteins, amino acids and many other substances found in agglutinates and inks.

This technique is both highly efficient and consumes fewer solvents than HPLC. In fact it is an excellent alternative to HPLC, being cheaper, providing higher resolution with the same precision, and requiring only minimal quantities of the sample.

Sampling

For our sample-taking protocol we factored-in two fundamental principles:

- to respect the physical integrity of the document
- and to obtain a representative sample offering maximum information, avoiding as far as possible its contamination with other elements

To determine the components of inks, a dual sample-taking process was carried out:

For the analyses undertaken with DRX, SEM-EDX and infrared and micro-Raman spectroscopy, the traditional system of gentle scalpel scraping from the different colours was used, avoiding as far as possible alteration of the physical integrity of the writing and contamination of the samples.

For the identification of colouring materials via HPLC and EC we conceived a new way of sample-taking with a paintbrush, which is more effective, less aggressive, and appropriate for the high sensitivity of these analytical techniques.

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RESULTS OBTAINED, REGARDING USE OF COLOUR IN AL-ANDALUS MANUSCRIPTS

Within medieval Islamic calligraphy culture, inks played an important role, with colour being intimately linked to the creation of codices.

The colour **black** was reserved for writing, and red, gold and the other colours used to highlight certain features of the text such as titles, key words, vocalisation marks or create drawings an decoration.

In addition to calligraphy and decoration, colour was also used extensively to dye the skins, paper or fabrics used in the making of the book.

Thanks to the texts and original recipe books (that is, the original sources which have been conserved), it is possible to ascertain the composition of the inks. However, the challenges of translation and, frequently, lack of knowledge of the subject, have given rise to errors. In this sense, use of chemical techniques enables us to obtain objective results.

From our experience to date in the analysis of inks, pigments and colourings employed in the above-mentioned collections, we can derive the following points regarding the use of colour in andalusi manuscripts:

The colour black came from carbon-based inks and iron gall or metalogallic inks.. These could be made in solid form and then dissolved prior to use; or equally they could be prepared in liquid form.

Carbon-based inks were prepared using:

- soot obtained by burning vegetable material such as oils or resins
- fats or animal products (bone or ivory)
- and, occasionally, certain minerals.

A binding agent such as gum arabic would then be added to these elements.

Depending on the preferences of the calligrapher, other elements might then be added to alter the look, structure, consistency, shine or tone of the ink.

Metallo gallic ink, is fluid, with little body. Basically it is composed of a vegetable extract rich in tannins, a metallic salt (iron or copper sulphate), an binding medium which could be water or wine, or a mixture of the two.

Over time this ink turns dark brown. One of its components, ferrous sulphate, becomes oxidised and turns into sulphuric acid which has a burning effect on the surface. It can even destroy it completely.

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The action of metallo gallic inks often causes these manuscripts to degrade. We can easily see their effect. In particular one can see very clearly the marked outline of the writing, visible from the reverse side of the sheet, and the presence of little perforations.

This ink can be used alone or combined with carbon-based ink. This combination, known as **mixed ink**, had the advantage of being thicker and stronger. It also provides a more permanent black thanks to the stability of carbon-based ink. In many of the samples we analysed, we found traces of pigments such as orpimente, realgar, umber earth or iron and magnesium silicates. These pigments were possibly used to give more depth or quality to the colour black.

In making coloured inks, it is a colorant or pigment that actually gives the colour. Just as with blacks, gum Arabic is added as binding agent. Although we may speak of organic and mineral-based inks, in fact all inks have an organic base, namely binding medium.

Inks known as organic are produced by means of boiling or fermenting animals or plants. As well as agglutinants, other additives could be combined to add subtle tones or precise characteristics to the colour. Sometimes a certain quantity of ready prepared ink would be set apart and other colorants would be added. This explains why we can sometimes detect elements such as iron or copper in samples where, according to the colouring, they should not appear.

In the manuscripts that we have studied, the colours used are reds, greens, yellows, blues, whites and golds.

The **reds** were made up of natural vegetable substances; certain insects; or pigments such as realgar, vemilion or minium. All of these we frequently used in conjunction with a lacquer.

The identification of carminic acid, either alone or mixed with another red pigment, could be the result of using cochineal to produce colour. However, this insect came to Europe from America after 16th century. Therefore, given the dating of the documents we analysed and the percentage of carminic acid that we found, it could be the case that that it was indeed this insect or another from, possibly, India, Turkey/Armenia or Poland.

As this particular component has been found so frequently in the documents we have studied, we intend to instigate a specific piece of research aimed at identifying the origin of the animal used in red colouring in andalusi manuscripts from the 15th and 16th centuries.

The colour **green** was achieved by using a base of copper, such as verdigris, using malachite, or by mixing other primary colours such as indigo blue and orpimente. Adding other pigments such as vermillion helped to add tonality to the colour.

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Yellow was made by heating up various vegetable elements, including natural colourings such as saffron, or using pigments such as orpimente or, albeit less so, yellow ochre. Results from our chemical analyses also confirm the use of lead and tin yellow.

The **blues** were achieved using vegetable colourings such as indigo, or from inorganic pigments such as lapis lazuli, azurite and enamel blue. By adding new elements to the basic formula, it was then possible to extend the chromatic range significantly, and to achieve different tones and hues.

In some cases, the greenish tone within the colour blue is due to the transformation of azurite to malachite where damp was present when the ink was applied, or where damp has contributed to overall deterioration.

The colour **white** is rarely used, with the support itself, of paper or parchment, normally providing the white background.

In this particular case, it has been used as a decorative element:

- we see delicate white lines forming vegetable motifs against coloured backgrounds
- it is used to outline titles
- and also to pick out aspects of the text

Analysis has detected the presence of lead white (basic lead carbon) in every example.

Gold leaf could be stuck directly on to the surface. Or they would make an ink by grinding the gold. Or by mixing the powder with acids or different compounds to wich saffron or ormpiment coud be added to form the desired colour. Use of gold is only to be found in high quality texts.

Finally, it is important to note that when we analyse colour in Arabic manuscripts, we may find elements derived from the production process of the support on which the ink was applied. This can lead us to make interpretative errors.

Arabic methods of paper production were not widespread, in other words there were very few sources of production. What we see are production processes that are similar, but with differences according to the timeframe and geographic location.

In general terms the presence of carbon, calcium and oxygen can be due to the nature of the fibres and the initial process of making the pastes. We must remember that to make Arabic paper, they would make up a paste by taking left-over rope or cloth and fermenting and bleaching it in lime after previously pounding and shredding it.

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On the other hand, high proportions of calcium and magnesium may indicate the use of a load material which would make the paper whiter and less absorbent.

The presence of chlorine in a great number of simples indicates elements derived from chlorine used as whiteners.

CONCLUSIONS

- The used methodology has been successful and effective; and is very adequate for the study of documents from Al-Andalus.
- Te proposed techniques for the analysis of dyes and pigments don´t have a negative effect on the manuscripts.
- The characterisation of these materials has a double use. On one hand, it allows us to put the manuscripts in its historical context and, on the other hand, it can be used to obtain a profound knowlodge that could be useful for a possible conservation or restauration process.
- In accordance with the obtained results each archive can establish strategic plans for the conservation of its collections and the safeguard of bibliographic and documental heritage.

It is only through comparative study that we will arrive at genuinely reliable conclusions. There is still much research to be done which will require continued collaboration and sharing of results.

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