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Theses for a DLA dissertation

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Connections between the conservators' examinations and other related sciences:
The Role of Polarised Light Microscopy in Identifying Inorganic Pigments

DLA dissertation by Éva Galambos

The dissertation is concerned – within the permitted purview – with the basic scientific use and role of polarised light microscopy in the analysis of artefacts.

In the treatment of the theme I should like to emphasize that this examination is an important station in the research of art works. In some cases it can be used as an independent analytic technique, in others it may be the preparatory phase for instrumental analyses. With the help of transmitted light microscopy, the extent to which inorganic pigments can be identified becomes more accurately definable.

A pigment dictionary has been compiled which may serve as a fundamental databank for scientific evaluation. To this belongs the summary tabular database of inorganic blue, green, red and yellow pigments.

Thesis 1

The determination of pigments and dating of the painted layers are of decisive importance in settling the questions of originality. Microscopy can best reveal pigment use and the layers. An important role is played by the examination of cross-sections and the evaluation of the findings. If, for instance, it can be established of the layers of a sample from one – or more – object(s) that not only their material but also their painting technique is identical, we have provided ample grounds for art historical researchers to evaluate originality or analogy, to reconsider our common knowledge.

"Valueless" over-paintings may also provide a lot of information about an age for researchers of different areas. I must lay stress on the importance of preparing detailed conservation documentation including the applied materials (e.g. pigments).

As a result of the collaboration of conservators and practitioners of related scientific fields, a fruitful situation arises in which the cultural entity and the material and spiritual potentialities it implies can be unfurled as thoroughly as possible.

The resultant data collection is useless by itself: it must be systematized for interpretation. It is imperative for practical reasons that the system be simple, transparent and extendable.

For the systematization of the necessary auxiliary materials I was motivated by the need to arrange the inorganic pigments in a dictionary under a given rationale.

Thesis 2

The emphasis is laid on the succession of examinations, on how one is built upon the other; it is important to know how the findings of photo technical and microscopic examinations are tied up during the expert evaluation. In addition to the microscopic findings, the precise documentation of the places of sampling, the information of the pigments gained by special photo technical procedures are also important in the final evaluation. From the simple – preliminary – photo technical examinations we progress towards the exploration of deeper layers and also of deeper-lying problems, before launching the next phase: microscopic examination.

Thesis 3

From among the broad spectrum of microscopic examinations, we use the normal reflected light and the luminescence techniques as well as the transmitted polarised light microscopy in the determination of inorganic pigments.

Concerning cross-section examinations in reflected light and in UV illumination, the stress is on the joint practical use of both normal and luminescence examinations of the layers. When evaluating luminescence examinations, a lot of viewpoints based on experience must be taken into consideration, for it is not enough to know how each material appears in UV illumination, since the pigments also appear in the luminescence of the environment in the layer, in the combined luminescence of the layer(s).

Clarifying the role of the transmitted light technique used in determining pigments in the practice of conservation acquaints practitioners of other areas with the process of this technique and makes the examination results intelligible for them.

In transmitted polarised light, the characterization of the pigment grains and their morphological features: size, shape, surface, aggregations, fractures, cleavages of the particles and other features like inclusions and other inter-particles can be defined. These are the primary properties for the identification of pigments. It is very important also to create the adequate terminology for the pigments.

In identifying pigments, the definition of optical properties – colour, pleochroism, refractive index and birefringence, extinction, interference colour, internal reflection – plays an important role, together with other optical information gained by using sensitive tint plates, filters.

Owing to limitations by the grain size of inorganic pigments and the enlarging capacity of the available microscopes, these techniques often have very limited practical use.

The sequence of conservators' examinations ends with instrumental analyses. On the basis of the properties outlined with the techniques mentioned above, with the help perhaps of a simple chemical analysis to verify the presence of some element, the pigments can be identified. Several materials can be defined on the basis of the recognized properties.

However, with the above-described procedures, we can often only arrive at a certain stage of identification. Then, with the method of exclusion, further

instrumental examinations can be conducted to determine the presence or absence of certain properties. In such cases, the so-far discussed techniques are used as preliminary examinations and sample-preparing methods.

The instrumental examinations are not automatic. Useful results can only be achieved on the right sample, the correctly chosen instrumental technique and the accurate evaluation. To achieve such results in the case of complex painted surfaces it is indispensable to formulate accurate questions with the help of photo technical and microscopic examinations.

Thesis 4

To evaluate the analytic findings about inorganic pigments in transmitted light, it is necessary to have a basic data collection, since the method is based on the identification of certain properties and the exclusion of others.

As for the most important inorganic pigments subsumed among the “historical pigments”, I briefly describe their microscopic identification on the basis of my experiences. I summarized the systematized data and properties required by their identification in separate tables so that they can be used effectively and easily during microscopic examinations. In the tables, the microscopic properties, refractive indexes, crystal system, infra red and UV illumination, basic chemical properties and tests, and the main instrumental analyses are included.

Besides, I have worked out a five-point scale for the evaluation of the process of identifying inorganic pigments by PLM and the conservator’s basic tests. It is meant to help those who are just getting acquainted with this special field.

Evaluation scale:
5 – easily identified by grain characterization and optical properties
4 – well identifiable, even with smaller experience, verified by chemical identification
3 – occasionally identifiable, with experience, verified by chemical identification, on the basis of the exclusion of other options
2 –perhaps identifiable as belonging to some group
By the term ‘group’ I mean such umbrella notions as *copper greens, chrome yellow, lead-containing yellows*. Sometimes there are certain research aspects that require the further investigation of pigments belonging to this category, but the lack of the identification of the exact composition does not necessarily influence the process of restoration or the researching of the artifact. In other cases, such categorization may help choose the right instrumental examination for an accurate analysis.
1 – only identifiable by instrumental examination, there remains too much uncertainty when only the above-mentioned techniques are used to identify the given pigment.

The easiest to identify microscopically are the blue pigments, because their refractive index is low in this group and most pigments have large characteristic grains easily analysed under the microscope.

Some green pigments are also well-identifiable but there are subgroups that have lots of unsettled questions to this day, e.g. the *copper greens* or *Scheele greens*. This means that over the times, several new pigments were also included among the “historical” greens and the group is not complete yet. These must surely be examined instrumentally.

Red pigments usually have high refractive indexes, few transmit light easily and their grains are small, hence they are harder to identify but with chemical analyses and the exclusion method they can relatively well be defined. (Luckily, there are few red pigments, which is an advantage for the method of exclusion, and they are not age-specific hence only require further instrumental examinations in well-justified cases.)

As regards yellow pigments, simpler examinations by conservators – photo technique, microscopy, chemical analyses – cannot achieve more than relegate the given pigment to the group named after the main component. Such are the *iron-oxide, chromate*, and *cadmium containing* groups and most of the *lead containing* group.

Earlier, when there were not more accurate analytic possibilities, these collective groups caused much headache to researchers. That is why over the time the designations of yellow pigments became quite chaotic. The correction of our knowledge about them has been made possible by the application of modern analytic methods.

Since most yellow pigments have too small grains for microscopic examination and regarding their composition they subdivide into several subgroups, the exact analysis of the majority requires instrumental examination, with the exception of *orpiment, mosaic gold* and some *cobalt yellows*.

At any rate, the competent evaluation of the instrumental examination of yellow pigments is also largely promoted by the knowledge of the possibilities – that is, the composition of the “historical pigments” and their variations.