Article: Conservation of New Photographic Art: Direct Printing and Textile Artifacts
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Conservation of New Photographic Art: Direct Printing and Textile Artifacts

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1. Introduction

The conservation of photography is a young science: thirty or forty years of professional development it is not a long time. Nevertheless, in such a short period of time it is possible to see how much the profession has changed, and to see how contemporary artifacts made by photographic means now have nothing to do with the photographic objects with which photograph conservators originally worked.

When I started in this profession I was working mainly with nineteenth century photographs. As time passed, most of my work was with photographs of the twentieth century, dating from as late as the 1970s. About five years ago, I took a leap to face the problems that affect contemporary photographs, those dating from the last decade of the 20^{th}-century to the present day. I suddenly had to deal with the developments in photographic art production systems which occurred over the last two years. These technologies open new challenges for the future. This is what this paper is all about: photographic artifacts are being created today that will challenge conservators in the years ahead.

Today's conservators are familiar with inkjet and lightjet (digitally made chromogenic prints) on cellulose supports, using known installation and exhibition systems.

Fig. 1. Inkjet photographs by Nadav Kander, on exhibit at the Andalucian Center for Photography, Andalusia, Spain.

In recent years I have encountered other photographic objects with more unusual physical characteristics.

These include digital prints where the primary support has become the substrate: this is usually done to ensure consistency of an artwork, especially with large format photographs. Artists may also print their works on various fabrics, use surface coatings, and present them in different and innovative ways.

Fig. 2. Photomontage (digital textile print) installed in a gallery space.

Searching for information on these new materials and techniques has led me to work with one of the most important printing laboratories in Spain, Clorofila Digital. Clorofila Digital has been making lots of contemporary artworks with a number of these new types of printing systems. I am currently working with their research department, studying, analyzing, and increasing my understanding the new digital printing systems and their possibilities. I am also helping them to develop their quality control system.

Fig. 3. Clorofila Digital's showroom. Image by Oscar Polanco, 2012.

2. Technologies for New Photographic Art Production

Direct printing can be done on a number of unusual substrates. The fashion industry has made excellent use of this. For example, it is possible to see a range of jewelry objects made with directly printed photographic elements and assembled with silver, gold and platinum components (Fig. 4). The photographic images are printed directly on glass, the primary support. Another similar artifact is an image printed onto white ostrich feather, with silver components (Fig. 5). It is also made by direct printing of the image.

Fig. 4. Jewelry by Saioa Aldaya, photographs by Daniel Dicenta.

Fig. 5. A white ostrich feather *(left)* and a direct printed photograph on a similar ostrich feather *(right)*. Jewelry by Saioa Aldaya, photograph on feather by Rafael Rodulfo.

Many artists are presenting their artworks as light boxes, which can be made using several different technologies. For example, when viewing the light boxes in Figure 6 from a normal distance, they look quite similar. However, they were made using very different photographic technology. The light box pictured on the left is a chromogenic print, printed with lightjet technology, and attached to the verso of a translucent plastic support using a silicone adhesive.

Fig.6. Light boxes: a chromogenic prints *(left)* and a direct print *(right)*, both adhered to translucent acrylic supports. Unknown photographers.

The object pictured at the right of Figure 6 is direct printed onto an acrylic substrate. The image is made up of inks which are cured with ultraviolet (UV) light: these types of inks are also known as photo-polymerization inks. The image layer is on the exterior of the light box. It does not require the use of an adhesive, but also has no protective varnish or glazing.

Fig. 7. Textile printed light boxes illuminated with light-emitting diode (LED) light sources installed in the Clorofila Digital showroom. Unknown Photographers.

Light boxes can be constructed in yet other ways. For example, the light boxes pictured in Figure 7 are printed onto fabric and stretched on round supports with diameters of 1.5 meters. The images are printed by dye sublimation onto a proprietary fabric support known as Backlit, which is manufactured by Fisher Textiles, Inc. They are illuminated with light-emitting diode (LED) light sources.

Fig. 8. Vertical, cylindrical, textile printed, free-standing light boxes by Ricardo Cisneros.

Yet another variation of the light box presentation style is pictured in Figure 8. The fabric elements with printed images are wrapped around vertical acrylic cylinders. The tubes are free-standing, and are illuminated from within.

3. Industrial Printing Contribution to Photographic Art

The technologies of direct printing on various substrates and printing on textile supports did not originate within the arts community. These techniques for creating digital prints were developed by the graphics printing industry (photomechanical or industrial printing) and later appropriated by photographic artists. Both technologies, direct printing and textile printing (inkjet-applied dye sublimation printing), became possible with advances in industrial printing, in combination with the development of inkjet technology, made over the past 20 years.

Fig. 9. Plastic bottle lids with commercial labels direct printed on top.

Direct printing was developed for printing text and graphics on plastic-coated electrical wires. After the improvement of the UV-curing systems, these inks were used to silkscreen posters, product labels, and commercial packaging. Inkjet printing with these inks became possible with reducing the viscosity of the ink and after subsequent improvements to the injector's capabilities.

Textile printing is the result of the evolution of large-scale textile printing systems in conjunction with technologies developed for dye-sublimation printing on transfer paper. After the initial printing onto the temporary support, a hot press is used to transfer the images onto a final support. The direct digital textile printing technology sometimes used in contemporary photography originated in the 1990s as an alternative to silkscreen technology. Later developments in dye sublimation inks and printers now permit images to be printed directly onto the fabrics.


Fig. 10. A textile printed curtain *(left)* and a direct printed ceramic wall *(right)*. Unknown photographers.

The use of textile supports has necessarily led to the use of large printers, allowing for the creation of extremely large objects. Because of the extreme sizes possible, this printing is done roll-to-roll: the unprinted material is initially rolled and after printing, is re-rolled for storage and space-saving purposes. This is mainly used for commercial advertising materials, such as flags, banners, signs, etc… Artworks produced in this way are 'low production' or 'print-on-demand' pieces.

4. Technical Aspects

The structure of these photographic objects is different depending on which printing technology is used. Both direct printing and textile printing, however, do have some technical aspects in common: the use of inkjet technology and unusual supports, as well as having images formed by applying energy in some form.

Inkjet technology involves transforming a digital image into a series of electrical pulses. These pulses them control the deposition of ink droplet onto a given support material. This is now fairly common and established printing technology. In addition to the possibility of printing on uncommon supports, the inks, once deposited on the supports, are designed to form an image by bonding with the support. This is done with energy, most commonly through heat and/or light.

Both technologies essentially function as follows:

ink + support + energy = digitally printed object

The differences between the two processes begin at the moment when the ink droplets arrive at the support material. The form of energy applied to the inks is different, and the resulting image materials have correspondingly different structures and appearances.

Fig.11. UV radiation causing the photo-polymerization of direct printing inks: the UV light source is passing over the applied ink, causing it to cure.

Direct printing uses energy in the form of UV light to cure the inks on top of the support material. Textile printing uses thermal energy, or heat, to form an image within the fibers of the (textile) support.

In direct printing, a high-UV light source passes over the applied ink, forming cross-links within binder and curing the ink. Once the ink is cured, the image is fixed onto *the surface* of the support. This is a chemical photo-polymerization reaction induced by light energy reacting with a photoinitiator compound in the ink. This is similar to what occurs in 19th century colloidal photographic processes such as gum dichromate and carbon printing.

The image formation of textile printing involves two separate steps. The first step is printing the image onto the textile surface. At this point the image is weak, and the colors are not saturated. To complete the image formation, as a second step, the printed fabric passes through a calender (rotary heat press). As the printed fabric passes through the heated press, the ink sublimates and forms an image *within* the fibers of the support.

What is occurring as the fabric passes through the calender is that the dye bonds to the fibers, increasing the saturation of the colors and the sharpness of the printed image. The printed fabric is then re-rolled to keep it safe and to save space.

Both technologies rely on the advanced development of inkjet printing, new machines to deliver the ink and create the print, specific media (the various substrates used to print), and special-purpose inks.

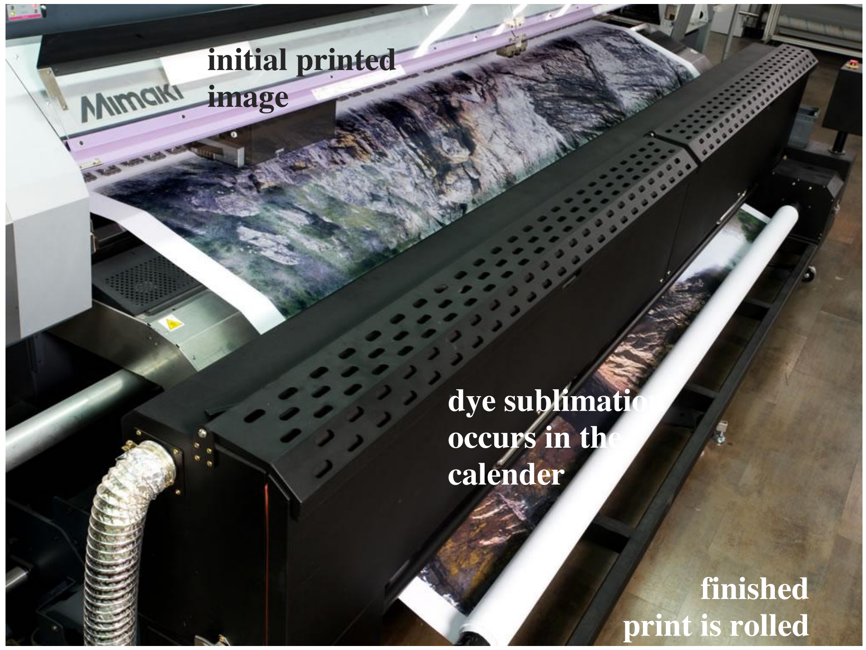

Fig. 12. Thermal energy causing the ink sublimation in textile printing.

Fig. 13. A photographic artwork combining both direct printing and textile printing. Installation made for CasaDecor 2011. Unknown photographer.

5. Process Identification

Direct printing and textile printing have advantages and limitations in terms of life expectancy, preservation needs, and scope of restoration options, if required. However, in order to realize these parameters, it is first necessary to properly identify the printing process used. The easiest way to identify the printing process used would be to focus on their physical characteristics through a detailed visual assessment.

This can be done by relating both technologies to the continuous tone of a chromogenic photograph. As photograph conservators are aware, under magnification both traditional and lightjet chromogenic prints exhibit gradations of continuous tone (Fig. 14). This continuous tone contrasts with the regular or irregular halftone screen patterns produced by direct printing. At a normal viewing distance the image appears to be continuous tone, but upon closer study, perhaps under magnification, the nature of the non-continuous tone pattern will become visible (Fig. 15).

Fig. 14. A lightjet chromogenic print, overall *(left)* and detail images *(center and right)*. The continuous tone of the image is evident upon closer examination.

Fig. 15. A direct printed image on a Dibond support, overall *(left)* and detail images *(center and right)*. The digital halftone screen patterns produced by the inkjet printer are visible upon closer examination.

The technology used to direct print older artworks were less advanced than what is currently used: the size of the ink drops was larger than the standard ink drop size is today. Smaller drop size results in higher quality images. This could necessitate examination using a microscope when determining if an unknown print has continuous tone or a digital halftone screen pattern. The current standard for the drop size in direct printing is 1.6 picoliters.

Textile printing can also be contrasted with the continuous tone of a chromogenic print. Again, at a normal viewing distance the image appears to be continuous tone. Upon closer examination the woven surface texture of the fabric support become readily evident. Under magnification, it is possible to see how the ink has penetrated the fibers of the support. During the thermal sublimation process the ink moves into and expands within the fibers, obscuring any digital halftone screen pattern and creating the illusion of continuous tone. There is a slight decrease in the sharpness of an image when compared with chromogenic printing, but the printing technique provides overall good image quality.

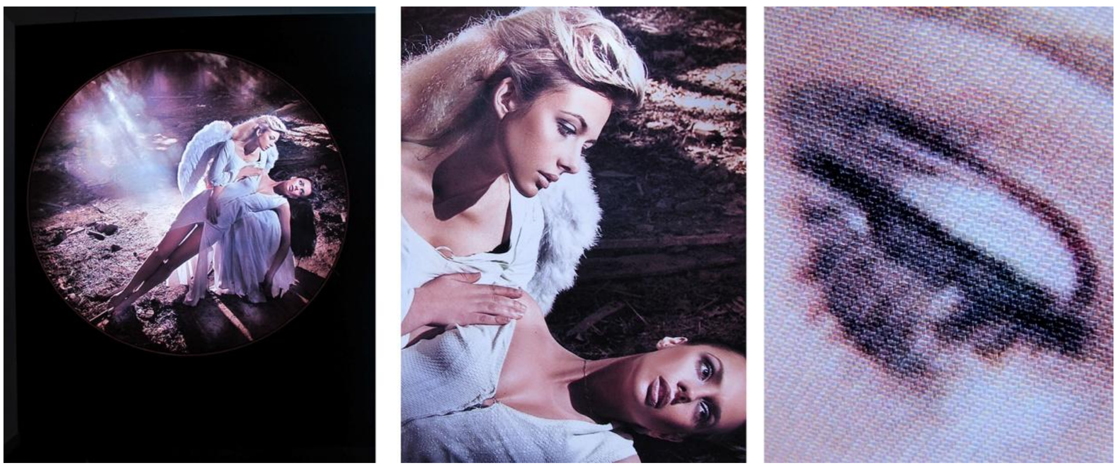

Fig. 16. A textile printed image, overall *(left)* and detail images *(center and right)*. The weave of the fabric is readily visible, and the printing technique gives the illusion of continuous tone.

Other physical characteristics can assist in identifying direct printed and textile printed artifacts. For example, in direct printing the inks forming the image sit on the surface of the support. Because it does not significantly penetrate the support, it is easier to observe the digital halftone screen pattern, especially in areas of low image density. In areas of high image density, the heavy amount of ink applied forms a continuous film on the surface of the support, creating a higher surface gloss in these areas (Fig 17).

Fig. 17. A direct printed image, overall *(left)* and detail *(right)*. High image density areas exhibit have high surface gloss and continuous ink film *(right)*.

Identification of textile prints is more straightforward because of the nature of the support material. The objects may also exhibit a matte surface gloss, almost having the appearance of satin in areas of high image density. Often the support fabrics are polyester, and the edges are cut with heat. This local melting and cooling of the plastic (polyester) fabric gives the object distinct hard plastic edges. These objects may also have a variety of attachments, such as sewn edges and fastening mechanisms such as grommets.

Fig. 18. A textile printed image: the flexible folded support *(left)*, matte surface gloss *(center)*, and melted plastic edge *(right)*.

It is possible to confuse textile printing (inkjet-applied dye sublimation printing) with other types of digital printing on fabric supports such as those made through dye diffusion thermal transfer printing techniques. However, the image created using those techniques remains on the surface of the fabric: it is not formed within the fibers.

Both direct prints and textile prints are often exhibited without any protective surface coating (laminates or varnishes) or housings (mats, frames, glazing).

Physical Characteristics		
	Direct Printing	**Textile Printing**
Support	any kind of media	synthetic fabrics
Image	UV-curable inks	sublimation inks
External Fastenings	rare, depending on the support	more common, including stitching, melted edges, grommets

6. Structural Components

6.1 Supports

As the UV-cureable inks can be used on a variety of supports (stone, iron, plastics, wood, steel, ceramic, etc.) broad statements as to the physical durability and chemical stability of these substrates are not possible: there are too many variables to take into consideration.

However, the most common supports used in direct printing are Dibond (a genericized trademarked term for an aluminum/polyethylene/aluminum composite material, first manufactured by 3A Composites) and Plexiglas (the tradename for a transparent thermoplastic glass alternative, poly(methyl methacrylate), first manufactured by the Rohm and Haas Company).

Fig. 19. The same image direct printed onto a Dibond support *(left)* and a Plexiglas support *(right)*.

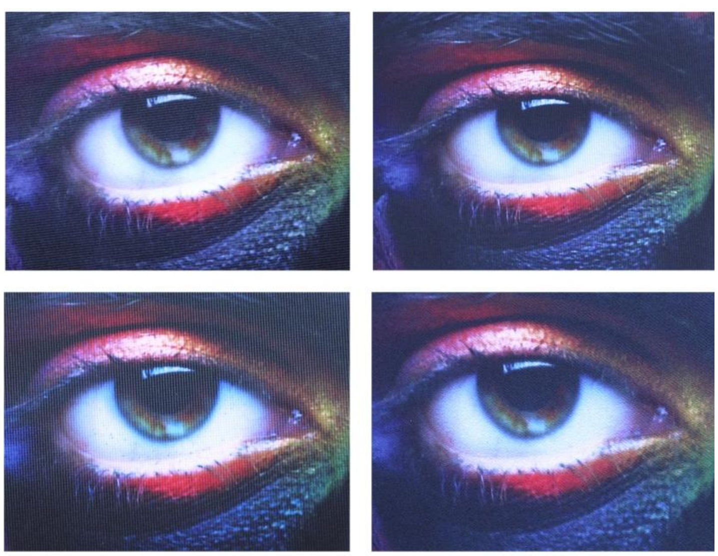

Fig. 20. The same image textile printed onto fabric supports with different, distinct weave structures.

The supports used in textile printing can vary, not significantly in chemical composition but in the weave structure and/or any sewn or attached elements. The chemical composition of the fabrics must contain, in some proportion, synthetic polymers. Though most are polyester, fabrics may include a certain percentage of cotton fibers (to provide different physical qualities regarding the hand or draping of the fabric) or polyamide fibers (to increase the strength and elasticity of the fabric). The intent of these fiber mixtures is to fabrics that are flexible, and able to withstand high stresses without tearing.

No matter the composition, all textile supports are waterproofed and treated with fire-retardant chemicals. These treatments give them greater resistance to biological contamination than conventional fabrics. They may also have surface coatings that assist in the creation of higher quality images.

6.2 Image forming substances

Direct printing inks consist of four basic components: 1) a photoinitiator, 2) acrylic resins, 3) colorants (pigments or dyes), and 4) other fluid modifiers and additives (Fig. 21).

As stated previously, the photoinitiator is activated upon exposure to a source of UV radiation between 200 and 400 nm. This activation begins the polymerization of the ink. The resins in UV-curable, or photo-polymerization, inks consist of acrylic oligomers and monomers. The large oligomers do not participate in any cross-linking reaction: it is the smaller monomers that polymerize upon activation of the photoinitiator component. The monomers also function as a plasticizer to the larger oligomer molecules. For a graphical representation of this, please see Figure 22.

The additive and fluid modifiers added to the ink serve to increase or decrease the viscosity of the ink during the printing process, and to adjust physical properties of the cured ink film such as flexibility and resistance to abrasion. The colorants present within both direct printing inks and textile printing inks will be discussed in Section 6.3.

As these inks do not contain volatile organic compounds (VOCs), they are known as "100 percent solid inks" (Maitland 2005, 287). With correct curing of the ink, all of the components are a part of the final ink film: all that remains is a layer of acrylic polymer containing the colorant, binding it to the support material.

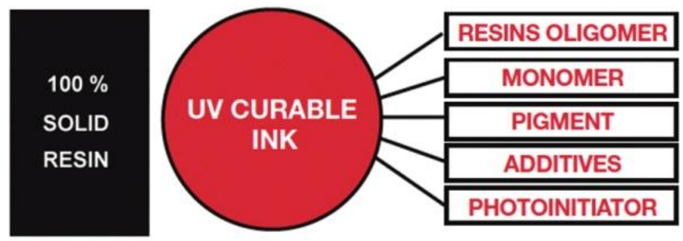

Fig. 21. A graphic representation of direct printing ink composition.

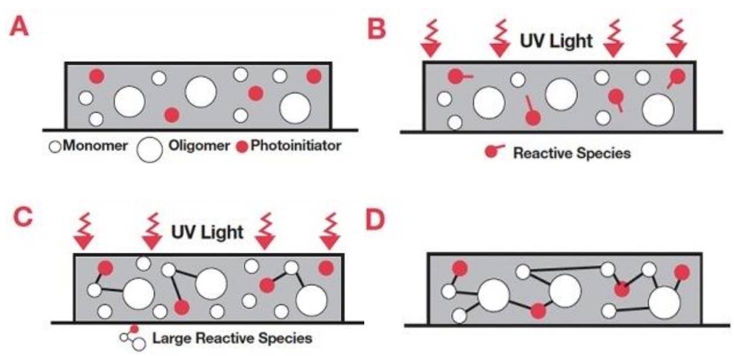

Fig. 22. The uncured ink film *(A)*: the ink is exposed to UV light and the initiator is activated *(B)*: the monomers begin to polymerize *(C)*: the cured and cross-linked ink film *(D)*.

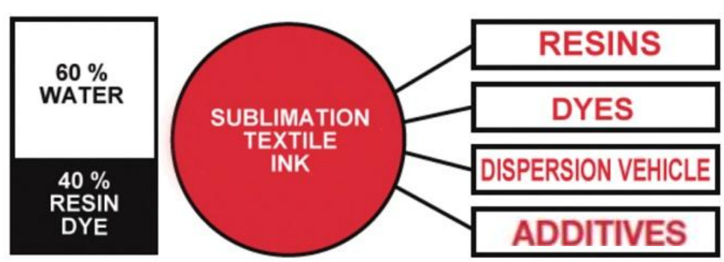

Fig. 23. A graphic representation of textile printing ink composition.

The inks utilized in textile printing are of a very different composition: they consist of solid particles (waxes and/or resins) dispersed in an aqueous solution (Fig. 23). During the heating process, the solids move into the textile fibers, redepositing as solids. These inks are designed to bond with synthetic polymers: the fibers are not colored with a physically-bound ink, the ink becomes part of the fibers themselves (Fig. 24.).

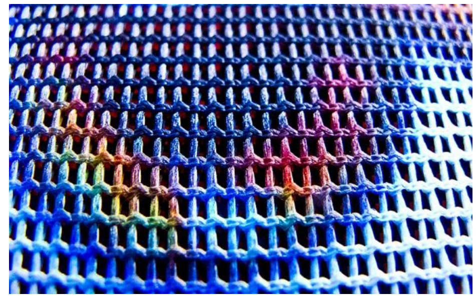

Fig. 24. Textile printed image: the ink is formed within the fabric's fibers.

6.3 Colorants

The colorants used in digital printing are either dyes or pigments, with pigments being the more stable, long-lasting option as a colorant. Permanence is of significant interested to digital print ink/equipment/paper manufacturers such as Epson, Agfa, and Minolta.

Information located by the author indicates that the inks used for direct digital printing utilize pigments as the colorants. No accurate information regarding the dyes used in textile printing was found. What is known is that textiles printed with this technology and used in the fashion industry can be washed and ironed. Therefore, it may be assumed that the inks can withstand a range of temperatures and relative humidities.

Fig. 25. Ruiz Galán fashion designs at Madrid Fashion Week 2012. Image by Oscar Polanco, 2012.

The need to conduct more extensive ageing and lightfastness testing is plain. However, further analysis and understanding of the composition of these contemporary photographic objects can be complicated by the proprietary nature of many of the products. Manufacturers are not always willing to divulge trade secrets.

7. Conclusions

The information on the stability of the products offered by these companies is often vague. In its product information, Agfa states that accelerated weathering tests with Anuvia UV-curable inks applied to various substrates indicate that the outdoor durability of the inks is "more than 2 years - probably even more than 3 years under Western European, outdoor conditions" (Agfa-Gevaert 2013).

Fig. 26. Photographs printed onto ceramic and acrylic supports, installed within a bathroom. Image by Oscar Polanco, 2012.

It is easy to forget that the ink is not the only thing to consider when thinking about the long-term stability of an artwork. On must remember that that the stability of the substrate, paper, fabric, ceramic, glass, etc, is also an important factor. For instance, empirical experience suggests that a direct printed image on a ceramic support is still in excellent condition after five years of outdoor exhibition in Spain. No doubt the use of a ceramic support lends a certain degree of long-term stability to such an object.

Fig. 27. *En algún lugar, ninguna parte: Proyectos no ejecutados de Le Corbusier* by Dionisio Gonzalez, exhibited by Solo Objects at ARCOMadrid 2013 (International Contemporary Art Fair). Photographs printed by the Clorofila Digital laboratory. Image by Oscar Polanco, 2012.

In order to more fully understand the life expectancy for these types of digital artifacts, it is necessary to continue to research the materials and printing techniques. Until our understanding develops, a conservative preventive conservation approach to these objects may be the best course of action.

To assist in answering many of these questions, the author is currently working to develop a research project in collaboration with the restoration laboratory at the Universidad Complutense in Madrid. If funding in secured, the intention of the project is to analyze the materials used in direct and textile printing, with the ultimate goal of increasing our understanding of these new photographic artworks.

8. Acknowledgements

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Unless otherwise noted, all images are by Pablo Ruiz García, 2011/2012.

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