# Trusting the body.
# Colour pattern making in glass inspired by Lithyalin glass formula.

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TABLE OF CONTENTS:

LIST OF FIGURES:



**Key words**: colour, haptic vision, touch, movement, glass flow, pattern, the fold, Gilles Deleuze, raw materials, Friedrich Egermann, Lithyalin colouring techniques, innovation, crystals, pâte-de-verre

**LIST OF FIGURES:**

* *Figure 17*: Beryl - Morganite, Elbaite, Spodumene-Kunzite, Albite, Quartz, Dimensions: 17 x 16 cm, Dara-i-Pech, province de Kunnar, Nuristan, Afghanistan, Le Muséum national d'histoire naturelle (MNHN), Galerie de Minéralogie et Géologie, Paris, p. 63

* *Figures 18 & 19 & 20* (from top and left): Ballade sur le Soleil, Izabela Dziepak, cold assembled flint glass, 2003, Eugeniusz Geppert Academy of Fine Arts in Wrocław, photo credit: Izabela Dziepak
The Trinity, Andrei Rublev, 1410-1427, Tempera, Dimensions: 150 cm × 100 cm, Galerie Tretiakov, Russia
Christ before Pontius Pilate, Follower of Hieronymus Bosch, c. 1520, Oil and tempera on oak panel, Dimensions: 80 cm x 104 cm or 31 in x 40 in, Princeton University Art Museum, Princeton, NJ, p. 64

**Figures 21 & 22 & 23* (from top, p. 60): The concave and convex mirrors might have been used to project a 'new space': Iris, Anish Kapoor, 1998
Turning the World Inside Out, Anish Kapoor, 1995
Nuit Blanche, Anish Kapoor (?), 2016, p.65

* *Figures 24 & 25 & 26*: Solaris (Russian: Солярис, tr. *Solyaris)* based on Stanisław Lem's novel of the same name published in 1961, science fiction film's snapshot, Andrei Tarovsky, 1972
Double Mirror, Anish Kapoor, 1998
Seated Figure, Francis Bacon, 1983, Etching and Aquatint, Dimensions: 101.5 cm × 71 cm or 40 in × 28 in, Edition of 99, Kunzt Gallery, p. 65

* *Figures 27 & 28 & 29* (from top, p.61): The dualism between internal and external form results from the fold – the form's dynamic stresses.
Jheronimus Bosch, Saint Christopher, 1490 - 1505, Oil on panel, loan: Stichting Museum Boijmans Van Beuningen 1940
Drapery study, Raphael, c. 1511, drawing on paper (verso of Phrygian Sibyl), Dimensions: 261 mm x 165 mm, British Museum, London
Johann Georg Pinsel, Saint Joachim, Lviv, National Gallery of Fine Arts, Wood, Height: 49 cm, p. 66

* *Figures 30 & 31 & 32*: Spatial Composition 4, Katarzyna Kobro, 1929, Painted steel, Dimensions: 40 cm x 64 cm x 40 cm, photo courtesy of Muzeum Sztuki in Łódź
Beaker, 1720-1730, Dresden, gilded double-glass, with engraved gold foil backed with oil colours, Victoria and Albert Museum, N° C.401-1936
Untitled, Izabela Dziepak, Hot-formed glass, detailed view of the marbled coloured pattern, Diameter: 5 cm, 2016, Royal College of Art, photo credit: Izabela Dziepak, p. 66

* *Figures 33 & 34:* Glosa Salomonis, Izabela Dziepak, Glass, Hot-formed, fused, cold assembled and carved, Dimensions: ≈ 4 cm x 12 cm or ≈ 10 in x 30 in 2015, Royal College of Art, photo credit: Sylvain Deleu, p.70

* *Figures 35 & 36 & 37 & 38 & 39 & 40*: Deposit of mineral-earth type pigments (ochres) containing naturally occurring metallic oxides with a predominance of iron oxides, Rustrel, France, photo credit: Izabela Dziepak, p. 77

* *Figures 39 & 40* (from left:) Tomb-relief, fragment bearing a royal head in sunk relief, limestone, excavated in 1889 in Kom Abu Billo, Egypt, Bristish Museum, London, N° EA650
Francis Bacon, Seated Figure, Oil paint on canvas, 1961, Tate Collection, London,
p.78

* *Figures 41 & 42 & 43:* Azurite and malachite pseudomorphed after selenite, Apex Mine, Jarvis Peak, Beaver Dam Mts, Washington Co., Utah, USA
Glass sample coloured with oxides and ochres, Izabela Dziepak, 2016, Royal College of Art
Egyptian glass face inlay of Akhenaten or Nefertiti (as the personification of Hathor), New Kingdom, Amarna Period, Dynasty XVIII, circa 1353-1336 B.C. H=4.2 cm, p.79

* *Figures 44 & 45:* Anna Dickinson, (from left:) Green Triangles, Glass and Copper, 13 x 26.5cm, Von Bartha collection Basel, Photo Credits - Robert Hall
Red Vessel 2015, Glass, steel and gold-plated copper, 18 x 19cm Private collection, Ariana Museum, Switzerland, p. 91

* *Figures 46 & 47*: Aurora, Izabela Dziepak, glass, pâte-de-verre made of different viscosity glasses, the white piece is cold assembled, Dimensions: ≈ 11 cm x 14 cm x 7 cm or ≈ 28 in x 35 in x 2,7 in, 2016, Royal College of Art, photo credit: Sylvain Deleu, p. 92

* *Figure 50*: Triangle du Ténéré, Fusions, Bernard Dejonghe, solid optical glass, Dimensions: 28 x 29 x 23 cm, Catalogue du Musée de Dunkerque, Conversation avec Alain Macaire, Musée de Dunkerque, Dunkerque: 1997, photo credit: François Goalec, p. 95

* *Figures 51 & 52* (from top): Sphere, Izabela Dziepak, Glass and water, 2005, Eugeniusz Geppert Academy of Fine Arts in Wrocław, photo credit: Jędrzej Stelmaszek
Concave Glass Lens, Izabela Dziepak, Black and white analog photography, 1995, Ognisko Artystyczne, Nysa, Poland, p.96

## ABSTRACT

The glass quality that I work to achieve is opaque or translucent glass with a surface resembling polished semi-precious minerals, veined with a spectrum of dark contrasting hues. Therefore, my methodology is based on exploration of the technological potential of glass to realise my formal aims. The Lithyalin colouring glass technique invented by Friedrich Egermann in 1828 is the principal inspiration that pushed my research further. Consequently, this dichroic phenomenon gave rise to the critical sense that colour may be perceived integrally as a dimensional constituent of form, and as such requires the use of 'haptic vision', once common to ancient Egyptian cognition. My aim was to understand what it means to reproduce a mineral entity, considering that not only ingredients and the process of making define the aesthetics of a final outcome. I had to define why it would be important to look at recreating particular coloured glasses, and I therefore sought to define what the idea of 'resemblance' is, and if we may subject it to a concept.

My research develops in discourse with my chosen sources (chosen painters, glassmakers and philosophers) through art-historical study, and through practice, by aspiring to extend their technological investigation. My research relied tightly on some philosophical concepts of Gilles Deleuze and in particular those found in *The Fold. Leibniz and the Baroque*, 1993. I aim to translate his theoretical reasoning into a glass object. I consider the progression of folding comparable to chromatic mineral growth under stress, and additionally, in a limited amount of time, glass material allows the reconsideration of process similar to that of crystal formation. Hence, through my artistic practice I constantly search for the appropriate practical modes of gesture in order to align my body with this movement.

Apart from fundamental glass blowing practice, where glass flow is examined directly, the original contribution of this project lies in the application of traditional engraving techniques in which sandstone wheels play a decisive role in the formal resolution. During long hours of carving, layer by layer, I discover new motifs and the sculpture's dimensions become illusive, as I follow or work against the object's outlines. These suggest the new perspectives of shape, which show the coloured, folded character of the glass flow. This highly mechanical method is in fact close to the activity of painting as successive approaches to colour build the object's theme.

Initially I focused on a simple method of fusion for glasses with different viscosities, which relates to pâte-de-verre principles developed by the French Art Nouveau artists Gallé, Argy-Rousseau, Walter, Décorchemont, and the brothers Daum. Subsequently I based my research on recent scientific data concerning colouring formulas of Ancient Egyptian glass production, using raw materials to obtain two background hues for my patterned structures: crimson red (kermes) and indigo (wadjet/keem), as compared with recent archaeological reconstitution.

The evolution of the human brain may be associated with the development of the hand as a precision instrument, which extends sensory processes of thinking. With this in mind, to enhance visual and multisensory experience I create hand-sized sculptures, perceived and apprehended by touch in motion.

## INTRODUCTION

This MPhil by-practice research at the Royal College of Art consisted of a two-year programme during which my methodology interlinked historical facts, philosophical concepts, psychophysics, cognitive neuroscience, and most of all experimental, tacit knowledge acquired by trusting the body. My wish was to examine the intimate relationship between a maker and her chosen material and I wished to exclude the process of imposing my conscious aesthetic choices into the glass material. While glass blowing, I followed liquid glass's movement, balancing it almost mechanically, to realise the influence of my role as a dominant creator. Among other aspects, by taking this position I could raise my awareness and strengthen my determination in decision-making while carving in glass. The difference in the two processes is the time factor, which in case of glass blowing I set for approximately forty minutes (with respect for an adjustment in case of difference in size of the worked material), while sculpting one glass object may take me more than a month.

The seeds of this research might have been sown as far back as my first creation in glass material 15 years ago. Since then I have been asking the same questions and I enquire into the same problem, which recurrently provides me with the stimulus for inspiration. My creative approach aspires to be the one of a polymath[1] with broad cultural interests that encompass the full spectrum of available knowledge in the subject. That is why my research question can be moulded by the ideas, which place the subject always in a new perspective. This approach, and respectively my eclectic methodology, as much analytical as synthetical, reflects the complex processes that are employed in my practice to create an object from an assemblage of different glass pieces. The focus is placed persistently on the idea of one's reciprocity with

[1] https://www.etymonline.com/word/polymath

the glass material, and further on developing a particular perception, the haptic sense of sight, which allows one to redefine, 'unfold' continuously, visible matter.

In order to understand what resemblance is, and therefore place this research in a wider art historical context, I refer to the term 'diagram' defined by Deleuze in - *'Francis Bacon: The Logic of Sensation'*. Diagram, this factor of 'analogical language', which painting represents par excellence, "acts not as a code *but as a modulator*"[2]. The diagram can be described as an operative set of traits, lines, zones, colour patches without any significance accorded to them: "Van Gogh's diagram, for example, is the set of straight and curved hatch marks that raise and lower the ground, twist the trees, make the sky palpitate, and which assume a particular intensity from 1888 onward."[3] I suggest that the same technical mode can be distinguished and the term 'diagram' extended to three-dimensional art objects, which exist within space and possess an element of time.

"Light is time, but space is colour"[4], according to Deleuze. Colour, in obedience to relations of expansion and contradiction, of warm and cold, and through its different regimes, shapes a haptic sense and finds its tactile-optical role. While actual touch enables one to assign tactile values to retinal estimations, it is diagram, the pictorial fact, that is responsible for the haptic vision of the eye with its distinctive lucidity. "It is as if the duality of the tactile and the optical were surpassed visually in the haptic function born of the diagram."[5] The same diagram represents the principal research issue to be determined – how does it deconstruct elements in order to reconstruct them into a new visual entity?

[2] G. Deleuze, Francis Bacon: The Logic of Sensation, trans. Smith D. W., University of Minneapolis Press, Minneapolis: 2003, p.84
[3] Ibidem, p.96
[4] Ibidem, p.72
[5] Ibidem, p.129

The title: "Trusting the body. Colour pattern making in glass inspired by Lithyalin glass formula." invites the comparison of what the eyes see and what the body perceives / believes, the "matter of fact". The starting point for further thinking is the statement of Gilles Deleuze who recognised that "there are several aspects in the values of the hand that must be distinguished from each other: the digital, the tactile, the manual power, and the haptic."[6] Further, Deleuze conceptualised Francis Bacon's creative process and this theory, alongside the artist's interviews with David Sylvester, provide a clear explanation of what can be called 'the act of painting'. Bacon's opinion was that "it is as if the hand assumed an independence, and began to be guided by other forces, making marks that no longer depend on either our will or our sight. (…) This is the act of painting, or the turning point of the painting" and further he added: "one has an intention, but what really happens comes about in working - that's the reason it's so hard to talk about it - it actually does come about in the working. And the way it works is really by the things that happen." Francis Bacon claimed that his work started at that very moment when consciously he did not know what he was doing. It can be suggested that this relation of the hand to the eye lets sight 'discover' its specific function of touch that is distinct from its optical one. An interest in possible states of interactivity with a given material is closely tied to our ever-developing repertoire of tactile and physical experiences which determine the way we perceive.

The aspiration to set up this dialogue in term of the glass material demands a specific practice to be established and an appropriate glass technique to be chosen in order to make the diagram reveal. The methodology resorts to some chosen painterly processes, which are adapted to be translated into glass and further extended by the concept of 'the fold' proposed by Gilles Deleuze. According to

[6] op. cit. Deleuze: 2003, p.124

Deleuze there are two painterly definitions that can be distinguished: "(…) by line and colour, and by the trait and the colour-patch", where the first is visual and the second manual. In this respect, to match glassmaking with painting practice I focus on a direct contact with the glass material always looking for suitable practical solutions to find the glass material ductile and fitting perfectly in hands. While glass carving, I handle the glass material using both hands. While glass blowing, I keep handling and spinning the hot glass using a wet folded newspaper to protect my hands from burning. This is a challenging proceeding as explicitly indicated by Alison Britton when clay and glass, belonging to the same family of materials, were compared: "(…) you can touch it (clay) with your bare hands, it is malleable and versatile and prods into shape responsively. Not like molten glass, which must be remotely manipulated at the end of a meter of iron with a crucial sense of timing and choreography, or cast in premeditated moulds."[7]

Considering that art can elevate colours and lines to the state of language, Gilles Deleuze, notably in '*Francis Bacon: The Logic of Sensation*', proposed two concepts of "digital language" and "analogical language". According to the philosopher, "analogical language' may be attributed to the right hemisphere of the brain, or rather fits in the nervous system from where the diagram or motif emerges, whereas the code is digital.[8] Following Deleuzian thinking, what can be called 'digital' is a pictorial use of geometry in reference to 'the basic units of a code."[9] Thus, the term 'analogical' can evoke "obviousness" but also a certain "presence that makes itself felt immediately, whereas the digital needs to be learned."[10]

[7] A. Britton, Seeing Things. Collected Writings on Art, Craft and Design, Occasional Papers, London: 2013, p. 39
[8] The term digital can be understood as convention, which is pertaining to the fingers (in:) op. cit. Deleuze: 2003, p.124
[9] Ibidem, p.93
[10] op. cit. Deleuze: 2003, p.93

The major shift in pictorial thinking in the code of painting started with Paul Cézanne and his suggestion to use geometry analogically.[11] The analogical language in an abstract organic sculpture can be activated by resemblance, whereas a digital code manifests itself as "analogy by isomorphism, or analogy by produced resemblance".[12] Hence, only through resemblance, which is derived from a diagram and makes the elements of one thing pass directly into the elements of another thing, the object's 'presence' may be brought forth.

The analogical process in my practice includes a few successive stages of carving and polishing, that allows one to slowly get accustomed to the glass object and differentiate the subtle nuances in term of texture, colour and reflection, while handling it for hours. The process of making a sculpture ergonomic is of fundamental importance, because the aim is to achieve an object which fits perfectly in the human hands. Progressively, the glass object is adapted this way with respect for its centre, an axial point or an elastic point placed in the zone of *inflection,* which would then be detectable by touch and emphasised aesthetically. The latter is expressed by what can be called 'an eye'; for instance a system of lenses, concave and convex carved in layers of translucent colour or clear glass. These modules have two distinct functions: the first is a possible interaction with the exterior by the object's projection of new space in front of it, where the vanishing points converge, and by looking at the world through them with one of their chosen profiles; or the second is an access to the inner strata of the glass object by passing through its texture's surface (shallow space). Looking at this central zone, as if at some cross-section-stripe muscles, where the pattern records the speed of the glass flow cooling vertically according to the gravitational force, we may experience an impression of

[11] "treat nature through the cylinder, the sphere, the cone, putting the whole in perspective" (in:) Doran M., Conversations avec Cézanne, Macula, Pierre Brochet, Paris: 1978, p.178
[12] Ibidem, p.94

infinite distance between our eye and the end point. It is a variation of a kaleidoscopic view, but the idea is to make this centre point slightly out focus to let it be 'found' individually.

I compare Francis Bacon's achievement in painting with Anish Kapoor's sculptural research in looking for their personal diagrams. Colour is here the modulator, employed by both artists to manipulate space and to create, or rather to project, a new territory outside the artwork. In my practice I assemble the coloured glass pieces to have them dismantled afterwards, in a certain sense. The coloured glass object can become visibly 'fluid' in space suggesting the multiplicity of shapes formed by multi-coloured outlines, like transparent glass or water does when subjected to some particular lighting conditions.

Before, I considered only clear optical glasses with their physical properties, like flint glass, which is of higher refractive index and dispersion than common soda-lime glass, capable of demonstrating this particular fluid 'presence' of a glass object in space. One of the study's outcomes, which has a significant importance for the development of the way I perceive, is the conscious shift from clear to coloured glass as a comparable means for producing optical illusion effects. While working with coloured glass one may develop a new way of thinking about colour 'as a condition and not as a covering'[13].

For many years now, Kapoor has been exploring the idea of constructed space, often acquired without actually using hands, arguing that "to make new art you have to make new space".[14] According to his vision, the traditional space in a realistic painting (conforming with linear perspective) is what we can discover

[13] http://anishkapoor.com/1072/jewish-museum-and-tolerance-centre-2015-2016
[14] http://anishkapoor.com/1072/jewish-museum-and-tolerance-centre-2015-2016

'inside', beyond, behind its material frame. This virtual[15] space was obtained thanks to the use of linear perspective whose theoretical basis was redefined during the Renaissance. The main principal of one-point perspective is to make possible a depiction of an object, which produces the same image, in an eye, as the object when the eye is in the location from which the object was depicted. This polar projection makes all the receding edges of the depicted object converge on a vanishing point on the horizon directly opposite the eye, whereas the receding horizontal surfaces of diagonals converge on two distinctive points (diagonal vanishing points).

In contrast to the metric space of Euclidean geometry, visual space and tactical space are both anisotropic[16] and diverse. My investigations into the haptic eye, movement, depth, optics, illusion, colour and light end up at the point where the essential distinction between my visual perception and that of Ancient Egypt turns out to be the understanding of the very idea of space (*spatio*). Kapoor's '*Space as an object*'[17] manifests this in-between state of being in the process of becoming; a movement that makes things come to be.

[15] understood in a way that it relates to the points at which rays would meet if produced backwards
[16] *anisotropic* - having a physical property which has a different value when measured in different directions
[17] http://anishkapoor.com/773/space-as-an-object

## 1.1. Light and colour in glass. Chromatic concept of sculpting.

The major question concerning what and why in an artwork engages the viewers' attention may be answered by the study of vision, which reveals interconnections between all the senses and the body. To experience an object in a sensorial aspect is to perceive and identify it in a personal way, which cannot be compared with any other values (i.e. symbolic) that this object may represent to us. Glass may become an appropriate medium to challenge our visual perception by the use of optical illusions. Movement by the observer, or of the glass object, changes the projection of its outline, which becomes invisible in the case of transparent glass, and projects reflections to its inside and to the exterior. "Transparency is an extraordinary characteristic for a solid material to have, and in allowing light to pass through it, it exchanges one kind of mystery, that of hidden depths, for another, which is the ambiguity of near and far, and outside and inside surfaces, added to the uncertainty of whether one is confronting coloured light or a coloured substance. Such subtleties are enviable."[18]It also allows the mix of different colours together when glass is translucent, and offers a multitude of viewpoints to fulfil our intellectual expectations. Actually, there is a fundamental difference between what we see and what we perceive. When we gaze at details of a glass object then it may be required to move our eyes, head or to employ touch to 'verify' its texture, weight, temperature, and to hear the sound generated by it.

It is reasonable to hypothesize that vision dominates touch and even shapes it. Nevertheless, the sense of touch in some cases has a 'dominant' role. In 2007, Charles Spence conducted an experiment in order 'to assess the relative contributions of vision and touch to texture perception'. Spence and Quest

[18] op. cit. Britton: 2013, p.39

suggested that "touch can dominate over vision in the perception of very fine surface texture (i.e. determining the roughness of micro geometric surface features), presumably because by itself touch is better at this task than is vision"[19], which determines rather the spatial density of texture elements. Consequently, it was suggested that 'the human brain weights the most accurate sensory modality more heavily than the inputs from those modality estimates having more variance.' Thus, for instance, the 'visual brain' takes into account only a subset of the information available in an image when determining the transparency of a particular surface, leaving room for better-suited senses to complete the image. If we become aware of the discrepancy between our senses, then we are offered the choice of responding either on the basis of what we are seeing, or on the basis of what we are feeling.

Moving gradually from the hand to the haptic eye, it is worth noticing that "the initial stages of visual progressing focus on finding discontinuities in brightness, colour, and depth, a scientific discovery which led to the awarding of the 1981 Nobel Prize to Torsten Wiesel and David Hubel."[20] Hence, the visual system produces an image from simple stimulus into more complex representations. Most people directly observe objects of interest, as visual activity is best at the centre of the gaze (the fovea centralis[21]). This influences standardised choices of attitudes while in contact with an artwork, which are often dependent on cultural context. In my work these principal pictorial aspects: transparency, colour and depth, are the core issues for new investigations challenging the fundamental idea that linear perspective[22], re-invented during Renaissance, is truly an imitation of natural

[19] Ch. Spence, The Multisensory Perception of Touch, pp. 87-106, (in:) Art and the Senses, ed. F. Bacci, D. Melcher, Oxford University Press, Oxford: 2011, p.89

[20] D. Melcher, P. Cavanagh, Pictorial Cues in Art and in Visual Perception, (in:) op. cit. Bacci, Melcher: 2011, p.362

[21] *Fovea Centralis* (FC) is the optic papilla (OP), from which retinal vessels (RV) spread. (in:) Krstic R.V., Human Microscopic Anatomy: An Atlas for Students of Medicine and Biology, Springer Science & Business Media, Berlin: 2013

[22] "*perspective* (n.) late 14c., "science of optics," from Old French *perspective* and directly from Medieval Latin

perception. The recognised failure of linear perspective to capture 'perceptual depth' opens up new possibilities in the development of visual perception for a roving eye[23]. Looking at a glass object with this haptic eye means looking through it by ignoring its inside structure, or rather unfolding the projection from its two-dimensional to its three-dimensional aspect. This approach allows the glass material to be seen with always changing detail and colour. Even a dense coloured glass can reveal its internal colour realm when particularly illuminated and in motion.

The contrast of round versus sharp is one of the basic formal features, which when used as an artistic tool might tend to work cross-culturally. On this account, the idea of depth, whose primary definition is an outline, contour or a boundary line, may be considered as a key element to interpret my glass sculpture. This elementary means of expression relies on evoking emotional responses responsible for the processing of coarse visual information. Further, the latter plays the predominant role for the stimuli to reach conscious awareness. It seems that artists have at least two paths to visual recognition: the slow and detailed, or the coarse one; and I consider both worth combining. Beginning with the artists of the Palaeolithic era, one common attribute of depiction is the use of contours to define the outline of objects. "The similarity between identifying an object by seeing its drawn contours and feeling the contours with the eyes closed has been confirmed in several studies using

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*perspectiva ars* "science of optics," from fem. of *perspectivus* "of sight, optical" from Latin *perspectus* "clearly perceived," past participle of *perspicere* "inspect, look through, look closely at," from *per* "through" (from PIE root **per-* (1) "forward," hence "through") + *specere* "look at" (from PIE root **spek-* "to observe"). Sense of "art of drawing objects so as to give appearance of distance or depth" is first found 1590s, influenced by Italian *prospettiva*, an artists' term." (at:) https://www.etymonline.com/word/perspective

[23] D. Melcher, P. Cavanagh, Pictorial Cues in Art and in Visual Perception, (in:) op. cit. Bacci, Melcher: 2011, p.384 "A partial list of the terrible flaws in the retinal image that is passed to our brains includes:

1) the image is only registered at high resolution at the very small portion in the centre, with most of the peripheral vision mainly useful only for detecting movement and no details
2) there is a complete lack of uniformity in the presence of each type of cone (colour receptor) across the retina, with very few cones outside the centre
3) there is a big hole in the image at the 'blind spot' where the optic nerve leaves the eye."

neuroimaging."[24] In my glass sculptures the coloured liner patterns are organised in such a way that each distinctive line forms a proper contour for the object that is either inscribed within it, or on the contrary, misleads the eye suggesting an illusory shape. This procedure is rooted in the idea that the edges' identification is of significant importance for vision, serving to support understanding objects through touch. "As such, artworks can be viewed as scientific data: perhaps by studying the use of lines by artists, scientists may learn the explicit rules of this implicit, secret knowledge."[25] The second reason is to create a structure of visible and invisible lines, which draws the exterior into an apparently hidden point. The final cause of the fold, this Deleuzian point of *inclusion* makes the object be defined by its centre. "It can be stated that what is folded is only virtual and currently exists only in an envelope, in something that envelops it."[26]

The subject is enlarged in my research enquiry into the nature of light and colour, and in particular their singular material existence in the glass matrix. According to the wave theory of light, colour is nothing more than light of a certain wavelength, and what we see is the reflection of light off surfaces.[27] The human eye responds to a limited range of frequencies of electromagnetic radiation of about 700 nm (red) and 390 nm (violet), known as visual visible light or the visible spectrum.

Molecular solution is colourless - atoms make up only a fourth-thousandth part of the wavelength of light, so they are below the limits of the colour region. Not matter as such, but the size and shape, or perhaps the motion of the particles, must

[24] D. Melcher, P. Cavanagh, Pictorial Cues in Art and in Visual Perception, (in:) op. cit. Bacci, Melcher: 2011, p.361
[25] Ibidem, p.362
[26] "(…) inclusion or inherence is the final cause of the fold. (…) We are moving from inflection to inclusion in a subject, as if from the virtual to the real, inflection defining the fold, but inclusion defining the soul or the subject, that is, what envelops the fold, but inclusion defining the soul or the subject, that is, what envelops the fold, its final cause and its completed act." (in:) G. Deleuze, The Fold, Leibniz and the Baroque, A&C Black, London: 2006, p.24
[27] Light with its protons bounds off atoms of matter and in revenge the matter rejects colour 'absorbing' as much of light's electromagnetic radiation as 'needed' for its particular taint.

be the cause and carrier of colour. It reaches its greatest expression in the realm of colloidal division that alone decides the colour. Colour can be produced by analysis of sunlight, by means of a glass prism, by diffraction passing through a slit, or finally on bodies that absorb certain wavelengths while the rest is reflected. The light is focused by the lens of the eye, and, via special cells in the retina is translated into a pattern of neural firing that is then sent to the brain. The brain is endowed with a network where a flat (static) image proceeds to be perceived in a dynamic three-dimensional way. Hence, there is a basic distinction between the interpretation of visual perception as concerned with light, or with objects. "Across various cultures and even in some animals, there is a surprising tolerance to flatness and stasis in images: this relative insensitivity to the dramatic difference between a picture and the real world is one of the foundations of visual art."[28]

Glass transmits, reflects and refracts light. Particularly when in motion, my glass sculptures render the experience of the fleeting perception of colour and light. This pictorial effect can be predicted and emphasised by a particular glass's form. Contrarily, contours are associated with those 'permanent' aspects of objects, which do not change with the variations of light. My research challenges the ability of our visual system to perceive objects as similar across different viewpoints and lighting situations. This 'perceptual constancy', can result from *unfolding* and is set as a final 'goal' while visually experiencing a glass object.

[28] D. Melcher, P. Cavanagh, Pictorial Cues in Art and in Visual Perception, (in:) op. cit. Bacci, Melcher: 2011, p.360

*Figure 1 & 2*: Alliance, Izabela Dziepak, Glass, 2015, Royal College of Art

According to Julian Henderson, "colouration is a key characteristic of glass and may have been the primary reason for making it in the first place."[29] Glass absorbs part of the visible wavelengths of light, as a result of its interaction with colourant oxides in glass, allowing colour to be observed. In the aesthetics of late Antiquity, the idea of light is closely allied with that of colour. Colour would be defined then with adjectives describing its reflective proprieties, like gleaming or brilliant; its polychromatic character and its brightness. Liz James, whose research expertise includes Byzantine Art at the University of Sussex, claimed that one has to understand the symbolic nature of colour understanding at that time, as operating with reference not to hue, but to the brightness or darkness of colours.[30]

Like light, colour may dominate the form, take control of it. Colour speaks for itself and by its deliberate use in form, it changes its expressive value. Colour, like music, may be considered abstract, with its indefinable nature determined by light and influenced by the presence of other colours. It is exposed to constant changes and relegated to the emotional sphere. Colour scale, like a musical scale, can be associated with some order, which in its totality represents the idea of 'harmony' – a rainbow. The French thinker Édouard Guichard established his own rules of colour harmony, breaking it down to a 'graphic' alphabet in *'The Grammar of Colour*', published in Paris in 1882.[31] In his five volumes of 'colour grammar' he matched a few colours together on each plate, and by gazing at them one can distinguish respectively intermediary hues. This visual effect, and the importance of the time factor in colour perception, was highlighted by another French scientist - Michel Eugène Chevreuil who is the author of *'The Laws of Contrast of Colour'* from 1839. Analysing Gobelins tapestry, he noticed that the brighter edges seemed to appear

[29] op. cit. Henderson: 2013, p.65
[30] A brief excerpt of the content at : http://muse.jhu.edu/article/43645/pdf
L. James, Color and Meaning in Byzantium. Journal of Early Christian Studies, 11 (2). p.223-233, 2003
[31] E. Guichard, La Grammaire de la couleur, H. Cagnon, Paris: 1882

when adjacent ranges of strips of identical colours, but of different intensities, is observed.

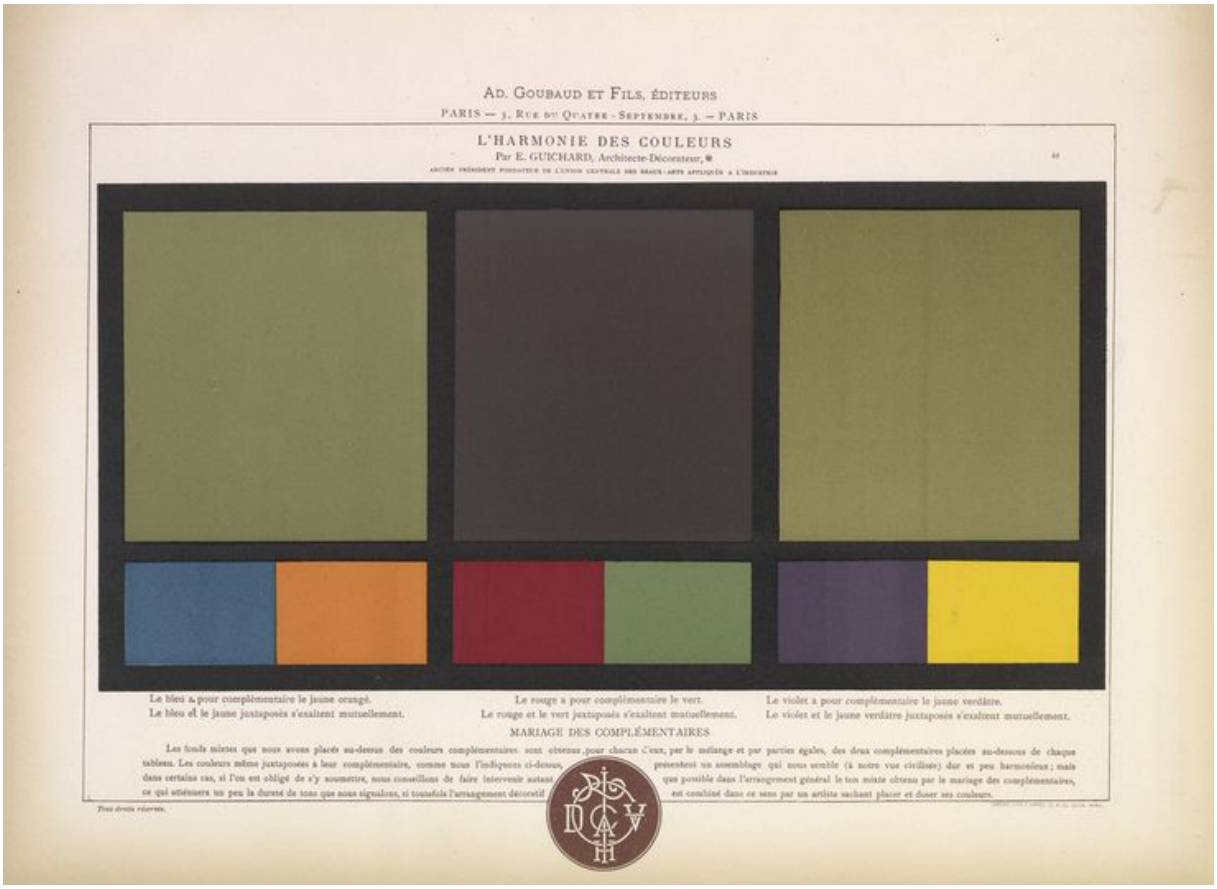



*Figure 3:* 'The Grammar of Colour' / 'L'Harmonie de la couleur', Édouard Guichard, about 1882[32]

In ancient Egypt colour was almost synonymous with the idea of substance: the words "jwn", "jnm" or "iwen" can be related to our word "colour" but also translated as "disposition", "character", "complexion" and "nature". This variety of thinking about the nature of colour confirms that it was perceived as being intimately linked to the essence of being.

[32] *Édouard Guichard*, architect and decorator, promoted the concept of colour harmony for the design of wallpaper, curtains, upholstery, and paint schemes in architecture and interior design.
(at:) https://archive.org/details/gri_c00033125010881106

Although transparency in glass was known by the Egyptians[33] it would not be until the wider use of stained glass that it became highly valued and popular. In the Early Middle Ages all matter was thought to incorporate light, while nowadays the preciousness of gems is identified with their transparency. This interest in the characteristics of transparency affected the presentation of gemstones themselves, as quite elaborate cutting and faceting started to be practiced on stones. For instance, in a treasure inventory of the jewels of St Albans compiled in the 13th century[34], the 'gems of gems' - the sapphire, might be shown as the opaque lapis lazuli. Powdered lapis lazuli, with a principal source in Afghanistan, might have been already in use as a pigment – ultramarine in ancient Egypt. Traditionally, the walls of Heavenly Jerusalem, which were symbolically represented by Christian ecclesial architecture, were built of sapphires in an oval form, emeralds (rectangular) and pearls. The same model was repeatable onto any object, which could be then considered as 'sacred', like i.e.: the Shrine of Charlemagne, destroyed in the Revolution. Again, in consequence, precious stones were considered to have healing and magical qualities by virtue of their divine associations.[35]

[33] Egyptian colourless / transparent glass (sirsu) is known from the Eighteenth Dynasty tomb of Tutankhamen. (in:) A. Lucas, J.R. Harris, Ancient Egyptian Materials and Industries, Courier Corporation, New York: 1962, p.219
[34] J. Gage, Colour and Culture. Practice and Meaning from Antiquity to Abstraction, Thames & Hudson, London: 2012, p.64
[35] Ibidem, p.70


*Figures 4 & 5:* (from left:) The ultramarine blue pigment of the garments came from the semi-precious stone – lapis lazuli.[36] The Wilton Diptych, c. 1395–99; English or French (?), Egg tempera on oak, National Gallery, London, Room 63
Cobalt blue colour in glass mingled with copper ruby red, Saint Chapel-Upper Chapel, Paris

[36] "Bis zur Entdeckung seiner künstlichen Herstellung 1826 ließ sich das Pigment ausschließlich durch Pulverisieren des Gesteins Lapislazuli gewinnen." (in:) Klaas J., Die „Ultramarinkrankheit", Studien zu Veränderungen in ultramarinhaltigen Farbschichten an Gemälden, Erlangung des akademischen Grades eines Doktors der Philosophie, Fakultät für Architektur, Technischen Universität München, Munich: 2010

## 2.1. Friedrich Egermann and his Lithyalin colouring technique.

Through this practice-based research, most of all, I intended to understand and control glass flow by looking at it from a wider point of view, which is determined by my theoretical research. I aimed to produce my own glass, which imitates minerals. The challenge was set for 'reconstructing' the intellectual context accounted for in ancient Egypt where highly sophisticated glass techniques were developed, i.e. mosaic glasses. The starting point was a comparison between minerals and glass including knowledge of the raw materials of glass during ancient times. The resemblance between glass and stones is related either to glass's aesthetic character, or in terms of its molecular structure when the vitreous material devitrifies becoming crystalline. I am interested in placing my research in a wider context of this glassmaking tradition by comparing it with a selection of examined historical glasses. In particular, I enquire into ancient Egyptian culture by referring to historical and contemporary literary sources, questioning Egyptologists, and afterwards creating my own connections. I examine my repertoire of gestures and the glass flow in order to control and combine both movements. Further, my next step was linked to the idea of handling objects – I try to assess if there is a kind of stimulus which makes an object *remarkable,* and how we may become reactive to certain formal and material qualities.

In the mid-second millennium B.C., a technological shift can be noted towards the deliberate production of translucent blocks of glass, control of the addition of colourants, and finally the creation of opaque glass either through the addition of crystalline materials, or the development of calcium antimonite crystals (out of solution) by heat treatment while annealing, which were all innovative processes.[37]

[37] D. Schwoerer, A Technical Supplement from Bullseye Glass Co., Compatibility of Glasses, COE Does Not Equal Compatibility, TechNotes 3, January 2013

The heat treatment of glass to produce opacity was possibly analogous to a similar procedure applied when annealing metals, although the visual outcomes are different. Reheating glass in order to get opaque colours might have also resulted from an evolution in the understanding of how glass behaves while melting at varying temperatures. Glass melt which cooled down too slowly results in crystalline silicates instead of glass, because the rate at which it cooled led to a crystal (solid) rather than an amorphous liquid-glass material formation. Finally, the creation of these crystals might contribute to the first name attributed to the vitreous material - 'stone of the kind that flows', which points to its similarity to minerals.

In ancient societies, the social and ritual significance of coloured glass was highly acclaimed. The efforts leading to its production can be regarded as a decisive driving force behind the high levels of innovation. Ancient opaque glasses are in fact what may be classified as '*glass ceramics*'[38]. When a glass melt is allowed to cool too slowly past the transition temperature, it produces what can be perceived as a kind of 'coloured stone', or coloured crystalline silica. Indeed, during the early stage of 'unsuccessful' glass production it was inevitable that silica-rich crystals, resulting from devitrification[39], would have appeared. Consequently, early glass could be referred to as a 'stone' because devitrification offered this visual analogy between minerals and true glass. Glasses are not particularly stable materials, and in the course of time they devitrify, become crystalline. Throughout history, artist-

https://www.bullseyeglass.com/methods-ideas/technotes-3-compatibility-of-glasses.html

[38] op.cit., Henderson: 2013, p.18

[39] "The growth of the primary particles through crystallisation is based on the fact that crystals below a certain critical size are thermodynamically unstable. Even if the dispersed crystals are only slightly soluble in the dispersing medium, one observes that the smaller crystals dissolve and the larger one grow in size. The rate of recrystallization depends on the diffusion coefficient of the substance which has to be transferred, and on the differences of solubilises of small and large crystals. The growth of the particles is governed, therefore, by the ordinary diffusion laws. Matter has to transported through the dispersing medium. This is another feature which distinguishes the striking process from the devitrification of a supercooled homogenous melt. In the latter there is no need for transportation, and the rate of crystal growth is influenced not by the diffusion of matter to the surface of the crystal, but by the speed with which the heat of crystallisation is dissipated." (in:) Weyl W.A., Coloured Glasses, Society of Glass Technology, Sheffield: 2016, p.75

technologists have devised ways of making glass look like a mineral. The most obvious strategy seems to have been the one applied in ancient Egypt, when to recreate the visual experience of the given material, as closely as possible, that same material was added to it as the medium.[40] Thus, my research focused on understanding the crystallisation of glass, and in practice consisted of using raw materials in such a way that crystals may be introduced within the glass matrix.

Accordingly, at the very dawn of my research project lay an aspiration to learn the process of making the inimitable marbled Lithyalin glasses of Friedrich Egermann and particularly, those which express a dichroic feature - the Lithyalin series of small goblets, manufactured by Egermann in 1830s, which have marbled dark glass whose surface is covered with lustres and / or yellow and red staining in such a way that the complementary colours alternate with each other revealing the similar dichroic effect noticed in the Lycurgus Cup.[41] This luxurious Late Roman vessel from the 4th century is called *diatretum* or *cage cup*[42] with reference to the cold working glass technique employed to carve it. Currently displayed in the British Museum in

[40] "Giotto used marble dust when depicting marble surfaces in the Cappella degli Scrovegni, presumably to try to convey qualities of the surface material that were difficult to replicate only with paint. Another example is the use of glass particles and gold highlights by Venetian artists. (…) For these artists, adding glass dust could give sparkle to patches of clothing, light, or water without compromising the saturation and hue of the colour. They were tackling the basic problem in painting of representing light without using a specific colour to indicate light."

[41] O. Drahotová, European Glass, Peerage Books, London: 1983, p.216
There were two identifiable types of the Egermann's Lithyalins: "After having been decorated with cutting, lithyalins with a base of opaque red marbled glass – either red hyalith or 'Italian red' glass – were marbled with lusters and staining on their entire surface. These types form the largest groups of lithyalins (…). Less frequently manufactured was glass 'overlaid with lithyalin'. In this case the base was a vessel of transparent glass overlaid with ruby red glass." (in:) J. Brožová, Bohemian Lithyalins and Friedrich Egermann, Journal of Glass Studies, Vol. 23, Corning Museum of Glass, New York: 1981, p.68

[42] *Cage cup* - « (Ancient Greek: Λυκουργος Ποτήρι ), also *diatretum*, plural *diatreta*, or "reticulated cup" is a type of luxury "vessel in which an outer layer has been carved away to leave an open network which is joined to the inner layers by fine glass struts." (in:) Ch. Bray, Dictionary of Glass Materials and Techniques, A & C Black, London: 2001, p.101
The openwork carved decoration or the outer shell of decoration stands out from the body of the cup while being attached to it by short stems, shanks or bridges. It contains a mythological frieze depicting the legend of King Lycurgus from the sixth book of Homer's Iliad. David Whitehouse has suggested that the change of colour from green to red symbolises the ripening of the grape, and that the cup, which had scenes on it that included the god Dionysus, god of wine. (in:) Whitehouse D. B., Roman Dichroic Glass: Two Contemporary Descriptions?, Journal of Glass Studies 31, Corning Museum of Glass, New York: 1989, p.119

London, it is identified by some scholars as dichroic, which means that it changes colour when exposed to the light passing through it.

The glass trader, technologist and inventor Friedrich Egermann (1777-1894) lived in Polevsko and later in Nový Bor/Haida, in Northern Bohemia, where the Bohemian art glass industry had been thriving for three hundred years by that time. In Bohemia and Austria in 1830-1840 two inventions prompted the popularity of *Steinglas* - glass imitating the opaque surface of stones: first Georg F. A. Longueval (1781-1851), count of Buquoy, invented in 1816 a dense opaque black and red glass. This marbled opaque glass called Hyalith glass[43] from the Greek *hyalos*, "glass", and lithos, "stone", was often decorated with gilding. The second invention was Lithyalin glass, whose name also comes from Greek *lithos*, developed by Egermann. Disguised as a knife whetter, young Egermann infiltrated a porcelain-painting studio in the Meissen factory and got to know about colour preparation, paint application and firing techniques. The technologist is also known for the introduction of painting on matte milk glass - agate glass, reviving the manufacture of yellow stains and decorating them with engraving.

Friedrich Egermann succeeded in making a red stain using a mixture of copper sulphide compound and ochre. Compared with the silver stain[44], known since the14th century - when it was particularly used to paint on stained glasses windows - the red etching of glass, or copper staining, is relatively new. The copper stain shows the formation of metallic copper by allowing copper ions to migrate into a glass surface and reducing them to this state. The technique of red etching is much more complicated than that of the yellow silver stain because it requires at least two,

[43] op. cit. Brožová: 1981, p.64
"Glass of the colour of red sealing wax with darker streaks was originally attributed to the well-known physicist and mathematician Ehrenfried Walther von Tschirnhausen, adviser to Böttger in his experiments in china production."
[44] *"Yellow staining* – a mixture of annealed ochre with silver sulphide, which forms a yellow layer on the surface of the glass after being fired in the furnace." (in:) op. cit. Drahotová: 1983, p.217

and in some cases three, separate firings.[45]


* *Figures 6 & 7*: (from left:) Friedrich Egermann or his workshop, Lithyalin glass beaker, 1830-1840, Bohemia, Novy Bor (Haida), blown, cut, marbled stains (Lithyalin), panel-cut glass with raised angular gilt bands, 'waisted' shape, Former Collection Workshop of Friedrich Egermann, Dimensions: Height: 9,1 cm, Diameter: 7,2 cm, Corning Museum of Glass, Corning, NY, US, N° 79.3.463 Friedrich Egermann or his workshop, Lithyalin glass beaker, 1830-1840, Bohemia, Novy Bor (Haida), free-blown and probably overlaid or flashed, gilded, Dimensions: Height: 10,5 cm, Diameter: 8,2 cm, Corning Museum of Glass, Corning, NY, US, N° 60.3.79

Another translucent glass and enamel colour in which copper is the colourant is '*copper ruby',* that Egermann also experimented with. This colour is due to submicron particles of copper, which cause light of a particular wavelength (530 nm) to be absorbed. Apart from ruby colour, 'struck' glass[46] when subjected to different temperatures can become crystallised, producing blue, ruby and purple-amethyst

[45] op. cit. Weyl: 2016, p.433

[46] "The phenomenon of striking, so far as it is caused by crystallisation, is usually treated in the same way as the devitrification of glass or the crystallisation of supercooled liquids. (…) The striking of glass, on the other hand, represents a crystallisation of a very dilute solution of a substance which on cooling became supersaturated in respect to this molecular species." (in:) Ibidem, p.355

colours. Since 1950, in the Czech Republic, continuous research has been carried out in connection with the Egermann's glass innovations, and the historian Gustav Pazaurek had been particularly effective in this field, publishing *'Gläser der Empire und Biedermeierzeit'* in 1932 in Leipzig.

*Figure 8:* The Lycurgus Cup[47], 4th century, probably made in Rome, displayed in the British Museum, London

According to Julian Henderson the coloration of the Lycurgus Cup is "due partly to the presence of 40 ppm of colloidal gold, and partly to 300 ppm of colloidal silver (…). The striking of gold-ruby glass is result of the crystal nuclei growing to colloidal dimensions. In reflected light, the particles of gold and silver are coarse enough to reflect light; in transmitted light, the particles scatter light wavelengths at the blue end of the spectrum more effectively than the red end, the result being that transmission occurs and the vessel appears a ruby-red colour."[48] The process of making the ruby-red glass involves significant expertise because "the main difficulty in developing coloured glasses on this basis is the reproducibility of such a system

[47]http://www.britishmuseum.org/research/collection_online/collection_object_details.aspx?objectId=61219&partId=1&searchText=lycurgus+cup&page=1

[48] op. cit., Henderson: 2013, p.76

and the interference of even the slightest inhomogeneity."[49] Glass's colour is normally associated with transmission and only rarely with scattered light. When held up to the light the glass undergoes a colour change as the intensity of the scattered light increases when the wavelength decreases. Consequently, this dichroic phenomenon gave rise to the idea that colour may be perceived integrally as a dimensional constituent of form and so requires the use of haptic vision, which was common to ancient Egyptian cognition.

The term *dichroic* or *dichroism*, which means literally 'two-coloured' in Greek, is used in at least two distinctive senses. In mineralogy, dichroic signifies that a crystal exhibits two or more colours in relation to "the direction of vibration of polarised light passing through the anisotropic crystal"[50]. Therefore, only if glass is partially de-vitrified can the crystals can produce this kind of dichroic effect, if not, the amorphous (isotropic) structure of glass cannot be described as dichroic in this sense.

The quest to replicate minerals in glass has resulted in the development of a few distinctive types of glass in late Renaissance Venice. The crystal clear glass of the soda-lime-silica sort was named '*cristallo*'[51] as it imitated rock crystal. Starting from the 16th century a Venetian glass vessel became one of the thinnest and lightest that could have been possibly made in this relatively fragile material. The virtuosity of the 16th and 17th century glass masters in Venice is remarkable because of the considerable revival and evolution of the glass techniques, like *vetro a filigrana* or

[49] "*The scattering of light* – scattering occurs whenever a beam of light is passed through a transparent medium containing in suspension small particles, the refractive index of which differs from that of the medium." (in:) op. cit. Weyl: 2016, p.369
[49] op. cit. Henderson: 2013, p.76
[50] op. cit. Weyl: 2016, p.222
[51] "(…) Angelo (Barovier) and another glassmaker, Nicolo Mozetto, were in February 1457 granted (…) a most favourable concession – to be allowed to use their furnaces for making '*cristallo*'" (in:) Tait H., Five Thousand Years of Glass, British Museum Publications, London: 1991, p.157

mainly in the 17th century *ice glass*.[52] It is significant for my own practice to notice that alongside the re-introduction of optical decoration (in form of ribbing), the tendency to employ dark colours in glass was clearly manifested. There are also two types of dichroic glasses that have been invented: the marbled Chalcedony glass resembling agate and displaying a colour change when in reflected light (yellows, greens, purples colours) or in transmitted light (orange-yellow hues) and *Girasole*, the opal glass resembling jasper.

Indeed, Venetian formulas preserved in the renaissance texts attest that the particles of colloidal silver were responsible for the glass's colouration. According to the detailed descriptions given by Johann von Löwenstern-Kunckel in his copy of Antonio Neri's '*Ars Vitraria*'[53], this glass, probably introduced with other metals, needed to be reheated for a few times in order to reveal the dichroic colour. Although the Lithyalins can manifest all the coloured marbled combinations, like grey-green, yellow-brown, red-blue-purple, blue-green and also red sealing-wax colours with sporadic darker veins,[54] their exact formula remains unpublished. I was free to remain inspired by these dichroic effects in the practical research of colour introduction into the glass matrix.

[52] op. cit. Drahotová: 1983, pp.35-36

[53] M. Verità, « Secrets and innovations of Venetian glass between the 15th and the 17th centuries: Raw materials, glass melting and artefacts (in:) Acts of the study days on Venetian glass about 1600, Arti dell' Istituto Veneto di Scienze, Lettere ed Arti 172, pp. 53-68, Venice: 2014, p.60
https://www.istitutoveneto.org/pdf/testi/vetro/2013_03_verita.pdf

[54] "A pattern book containing samples of his lithyalins appeared at auction sale in Dresden in 1921 (…)" (in:) op. cit. Brožová: 1981, p.65

## 2.1. Glass flow and the fold. Critical perspective on my series of glass sculptures.

*Figure 9*: Untitled, Izabela Dziepak, Coloured hot-formed glass, 2016, Royal College of Art

> "The digital seems to mark the maximum subordination of the hand to the eye: vision is internalized, and the hand is reduced to the finger; that is, it intervenes only in order to choose the units that correspond to pure visual forms. The more the hand is subordinated in this way, the more sight develops an "ideal" optical space, and tends to grasp its forms through an optical code. But this optical space, at least in its early stages, still presents manual referents (such as depth, contour, relief, and so on) *tactile* referents. This relaxed subordination of the hand to the eye, in turn, can give

> way to a veritable insubordination of the hand: the painting remains a visual reality, but what is imposed on sight is a space without form and a movement without rest, which the eye can barely follow and which dismantles the optical. We will call this revered relationship the *manual*. Finally, we will speak of the *haptic* whenever there is no longer a strict subordination in either direction, either a relaxed subordination or a visual connection, but when sight discovers in itself a specific function of touch that is uniquely its own, distinct from its optical function. One may say that painters paint with their eyes, but only insofar as they touch with their eyes. And no doubt this haptic function was able to reach its fullness, directly and immediately, in ancient forms whose secret we have lost (Egyptian art). But it can also be re-created in the "modern" eye, through violence and manual insubordination."[55]

Already in antiquity Aristotle already compared memory to seeing a picture, and St Augustine, also, understood vision as a paradigm for spiritual and intellectual contemplation. Aristotle was against the Atomists (Democritus) and Plato's definitions that light can be understood as a solid body (corpuscular emanation), and argued instead that light is reflected by an object and transmitted by a medium into the eye. Therefore colour and medium, by interacting with each other, make vision come about. It is interesting to realise that colours then were understood as layers of the objects' surfaces, which set the transparent medium in motion.[56] The link between the earthly and heavenly spheres, rhetorical and experiential at the time, were interpretations of the physical ocular experience and one's participation in art. My particular focus here is placed on the Egyptian way, which means

[55] op. cit. Deleuze: 2003, pp. 124-125
[56] D. C. Lindberg, Theories of Vision from Al-Kindi to Kepler, University of Chicago Press, London: 1976

according to Aloïs Riegl the use of haptic vision, in which painting might come to be seen as inseparably analogous to sculpture. Western painting tradition shifted its emphasis away from 'primitive' haptic vision and its spatiality to a tactile-optical space definitely beginning in the Renaissance. In ancient Egypt, the use of perspective is consciously avoided in favour of offering a visual experience within an existing and an actual space. The border between beholder and representation is erased to the point where an existing, actual space – avoiding, if possible, depicting space at all – seems to be one of the most subjective of all dimensions. Riegl thinks of the concept of 'haptisch' as close-up (or close-range) vision. He finds three major relations of the eye and touch in ancient art and haptic seeing is seeing like touching; without three-dimensional perception. The term 'haptisch', 'haptique', or 'haptic*'* (from Greek: *aptô* 'to touch', *haptós* "palpable", *haptikós* "suitable for touch"), as proposed by Gilles Deleuze, signifies a 'possibility of seeing ('regard' in French)' constituting therefore a type of vision distinct from the optical.

Vital knowledge about objects and their existence in space, as well as our sensations in relation to them and ourselves, is acquired by the senses. In '*The Primary World of the Senses'* Erwin Straus argued that perception is a secondary rational organization of a primary, non-rational dimension of sensation.[57] According to Vittorio Gallese[58], the brain is able to reconstruct actions *a posteriori* by merely observing the static graphic outcome. Key aspects of human social cognition are produced by neural exploitation, that is, by the expatiation of neural mechanisms originally evolved for sensory-motor integration. Hence, the development of hand cognition abilities can be associated with the evolution of the human brain.

[57] E. Straus, The Primary World of the Sense: A Vindication of Sensory Experience, Free Press Glencoe, New York: 1963
[58] op. cit. Bacci, Melcher: 2011, pp.455-63

The American sculptor - Malvina Hoffman (1887-1966) - reported the phenomenon of tactile acquisition of information during the carving of stone as responsible for an artist's stylistic choices.[59] What expert hands have learnt to discern is 'the needs of the material' and 'the resistance of stone'; it is this tactile learning that shapes the formal thinking of the sculptor. As a result of deliberately unconscious tactile interaction with the raw matter, while neglecting a visually suggested choice, sight may learn what should be the final appearance of the shapes obtained by satisfying the conditions posed by the sense of touch. This practice may seem evident not only for sculptors: "it is as if the hand assumed independence, and began to be guided by other forces, making marks that no longer depend on either our will or our sight. (…) This is the act of painting, or the turning point of the painting."[60] In this creative process image matters more than beauty, in contrast to a modelling activity where a subjectively imagined shape of form is imposed on the material. Constantin Brancusi, Barbara Hepworth and Henry Moore tried to establish a view of tactile aesthetics by following the concept of the 'integrity of materials' and of 'direct carving' where the object's ponderability and volume are as important as its visual appearance.

Considering the fact that the number of senses was already restricted to five by Aristotle, for theoretical rather than empirical reasons, the sense of touch and feeling remained a puzzle. Further efforts committed to searching for a sixth sense divided feeling into vestibular movement, muscle senses and multiple dimensions of cutaneous sensitivity. My research aimed to examine glass flow's movement in the different conditions of kiln casting, and to establish knowledge concerning the

[59] F. Bacci, Sculpture and Touch, Exhibition essay, Book Library Exhibition Space, The Courtauld Institute of Art, London: 31.10.2008 / 15.01.2009

[60] op. cit. Deleuze: 2003, p.71

applied mode of gestures while glass blowing. Both concepts are possible to picture through the practical research, though the idea of movement, as such, was approached through an analysis of the principles of linear perspective. It seems that the modes of gesture and position, taken in front of an art object, were at one point codified in Europe. These changes in the mode of perception are recognisable from the Gothic era, and significantly from the Renaissance, when the major reason for that can be sensed in the re-introduction of linear perspective, and consequently in the invention of the museum, as the term is understood today. Therefore, in order to discover one's capacity to perceive in a new way, I propose to encourage handling of my sculptures. To look at the object from different angles makes it a training of the extra-ocular muscles, which leads to increased awareness of a conscious appreciation.

A concave mirror has a focus conditioned by its curvature, which interacts with the given space by projecting the space of an object in front of the mirror. Therefore, I found it logical to interrogate this special effect produced by curvature, and that of inverse perspective of the icon, in order to understand if this potential can be translated into a carved glass object. Nevertheless, there is a problem in making it evident because the icon has a multiplicity of centres and of horizons. The term reverse, or reversed perspective, was proposed by Pawel Florensky, a philosopher and a polymath, who explained the use of *'poly-centredness'* in the icon's representations: "the composition is constructed as if the eye were looking at different parts of it, while changing its position."[61]

There is a particular time factor involved in perceiving an icon, due to the extended planes (diagonals) beyond the image with their vanishing points, which create an invisible construction that can be tracked like a constellation. This new invisible

[61] P. Florensky, Beyond Vision: Essays on the Perception of Art, Reaktion Books, Islington: 2006, p.204

reality is perceptible bodily, and the space of the object 'enters' in relation with one's personal space. It is possible to extract this phenomenon of the icon from orthodox theological dogma because "it is possible for sensory information to be processed through the perceptual system without being "perceived.""[62] One of the probable reasons behind this fact is that the creative process, which determines the use of analogical language or the haptic sense, is goal-oriented and makes this realm detectable.

At this point, it is worth considering what the fundamental impact of linear perspective is as a proposed viewpoint, not only in terms of art appreciation, but also self-orientation. I chose two distinct historical facts in order to reconsider the concept of space, and the perception of distance: the first was the re-invention of linear perspective in 15th century, and the second was stained glass windows realised by Abbot Suger (c. 1081 – 1151) in St Denis Abbey in Paris.

Abbot Suger was influenced by Dionysian Aesthetic principles, which proposed a new way of conceiving light and colour for an innovative decorative scheme designed for St Denis Abbey in Paris. Shifting from Ancient Egypt to the classical era in Europe, light has a far more important structural notion. Codified in the optical writings of the thirteen-century, a 'metaphysic of light' in relation to stained glass was considered to be an aspect of the divine. Since the first centuries of Christianity, sacred depictions were subject to dogma in fear of idolatry and in conjunction with the union of political power and the Church. One of the earliest traditions had developed glass mosaics to express a new concept of luminosity, which was called '*nova lux*' – a new light. The modulation of colour in Byzantine mosaic was achieved by introducing four pure tones: gold, red, blue, and green, and

[62] P. King, fmr UC Berkeley Redwood Center for Theoretical Neuroscience (at:) https://www.quora.com/What-is-perceptual-awareness-Is-awareness-without-perception-or-perception-without-awareness-possible

thus colourism and luminism were simultaneously invented. According to Deleuze "(…) Byzantine art reverses Greek art by giving such a degree of activity to the background that we no longer know where the background ends and the forms begin."[63]

The revaluation of the role of light, and consequently institutional and technological developments, resulted in the growing luminosity of late medieval glass. Abbot Suger's idea was to manifest the idea of '*nova lux*' though the stained-glass window. Accordingly, the most difficult glass to manufacture, with the pale yellow colour of silver-stain[64], was developed about 1300. Though transparency, in terms of changes in visual perception system, could not be introduced alone - on a purely physical level the light was also darkness – that 'incomprehensible and inaccessible light' in the Dionysian formulation.[65] There is the very nature of glass, which manifests one of the major cultural shifts by introducing new qualities for the perceptions to explore.

Nevertheless, the essence of this technique lies elsewhere. The 'macro' view, a natural view, should reflect the 'micro' internal glass structure, and the mode of achieving it is 'the fold'. This coherence allows for the coarse information to be taken into our perception to grasp depicted movement and colour first in its macro scale. If it corresponds with our visual preferences, if 'approved', it can be further inspected until the blur point is found in infinite space. This concept, which originated from before making, shares a belief in the correspondence of microcosm and macrocosm, in the harmonic structure of the universe, and in understanding it through the mathematical symbols of centre, circle and sphere. All these closely

[63] op. cit. Deleuze: 2003, p.103
[64] *Silver staining* - is a technique in traditional stained glass to produce the yellow, brown, or amber shading when painting on glass ; i.e. used for realistic hair colours.
[65] op. cit. Gage: 2012, p.75

related ideas had their roots in ancient Egypt, and also belonged to the tenets of medieval philosophy and theology. They finally acquired new meaning in the Renaissance. According to Riegl it was precisely Baroque art, with its limitation of material in space, that started to incorporate the position of the viewer and actively involve him or her in scenographic artistic space.

This is the idea of Baroque perspectivism[66], which follows what had been started during the Renaissance: there are many possible perspectives, as a truth of relativity (and not a relativity of what is true); or rather points of view, in which an evaluation of what is physically real, or true, can be made. This status of the object makes it exist only through its metamorphoses, or in the declension of its profiles. It calls for the relativity of clarity, as much as of movement, and operates in favour of an 'architecture of vision'. By the effacement of contour, the inseparability of clarity from obscurity is proclaimed in opposition to Descartes, who, according to Deleuze, remained a man of the Renaissance, from the double viewpoints of a physical theory of light and a logic of ideas.[67]

The purpose of colour is to dematerialise form and reconnect it with space. What is then the purpose of an uncoloured transparent material? When looking at my sculpture, one may apply haptic vision and its spatiality to look into the glass's structure while gazing at its texture's shallow depth. Its microstructure, which makes the coloured pattern in the glass, depicts the movement of glass's molecules registered in the sculptural form. In fact, the glass in the image you may see (please refer to the *Figures 11 & 12 & 13*), has the light brown to deep translucent carmine

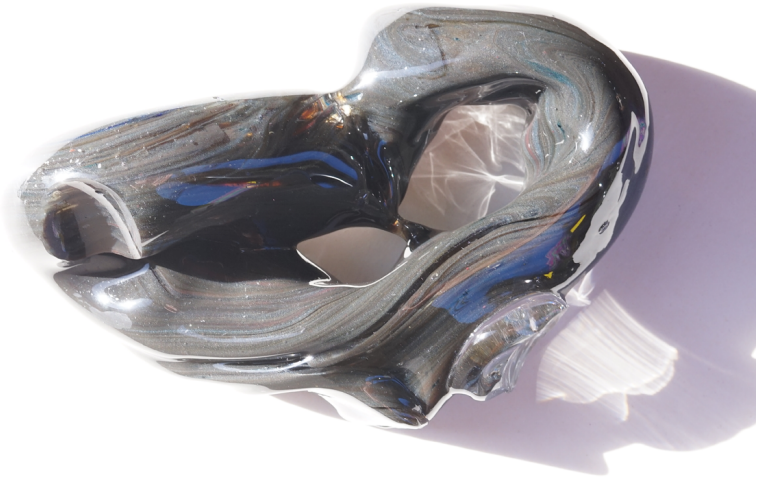
[66] "For Leibniz, for Nietzsche, for Wiliam and Henry James, and for Whitehead as well, perspectivism amounts to a relativism, but not the relativism we take for granted. It is not a variation of truth according to the subject, but the condition in which the truth of a variation appears to the subject. This is the very idea of Baroque perspective." (in:) op. cit. Deleuze: 2006, p.21

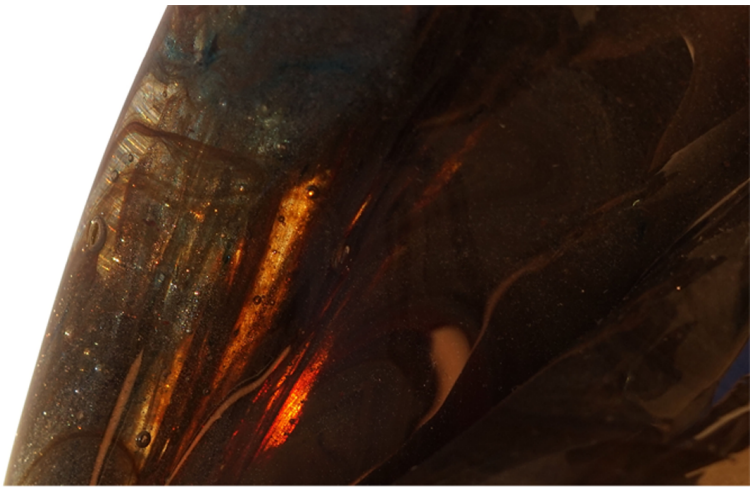
[67] Ibidem, p.36

colour when seen with light passing through it. With direct light on it, however, we may notice bands of oxidised copper oxide producing the blue colour, as well as the microbubbles. These are bubbles smaller than one millimetre in diameter, larger than one micrometer, which, with the nanobubbles, mirror colours surrounding them by reflecting them. This microstructure consists of small particles of metals, with mica and colour stains melted in it; the bands of previously melted glass coloured with metal oxides, like crocus martis, copper or cobalt with addition of rutile and lepidolite, and the bands of coloured glass made of clear Glasma glass and colour rods.

*Figure 10:* Friedrich Egermann or his workshop, Lithyalin glass beaker[68], 1830-1840, Polevsko (Blottendorf), Northern Bohemia

[68] http://www.andreewitch.at/verkauft.html





*Figures 11 & 12 & 13*: Untitled, Izabela Dziepak, Coloured hot-formed glass seen in daylight[69] with the sky reflected on its surface
Untitled, Izabela Dziepak, Glass pattern seen with the direct sun light[70] passing through, Detailed view, 2016, Royal College of Art

[69] *Daylight* - is the combination of all direct and indirect sunlight during the daytime.
[70] Direct sun light contains more yellow shade than the daylight

My series of translucent, patterned colour glass sculptures is the practical outcome of my research. The aspiration to place this research in the continuum of glassmakers' achievements in the context of artificial gemstone production resulted in the possibility of comparing it with semi-precious stones at the different levels. Attempts to recreate a similar quality to precious stones led me to invent some new solutions in term of glass techniques. Indeed, the most important aspect of my methodology is the choice of an appropriate process of making. Apart from a basic visual aspect, another comparison between precious stones and their glass imitations is the use of the same colouring ingredients – metal oxides. In some cases, through history, the implicit and explicit meanings, and symbolic value, attached to the precious stones were transmitted to their imitations made in glass. Therefore, the idea of resemblance was understood as a relationship between a mental image and its transition into a copy, whereas its original 'exists' elsewhere. Gilles Deleuze explained the concept that follows Leibniz's thinking:

> "Resemblance is equated with what resembles, not with what is resembled. That the perceived resembles matter means that matter is necessarily produced in conformity with this relation, and not that this relation conforms to a pre-existing model. Or rather, it is the relation of resemblance, it is the likeness that is itself a model, that makes matter be that which it resembles."[71]

The process of making, which is a key aspect of my methodology, is as important as the final outcome; a glass sculpture. I am inspired by, and I aim to interpret, the philosophic concept of 'the fold' proposed by Gilles Deleuze in 1993, and apply its principles in my art practice. This approach, following the French philosopher's

[71] op. cit. Deleuze: 2006, p.110

thinking, primarily demands an understanding of his conceptual starting point. This is here the idea of the monad theorised by Gottfried W. Leibniz in 1714. "He borrows this name (monad) from the Neoplatonists who used it to designate a state of One, a unity that envelops a multiplicity, this multiplicity developing the One in the manner of a 'series'"[72]. Leibniz, in order to undertake his fundamental examination of things, explained phenomena by the sole perceptions of monads claiming that there exists only what is perceived, interior to the monad, while the phenomenon is what is perceived.[73] Conscious perception and unconscious perceptions have no object and do not refer to any physical mechanism. In contradiction of René Descartes, Leibniz states that clarity emerges from obscurity and by way of a genetic process plunges back into darkness. A blooming of obscurity, to a certain degree, is conditioned by sensibility which may reveal it as such. Therefore, Gilles Deleuze, following the idea, makes clear his concept of the fold: "I am forever unfolding between two folds, and if to perceive means to unfold, then I am forever perceiving within the folds."[74] The first 'filter' would then be applied to ordinary perceptions, to extract from them whatever is 'remarkable' - clear and distinguished.

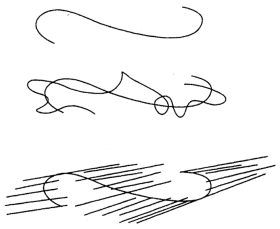


*Figure 14*: Paul Klee – '*Figures'* (1, 2 & 3)[75]

[72] op. cit. Deleuze: 2006, p.25
[73] Ibidem, p.108
[74] Ibidem, p.107
[75] "An active line on a walk, moving freely, without goal. A walk for a walk's sake. The mobility agent, is a point, shifting its position forward (Fig. 1): The same line, accompanied by complementary forms (Figs. 2 and 3)" (in:) P. Klee, Pedagogical Sketchbook (1953), trans. Moholy-Nagy S., Praeger Publishers, New York: 1972, p.16

Gilles Deleuze refers to Paul Klee's drawings that proposed variations in a linear composition, where the starting point is the fold. The sinusoidal shapes work according to optical laws, transforming inflection at a turning point, in an ogive or an arch. In my view, the theory of the fold proposed by Deleuze can clarify, on some visual level, how this gesture-movement can be recognised:

> "The unit of matter, the smallest element of the labyrinth, is the fold, not the point which is never a part, but a simple extremity of line. (…) Particles are 'turned into folds', that a 'contrary effort changes over and again'. Folds of winds, of waters, of fire and earth, and subterranean folds of veins of ore in a mine. In a system of complex interactions, the solid pleats of 'natural geography' refer to the effect first of fire, and then of waters and winds on the earth; and the veins of metal in mines resemble the curves of conical forms, sometimes ending in a circle or an ellipse, sometimes stretching into a hyperbola or a parabola. The model for the sciences of matter is 'origami', as the Japanese philosopher might say, or the art of folding paper."[76]

I focused on controlling my gestures while glass blowing by applying knowledge gained through my participation in drawing classes given by Dilip Sur at the Royal College of Art. The main principle there was to exclude vision in favour of hands, which are the proper means of expression on paper, whereas eyes were fixed uniquely on a model. This 'physical' training allowed me to later coordinate a bodily movement with the glass flow while blowing. The initial, 'simplified' gesture follows a pure sine wave by balancing liquid glass within a determinant of a circle

[76] op. cit. Deleuze: 2006, p.6

with its radius centred at the end of a blowing pipe. Paul Klee described it as a change of curvature from convex to concave at a particular point on a curve,[77] which is extracted as a genetic element of an active, spontaneous line (please refer to the image attached below). My glass blowing practice resulted in a series of glasses where the pattern can be seen through clear glass intersections. These sample glasses show a wide range of possibilities, which can be further translated while employing 'indirect', kiln casting technique.

This new approach allowed me to follow my particular eclectic methodology. This was based on qualitative criteria resulting in the proposed comparison between the concept of the fold, defined by Gilles Deleuze, and its spatial interpretation / existence dependent upon colour. These two form a certain kind of equilibrium that I wish to develop in a material form.

> "Everything is folded in its own manner, cord or rod, but also colours distributed according to the concavity and convexity of the luminous rays, sounds, all the more strident where 'the trembling parts are shorter and more taut'. Hence texture does not depend on the parts themselves, but on strata that determine its 'cohesion'.[78]

Colour may be effective on two distinctive levels: either through its tonality or through its value. The two scales of colour interweave with each other and when combined set up a powerful means of expression. I examined the way line emerges from homogenous colour in glass trapped with subtle internal variations that are conditioned by the relative proximity to other colours. In this regard, the coloured glass material seems to represent a particularly inspiring aspect linked to its

[77] P. Klee, Théorie de l'art moderne, trans. Gonthier P.-H., Collection Folio essais, (n° 322), Gallimard, Paris: 1998
[78] op. cit. Deleuze: 2006, p.41

translucency, which allows both scales and play to fully deploy, with their subtle interference in the field of shallow depth. The inquiry into the dichroic glasses was motivated by the wish to understand the material's nature, to master and to control the glass flow. I wondered what the relationship between the dichroic effect and molecular properties of glass might be. My eclectic methodology for investigating the subject included research into chosen modes of visual perception in European and Egyptian civilisations. It is probably no coincidence that glass material is relatively easily coloured in blue or green (by use of iron, copper or cobalt oxides) because when in its hot state it exhibits their complementary colours – red and orange. Following this thinking, the dichroic effect in glass not only reveals the physical nature of glass but also refers to its transparency, which is its distinctive state of matter.

Respectively, to explain the phenomenon, I found it useful to refer to the famous icon '*The Trinity*' of Andrei Rublev, where atmospheric perspective is applied along with the inverse perspective, that seems to be a summarized and synthesized view of several aspects of the represented object.[79] The result is that contradictory spatial effects are created and result in a particular feeling one may experience regarding the represented space. A viewer perceives simultaneously the space that is projected towards him, thanks to the principals of inverse perspective, while being 'placed' far away from the represented scene, due to the use of aerial perspective. Technically this end result was achieved by glaze technique ('glacis' in French), whose function is to modify the aspect of the underlying paint layer.[80]

[79] There are different terms describing the same phenomenon: reverse perspective, inverse perspective, inverted perspective, divergent perspective, Byzantine perspective.

[80] "A thin transparent or semi-transparent layer on a wall painting with the function of modifying the appearance of the underlying paint layer. (…) It consists of a great amount of binding medium in relation to a very small amount of pigment. It can extend the tonal range of a colour applied underneath. The transition of colours underneath a glaze can appear more subtle and colours may take on another nuance." (in:) Weyer A., Haake-Harig S., Hentschel B., Neubauer B., Corradett V., Schinken K., Thalguter N., Glos E., European Illustrated Glossary of Conservation Terms for Wall Paintings and Architectural Surfaces, Michael Imhof Verlag, Petersberg: 2015

In iconographic terms, these '*oziwki*' – bright patches of colour, as in Greek icons, make the colours located in the foreground seem to disappear[81]. In this case, Rublev's diagram included not only the traditional use of white, but also bluish broken tones, which are matched in terms of their complementary earthly colours like ochre and purple-brown, distinguished in the angels' robes. *Accordingly, the dichroic colours became transparent.* Egon Sendler, the expert on icons, claimed that Rublev's contemporaries were already fascinated by this effect; called at the time: '*dymon pisano*", which means 'transparent like a cloud'[82]. The icon writer explains that this pictorial matter with its shallow space is present in the western tradition of painting, and comparable with the '*sfumato*' technique developed by Leonardo da Vinci and called also '*Leonardo's smoke'*.

Already the art practice of Theophanes the Greek, the mentor of Rublev, consisted of drawing colours instead of applying them as opaque flat surfaces[83]. The master's broken tones produced the effect of transparency, which was a breakthrough discovery via a new visual perception. The latter was influenced by the cultural and historical background of the time, and determined by a new relationship between man and his natural environment. Consequently, the depictions of Theophanes the Greek represents a shift from polychromatic to colourist thinking (from relation of tonality to that of value). Although, through colourism the reality may seem to be abstract, its broken tones are taken from nature; from the objects' material aspect. Each colour relates to others and is at the same time being subordinated to a unified whole, thanks to the 'transitionary' function of colours.

[81] « *traits vifs* » (in:) E. Sendler, L'icône, image de l'ivisible, Eléments de théologie, esthétique et technique, Collection Christus, n°54, Desclée De Brouwer, Paris: 1981, p.166
[82] « Déjà les contemporains étaient fascinés par cet effet et l'appelaient *dymon pisano*, c'est-à-dire « transparent comme une nuée ». (in:) Ibidem, p.166
[83] Ibidem, p.154

The opposite theory of process, and the geometrical-optical illusions explained by the German physiologist Ewald Hering in the mid-19th century, provided some evidence concerning the perception of complementary colour,[84] which was certainly known by old masters and icon writers. If one keeps staring at a colour for more than thirty seconds, then the retinal image processes it into an opposite colour from the colour wheel.[85] In fact the same stimulus can produce different afterimages colours, which are uniquely in relation to the ensuing surface colour. Riccardo Manzotti further elucidates that "… the usage of an achromatic surface is tantamount to having all colour components, one will draw the wrong conclusion that the afterimage is not a perception – i.e., it seems that the mind can produce all colours while all colours are physically contained inside the grey, *ergo* white contains all colours."[86] The author of the publication entitled: "*Consciousness and Object: A mind-object identity physicalist theory"* argues that « if afterimages were created inside the visual system, the visual system would be able to create any colour, regardless of the ensuing background. On the contrary, all findings show that the surface constrains what one afterimages.

Although experimentation within relations of tone, corresponding to the dichroic phenomenon in glass, predominates in my practice, I also aspire to make objects that achieve a tactile-optical space by always looking for new colour solutions. Deleuze differentiated the relation of value, as based on "contrast of black and white, in which a tone is defined as either dark and light" and the relation of tonality as "the opposition of yellow and blue, or green and red, in which this or that pure tone is defined as warm or cool."[87] We can therefore differentiate the optical

[84] E. Hering, The Theory of Binocular Vision: (1868), Springer Science & Business Media, Berlin: 2012
[85] op. cit. Sendler: 1981, p.154
[86] R. Manzotti, Consciousness and Object: A Mind-object Identity Physicalist theory, John Benjamins Publishing Company, Amsterdam: 2017, p.166
[87] "And Cézanne often made the two systems coexist, the first through a local tone, shadow and light, shaped by

function of the eye, which is activated when relations of value predominate, with the haptic function that is present when "the planar character of the surface creates volumes only through the different colours that are arranged on it"[88]. The French philosopher argued that Turner, Monet, or Cézanne eliminated relations of value in favour of these of tonality whereas Van Gogh introduced the principles of colourism, the use of broken tones with their transparent quality, "which he derives from Delacroix rather than the Impressionists".[89] This proposal had already been suggested in "The Art of Colour" by Johannes Itten who also thought that "Delacroix, rather than Cézanne, is the founder of the tendency, among modern artists, to construct works upon logical, objective colour principles, so achieving a heightened degree of order and truth."[90]

To experience the dichroic effect from materials means to look for broken tones. "When the complementary colours are produced in equal strength, that is to say in the same degree of vividness and brightness, their juxtaposition will intensify them each to such a violent intensity that the human eye can hardly bear the sight of it"[91] said Van Gogh in his letter to his brother Theo. If painters substitute relations of value for relations of tonality, they can render the whole range of aspects (like time, light, shadow) uniquely through the use of colour itself. Deleuze thought that ""colourism" means not only that relations are established between colours (…), but that colour itself is discovered to be the variable relation, the differential relation, on which everything else depends".[92] There is therefore a need to define a possible analogy between the fold, colour and inverse perspective.

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chiaroscuro, the second through a sequence of tones in the order of the spectrum, a pure modulation of colour that tends to be self-sufficient." (in:) op. cit. Deleuze: 2003, p.106-7

[88] Ibidem, p.107

[89] Ibidem, p.112

[90] J. Itten, The Elements of Color: A Treatise on the Color System of Johannes Itten, based on his book - The Art of Color, ed. F. Birren, trans. (van) Hagen E., Van Nostrand Reinhold Co, New York: 1970, p.30

[91] V. Van Gogh, Letter 401, to Theo, (in:) Complete Letters, vol. 2, p.365 (in:) op. cit. Deleuze: 2003, p.165

[92] op. cit. Deleuze: 2003, p.112

My glass material in this case was inspired by Egermann's Lithyalin glass beakers from 1830s, which reveal the dichroic colour effects. In my practice, this concept is challenged by allowing the juxtaposition of complementary colours and clear glass sections or lines in the coloured glass layers to create optical illusions, which deform the visual image of a sculptural object suggesting its new shapes. This approach requires reconsideration of the place the object acquires in space, considering that all sculptural objects are parts of space within their material limitations, but also consist of it. Colour viewed as a dimensional essence, applied in a three-dimensional object, comes up with possibilities to extend strictly two-dimensional pictorial awareness into a more 'complex' visual perception.

In this regard, I refer to the visual theory called 'Unizm' in Polish, which was conceived by Katrzyna Kobro and Wladyslaw Strzeminski in 1930s under the influence of Constructivism. Katarzyna Kobro, born in Moscow in 1898, married to the Polish painter Wladyslaw Strzeminski in 1920, lived and worked in Łódź where she passed away in 1951. Katarzyna explained that sculpture is not an amalgam of forms enclosed into a material / mass[93]. The space inhabited by her sculptural object is uniform and infinite. This space is subject to a spatiotemporal rhythm created by forms co-existing within it. According to Kobro, there is a 'gap' in the history of European sculpture starting with the death of Bernini (1680) and ending up with the redefinition of space-object relationships in Minimal Art. The artist distinguished three types of sculpture starting from its oldest concept, which is a solid matter, with its inner space being considered by its author as the only space that exists.

[93] The same can be extracted from the Bacon's testimony: "And then I made these things, I gradually made them. So that I don't think the bird suggested the umbrella; it suddenly suggested this whole image"
(in:) op. cit. Deleuze: 2003, p.167

The second type is Baroque sculpture, which respects duality of a core, a reminiscence of the solid, and of a zone named by Kobro as the 'limiting border'. Consequently, Baroque sculpture with its formal dynamism aspires to get a direct bond with its exterior. The third type is a sculpture, which respects the equilibrium of space that is principally non-dynamic. Accordingly, as in nature, the 'organic law of sculpture'[94] allows it to become unified and inter-connected within space. The explicit Baroque themes find their new language in Minimal Art, which is "appropriately named following a law of extremum"[95], according to Deleuze. Kobro combined Futuristic and Cubistic visions to define how sculpture may be apprehended after the proto-forms of the cross and the circle introduced by the Suprematism of Kasimir Malevich. Because movement is the spatio-temporal phenomenon, Kobro argued that sculpture has a notion of movement inscribed in it and therefore it exists in space but it also happens in time. Thus, the issue is to exclude the solid core by reducing sculpture to its strict spatial divisions like plain surfaces.

Just a few years before Kobro's statement, in 1927, Erwin Panovsky has published one of his first art historical papers: "Perspective as Symbolic Form[96] ». The art historian explained how space might possibly have been apprehended in the past: "as various as antique theories of space were, none of them succeeded in defining space as a system of simple relationships between height, width and depth. In that case, in the guise of a "coordinate system", the difference between "front" and "back", "here" and "there", "body" and "non-body' would have resolved into the

[94] K. Kobro, W. Strzemiński, Kompozycja Przestrzeni: Obliczenia Rytmu Czasoprzestrzennego, Sztuka i Filozofia 13, pp. 88-99, Warsaw: 1997, p.11

[95] "The law of extremum of matter entails a maximum of matter for a minimum of expansion. Thus, matter tends to flow out of the frame (…)" (in:) G. Deleuze, The Fold, Leibniz and the Baroque, trans. T. Conley, The Athlone Press, London: 2006, p.160

[96] E. Panofsky, Perspective as Symbolic Form, trans. Christopher S. Wood, Zone Books, New York: 1991, p.43

higher and more abstract concept of three-dimensional extension, or even, as Arnold Geulinex puts it, the concept of a "corpus generaliter sumptum" ("body taken in a general sense"). Rather, the totality of the world always remained something radically discontinuous." This theory may be questione in view of the refusal of depicting space at all in Ancient Egypt; the consequence of this decision notable in posterior perceptual awareness, and thus the eventual representations of space existing within the influenced cultures. Moreover, the Kobro's concept of the spatio-temporal object-space continuity is overlapped by the idea of depicted / created space by / within material limitations of an object. Although I understood that it is possible to re-consider this concept practically, it remains a hypothesis from the theoretical point of view. It can be subjected to a philosophical concept, but it is challenging to have it proven, because to understand the differences in perceptual awareness within Ancient Egyptian civilisation and the European, demands an extended research.

The Renaissance period restored some ancient concepts - the reconciliation between a 'flat' space, a plane with its objective composition, and a 'deep' space with its subjective composition. Visually, we can imagine this shift as a mirror being turned over – painting becomes illusive in the way that its highly 'realistic' composition shows the artist's point of view, which often was more important than the story told. A mirror reflection creates the visible replica of the real world by 'extracting' from its material limitations to the exterior. "Indeed, the two periods during which there was the greatest interest in optical images and reflections are late Roman and Renaissance art, when mirrors, glass, and lenses are often included in painting."[97] Until the 15th century, art was rather object-oriented, manifesting the 'essence' rather than caring about the beholder. In this sense the term '*humanism*',

[97] D. Melcher, P. Cavanagh, Pictorial Cues in Art and in Visual Perception, (in:) op. cit. Bacci, Melcher: 2011, p.377

which placed man in the centre of main interests, clarified the visual aspects of our human condition.

As claimed by Gilles Deleuze, it was in *mannerism,* and particularly the work of Michelangelo, that "the Figure or the pictorial fact was born in its pure state, and which no longer needs any other justification (…)". Furthermore, the "fact" is inseparably combined of several forms, and if narrative and figurative elements are extracted from the image, it becomes a "matter of fact" or a properly pictorial (or sculptural) ligature, which no longer tells a story and no longer represents anything but its own movement, and which makes these apparently arbitrary elements coagulate in a single continuous flow.[98]

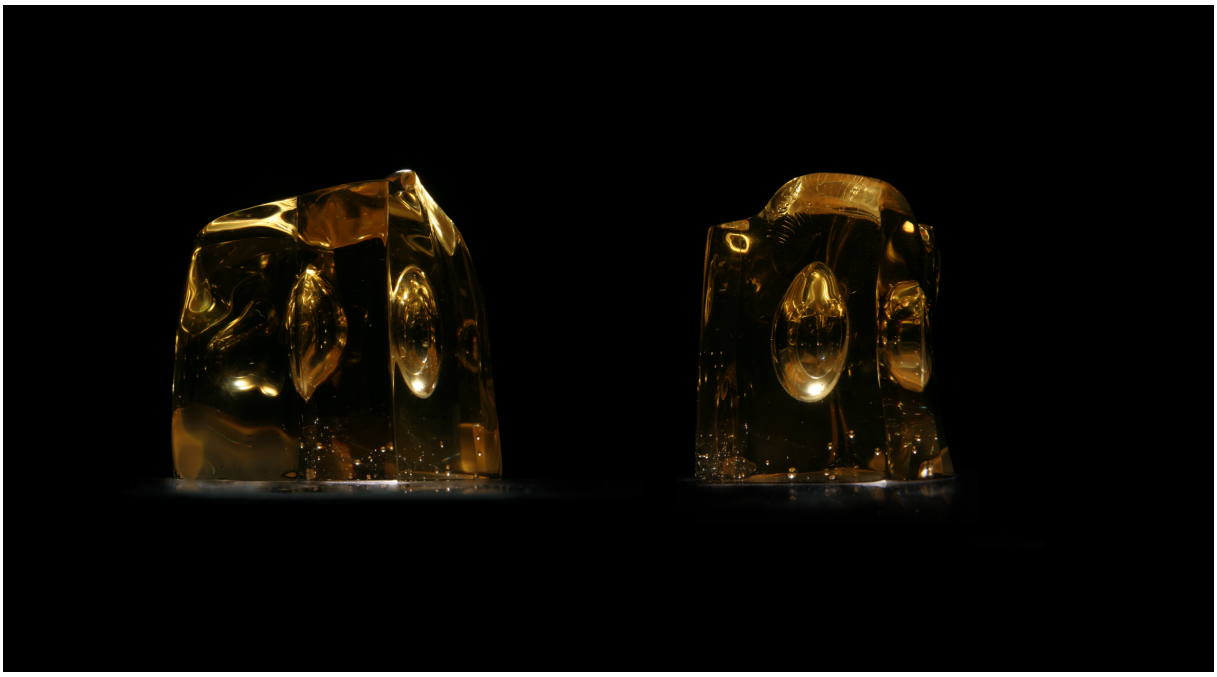
In my work the cross-section views are available to see due to the flat cut surface, which makes its assembly possible with a transparent, or eventually translucent, piece of glass. This usually smaller piece is cut to create a set of convex and concave lenses, which can reflect the cross-section's pattern and deforms the inside structure, or reflects it. It was confirmed in experiments that people cannot easily judge the size and angle of mirror reflections (we can try to check it by asking: how big is our reflection in a mirror?)[99]. Therefore, calculating if a surface can, in certain lighting conditions, reflect the desired image, makes the work physically 'disappear' in another way. The same transparent pieces can cut the object by existing only as a reflection of the surroundings.

[98] D. Melcher, P. Cavanagh, Pictorial Cues in Art and in Visual Perception, (in:) op. cit. Bacci, Melcher: 2011, p.128-9
[99] Ibidem, p.377

*Figures 15 & 16*: (from top) Florian, Izabela Dziepak, Glass, 2015, Royal College of Art

*Figure 17*: Beryl - Morganite, Elbaite, Spodumene-Kunzite, Albite, Quartz[100], Dara-i-Pech, province de Kunnar, Nuristan, Afghanistan

[100] http://www.galeriedemineralogieetgeologie.fr/fr/collections/specimens-phares/beryl-morganite-elbaite-spodumene-kunzite-albite-quartz



* *Figures 18 & 19 & 20* (from top and left): Ballade sur le Soleil, Izabela Dziepak, Glass, 2003, Eugeniusz Geppert Academy of Fine Arts in Wroclaw
The Trinity[101], Andrei Rublev, 1410-1427, Tempera, Dimensions: 150 cm × 100 cm, Galerie Tretiakov, Russia
Christ before Pontius Pilate, Follower of Hieronymus Bosch, c. 1520, Oil and tempera on oak panel, Dimensions: 80 cm x 104 cm or 31 in x 40 in, Princeton University Art Museum, Princeton, NJ, USA[102]

[101] op. cit. Sendler: 1987, p.181
[102] http://artmuseum.princeton.edu/collections/objects/34742

ANISH KAPOOR
Iris
1998

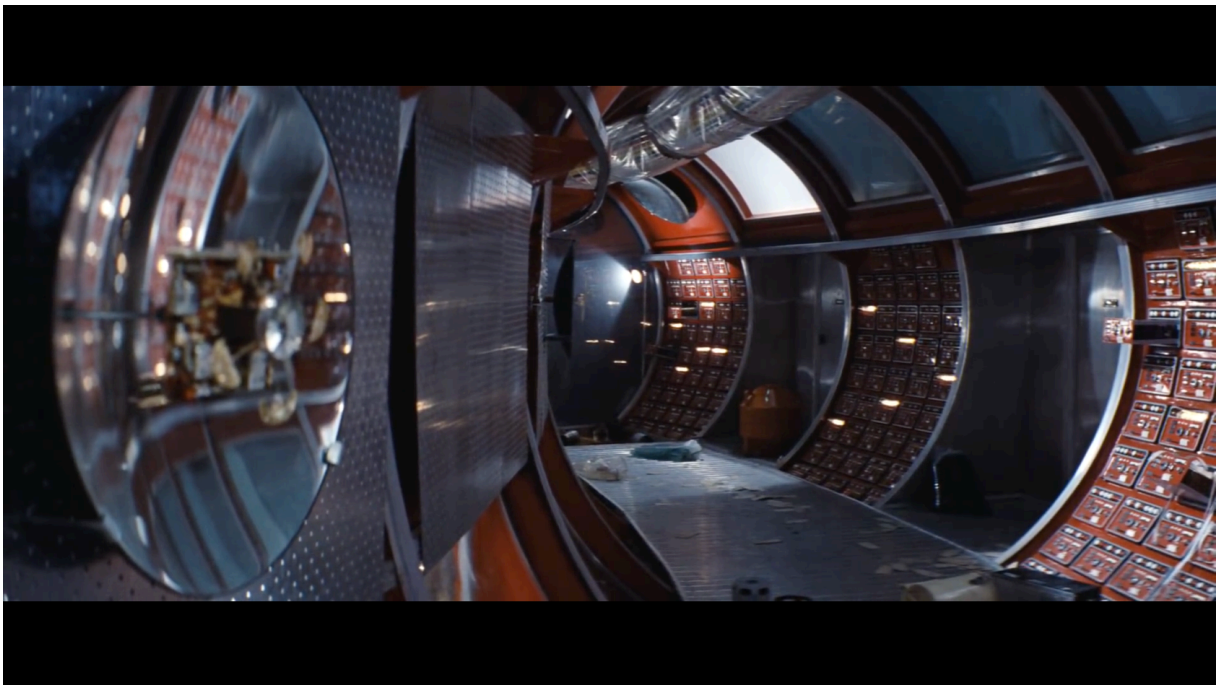
1 2

Stainless steel
200×200×200 cm

ANISH KAPOOR
Turning the World Inside Out
1995

Stainless steel
148×184×188cm

ANISH KAPOOR
Nuit Blanche 2016
Descension
1st October
The Seine, Paris



ANISH KAPOOR
Double Mirror
1998

FRANCIS BACON
SEATED FIGURE
1983


6
5

**Figures 21 & 22 & 23* (from top, p. 65): The concave and convex mirrors might have been used to project a 'new space': Iris[103], Anish Kapoor, 1998
Turning the World Inside Out[104], Anish Kapoor, 1995
Nuit Blanche[105], Anish Kapoor, 2016

* *Figures 24 & 25 & 26*: Solaris (Russian: Солярис, tr. *Solyaris)* based on Stanisław Lem'snovel of the same name published in 1961, science fiction film's snapshot, Andrei Tarovsky, 1972
Double Mirror[106], Anish Kapoor, 1998
Seated Figure, Francis Bacon, 1983, Etching and Aquatint, Dimensions: 101,5 cm × 71 cm or 40 in × 28 in, Edition of 99, Kunzt Gallery[107]

* *Figures 27 & 28 & 29* (from top, p.66): The dualism between internal and external form results from the fold – the form's dynamic stresses.
Hieronimus Bosch, Saint Christopher[108], 1490 - 1505, Oil on panel, loan: Stichting Museum Boijmans Van Beuningen, Rotterdam, Netherlands[109]
Drapery study[110], Raphael, c. 1511, Drawing on paper (verso of Phrygian Sibyl), Dimensions: 261 mm x 165 mm, British Museum
Johann Georg Pinsel, Saint Joachim,[111]Lviv, National Gallery of Fine Arts, Gilded limewood, Height: 49 cm

* *Figures 30 & 31 & 32*: Spatial Composition 4[112], Katarzyna Kobro, 1929, Painted steel, Dimensions: 40 cm x 64 cm x 40 cm, photo courtesy of Muzeum Sztuki in Łódź
Beaker[113], 1720-1730, Dresden, Gilded double-glass with engraved gold foil backed with oil colours, Victoria and Albert Museum, N° C.401-1936
Untitled, Izabela Dziepak, Hot-formed glass, detailed view of the marbled coloured pattern, Diameter: 5 cm, 2016, Royal College of Art

[103] http://anishkapoor.com/91/iris
[104] http://anishkapoor.com/95/turning-the-world-inside-out
[105] http://anishkapoor.com/4205/nuit-blanche-2016
[106] http://anishkapoor.com/606/double-mirror
[107] https://www.kunzt.gallery/?
[108] http://collectie.boijmans.nl/en/in-depth/hieronymus-bosch-the-devil-maker
[109]http://www.britishmuseum.org/research/collection_online/collection_object_details/collection_image_gallery.aspx?assetId=234913001&objectId=715554&partId=1#more-views
[110]http://www.britishmuseum.org/research/collection_online/collection_object_details/collection_image_gallery.aspx?assetId=234913001&objectId=715554&partId=1#more-views

[111] https://www.offi.fr/expositions-musees/musee-du-louvre-2615/johann-georg-pinsel-46968.html
https://www.louvre.fr/sites/default/files/medias/medias_fichiers/fichiers/pdf/louvre-pinsel_0.pdf, p.8
[112] http://culture.pl/en/gallery/selected-works-by-katarzyna-kobro-image-gallery
[113] http://collections.vam.ac.uk/item/O4669/beaker-unknown/

## 4.1. Glass in comparison to minerals.

"Because the universe being ruled is a perfect order, there must also exist an order in a representative, that is, in the soul's perceptions."[114]

My starting point, an intimate relationship to a chosen material, was the idea that it is possible to reproduce mineral strata in glass in an innovative way. My project involved a few different glass techniques and the ongoing research into the idea of movement, gesture and particularly into axial movement.

The circumstances leading to the discovery of glass are still uncertain, and its further application by ancient people gives reason to think that it was first considered as a sort of stone. Throughout history glass did not clearly comply with scholars' attempts to classify materials, though not only its aesthetics but also its symbolic meaning was linked to that of minerals. In this respect, to reproduce the strata of a mineral growth my emphasis has been equally placed between aesthetic and scientific ideas, which I consider inexplicitly as a combination of affiliated activities where arts and science are both intrinsic fields of study. Therefore, my methodology embraces different approaches and glass techniques in order to master glass's flow and thence to understand the very nature of this medium. The main point is to take control over the given material by observing, imagining and visually evaluating glass molecules in motion from macro to micro scale.

> "Macroperception is the product of differential relations that are established among microperceptions; it is thus an unconscious

[114] G. W. Leibniz, Monadologie, Chapter 63 (Parkinson, 189), (in:) op. cit. Deleuze: 2006, p.179
Further, Paul Klee claimed that "For the artist communication with nature remains the most essential condition. The artist is human; himself nature; part of nature within natural space." (in:) Pedagogical Sketchbook (1953), trans. S. Moholy-Nagy, Praeger Publishers, New York: 1972, p. 7

> psychic mechanism that engenders the perceived in consciousness. (…) Microperceptions or representatives of the world are these little folds that unravel in every direction, folds in folds, over folds, following folds (…). Tiny perceptions are as much the passage from one perception to another as they are components of each perception. (…) The point is one of knowing how we move from minute perceptions to conscious perceptions, or from molecular perceptions to molar perceptions. (…) In truth, Leibniz never fails to specify that the relation of the inconspicuous perceptions to conscious perceptions does not go from part to whole, but from the *ordinary* to what is *notable* or *remarkable*. (…) Contrary to Descartes, distinction in Leibniz's begins in darkness. (…) For clarity has to emerge out of darkness, as if through a first filter that would be followed by many other filters, for what is distinct, what is confused, and so on. (…) It is decisive in respect to other perceptions, and the first filter is obviously applied to *ordinary* perceptions in order to extract from them whatever is *remarkable* (clear and distinguished)."[115]

This theory of the fold determined my pursuit of technical investigation into the nature of chosen historical glasses and cultural contexts related to them. Since the very early stages, my focus was placed particularly placed on the Lithyalin series of goblets, manufactured by Friedrich Egermann.

[115] op. cit. Deleuze: 2006, p.98

*Figures 33 & 34:* Glosa Salomonis, Izabela Dziepak, Glass, 2015, Royal College of Art

The principal difference between crystals and glass is their molecular structure: symmetrical, ordered and homogenous aggregation of atoms, or amorphous in the case of vitreous materials. The intention to obtain crystallisation within the glass matrix was motivated to embrace the complexity of process of colour emergence in minerals. To understand crystallisation in glass means to fully master this material.

In crystals, that I wish to compare with glasses, the different coloured layers reflect nothing more than the course of growth, the happening of time. However, the perfect crystal cannot show a trace of its origin. It is colourless because visible light does not have sufficient energy to excite any of its valence-band electrons and be absorbed.[116] A perfect diamond must therefore be transparent which in reality means invisible. It is perceptible, like water is, because the light is refracted during passage. Nonetheless, the energy of light can excite an electron to make the energy transition in a similar way as a diamond manifests colour if some impurity, for instance of dispersed nitrogen atoms, creates an energy level, or state, for an electron between the two broad bands. Isolated nitrogen atoms provoke the absorption of violet, blue, and green, resulting in visible yellow, orange and red tints. In a vitreous material, the wavelengths of light are transmitted by transparent and by translucent glasses, whereas the inclusions in opaque glass have the opposite effect where the presence of crystals allows the wavelengths of light to be reflected from the glass. Due to partially reacted silica crystals and gas bubbles, complete or partial opacification can be produced after the glass's manufacture. Opacity may result from heat-treating (called 'striking' effect) or by the deliberate addition of materials called opacifiers to the glass. A semi-opaque, opalescent colour in glass signifies that glass's molecular structure is made of nano-crystals (e.g. in ruby glass).

[116] G. E. Harlow, The Nature of Diamonds, American Museum of Natural History, CUP, Cambridge: 1998, p.29

Although the amorphous state of a vitreous substance is not homogenously ordered there is no chaos present within its structure. Due to that, it can be examined by a proper analytical method either in the field of science, art or philosophy.

This research started with the focal point of the appearance of colour in minerals, in comparison with colour produced in glass. It is based on a series of practical tests combined with focused studies and case studies in opaque coloured glass from the earliest historical periods to the 19th century neo-styles.

In ancient Egypt, the 'essential' can be seen directly rooted in nature and more specifically in the East desert, associated with the black colour km (kmt) that might signify the resurrected body of Osiris. Before even establishing the kingdom in the Nile Delta, the Eastern desert was prized for its mineral richness resulting from tectonic movements, which originated in the upheaval of its steep mountains. On the contrary, the Western desert - Libyan - comprised of a vast plain of sand, was known to be overtly hostile except for some few fertile oases. In ancient Egyptian collective mentality, the desert could act as a kind of divine mediator between humanity and divinity.

A powerful theorem was built up by acknowledging that the land where the sun rises - the East, was the birthplace of gods and goddesses. Amoun-Rê was important from the Egyptian gods' pleiad and his emblem was the sun itself. Therefore, metal ores and precious minerals, which were mined in the Sinai Peninsula, were believed to possess true potential as an intermediary between divinity and humanity, being considered as a sort of divine bodily part. Their material aspect emanated not only from the venerated god's realm but moreover, they were allowed to draw their wonderful capabilities from it. Gods were light

itself and as the economy was sustained by religion, the population had to follow the ruler in this faith. The relationship between humans and this hostile environment is a subject rooted in this peculiar perception of the human-nature relation. The monuments and, most of all, the desert temples were set up to serve the perpetual destinies of rulers, and therefore to maintain religious order ensuring that mining works result in desired outcomes under 'uninterrupted' sunlight. The cosmological space was subject to strict rules of decorum that depicted human interaction with deities, highlighting the role of the king who was the sole hierarchically valid human protagonist. Furthermore, he delegated the practical performance of the cult to priests who were given the privilege of manipulating metals and minerals. The most important desert temple was in Dendara and was devoted to Hathor-Quadrifrons, which is at once a holy cow, lioness, uraeus, a woman and an opaque turquoise colour.[117]

An Egyptian tradition, handed down for generations, tells us that four prophets were in charge of delivering precious stones as offerings, which were intended to ensure a high level of human health, protection, and eventually a swift change of destiny thanks to planets and stars that governed them. The first prophet was responsible for gold and silver, the second for lapis lazuli, the third for turquoise and finally the fourth one for faïence.[118] Usually these venerated stones were left in their raw state and in order to give them a shiny finish they could be covered with a layer of natural varnish, from animal glue or plant gums.

[117] S. H. Aufrère, Les Trésors dans les Temples Egyptiens, (in:) Caubet A., Cornaline et pierres précieuses: la Méditerranée, de l'Antiquité à l'Islam : actes du colloque organisé au Musée du Louvre par le Service culturel les 24 et 25 novembre 1995, Musée du Louvre, Documentation Française, Paris: 1999, pp.271-283

[118] S. H. Aufrère, L'Univers minéral dans la pensée égyptienne: essai de synthèse et perspectives, (in:) Archéo-Nil, n° 7, October 1997, p.132

Glazed steatite,[119] or soapstone, was produced before the first faïence. Unlike true faïence, (tin-glazed earthenware), it was a ware made from glazed quartz frit. There were five different combinations of applying a glaze layer on a silica core, from an alkaline glaze on powdered quartz to a glaze on high silicon burnt clay ware. Glaze was combined with the quartz of the body to overcome the fragility of ordinary faïence, making it more receptive to enamel. The fact that, in many found samples from that time, faïence compositions turned completely vitreous when they were overfired,[120] may suggest that the existence of glass, as a distinct medium, was determined by its production in ancient Egypt. Therefore, the manufacture of glass represents a significant development in terms of material transformations beyond the manufacture of vitreous components in faïence. This cultural context was far from modern stereotypes where artists can be driven by ideas of originality.

Indeed, early glass could have been perceived as a man-made form of rock making it comparable with semi-precious stones and with colour as its main feature. Plant ash and silica (in ratio 2:1 by weight) were established as the two basic raw ingredients in the production of vitreous slags[121]. This early glass was certainly intended to imitate precious stones and was seen to have apotropaic properties. Even if produced by accident at an early stage, it is known that the Assyrians and the Egyptians combined glass production with religious functions reserved for priests, and attributed to it a ritual significance to them. Thus, the forms and colours of vessels and beads made of glass were a reflection of the period in which

[119] *Steatite* - is mainly composed of talc with minor amounts of other minerals, such as chloride; it is a hydrated magnesium silicate.
[120] J. D. Cooney, Glass Sculpture in Ancient Egypt, Journal of Glass Studies, II, 1960, p.11

[121] *Slag* - is the glass-like by-product left over after a desired metal has been separated (i.e., smelted) from its raw ore. Slag is usually a mixture of metal oxides and silicon dioxide. However, slags can contain metal sulfides and elemental metals.

they were made.

The development of opaque glass production to imitate semi-precious stones was accompanied by a range of other pioneering innovations. These included the production of the first core-formed vessels, the first mosaic glass vessels using sections of opaque glass assembled in a mould, and the first mass production of core-formed vessels. By the fourteenth century in Egypt, larger kilns and their associated structures were introduced to maintain a consistent temperature of 1100°C.[122] To do this it was necessary to acquire considerable knowledge of a range of fuel types and their calorific values. The changing colour of molten glass not only provided ways of assessing the stage that the chemical reactions had been reached, but also a variety of characteristic smells produced while burning fuels. Observed colour changes in the glass batch are also described in medieval texts (e.g. Theophilus Presbiter). Furthermore, there were rituals associated with the use of specific raw materials at particular times of year.

A turning point for the development of glass techniques came in the 1st century B.C. and is linked with the invention of blowpipes. This discovery has influenced manual glass production to this day, as it enabled larger-capacity vessels to be made. In Bronze Age Mesopotamia, Mycenaean Greece and in parts of Europe, one of the most common early glasses is again the oxidised form of copper, which is turquoise green colour. Another colour delivered by the copper ore, which has been mentioned before, is 'Sang de boeuf', the blood-red colour, which was produced from the presence of reduced copper in metal smelting.

[122] op. cit. Henderson: 2013, p.20

Consequently, the provenance of glass has central importance for its colour scheme. While studying at the Bezalel Academy of Art and Design in Jerusalem in 2007, I decided to examine the desert environment, which constitutes today the major territory of the Middle East. I was hosted mostly by semi-nomadic Bedouin tribes in Israel, Jordan and in the Sinai Peninsula, in Egypt. My aim was to travel with my sculptures and show them to people, asking if I may document their first reactions by recording a video or by sketching. At the same time, I made photographic documentation of the geological formation of mountains, and I collected samples of some chosen minerals, sand and certain plants. Today, I use raw materials for the colouration of my glass, which I find locally in France: ochres rich in iron oxides and powdered rocks containing mineral ores (like copper).

*Figures 35 & 36 & 37 & 38 & 39 & 40*: Deposit of mineral-earth type pigments (ochres) containing naturally occurring metallic oxides with a predominance of iron oxides[123], Rustrel, France

[123] "Argiles naturelles de couleur variable, plus ou moins riches en oxyde de fer et contenant du quartz (silice). Couleurs des oxydes de fer: Hématite (rouge) et Goethite (jaune), parfois la limonite pour les brunes. Les terres peuvent contenir aussi du Manganèse ou du Cuivre (également magnétite...). Le pigment est un ensemble de particules contenues dans le sable ocreux."
(at:) http://www.or-pigments.com/couleurs_mineraux_les_terres.html

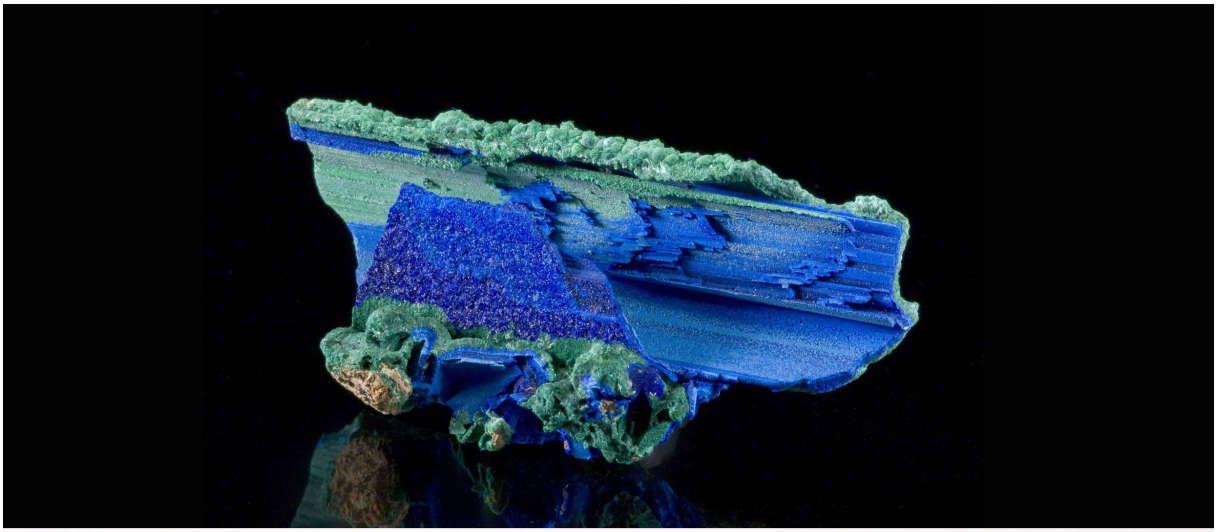
## 4.1. Ancient Egyptian glasses.

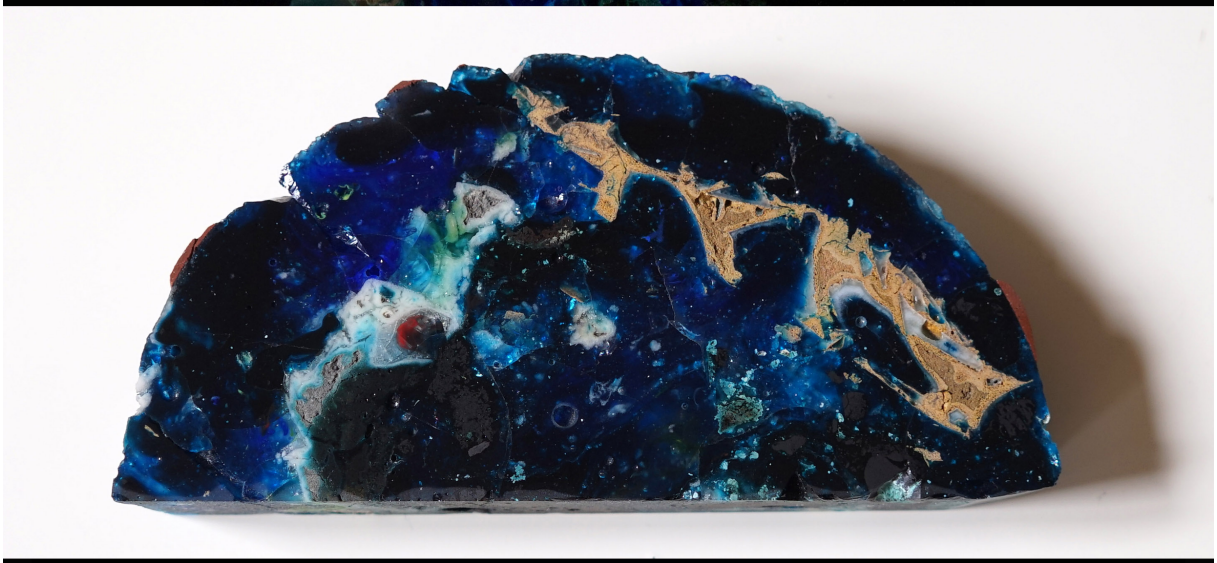
> "Bacon first of all seems to be an Egyptian. This is his first stopping point. A painting by Bacon first of all has an Egyptian look to it: the form and the ground, connected to each other by the contour, lie on a single plane of a close, haptic vision."[124]

*Figures 41 & 42* (from left:) Tomb-relief, fragment bearing a royal head in sunk relief, limestone, excavated in 1889 in Kom Abu Billo, Egypt,[125] Bristish Museum, London, N° EA650
Francis Bacon, Seated Figure[126], Oil paint on canvas, 1961, Tate Collection, London

*Figures 43 & 44 & 45* (from top, p. 76): Azurite and malachite pseudomorphed after selenite, Apex Mine, Jarvis Peak, Beaver Dam Mts, Washington Co., Utah, USA
Glass sample coloured with oxides and ochres, Izabela Dziepak, 2016, Royal College of Art
Egyptian glass face inlay of Akhenaten or Nefertiti (as the personification of Hathor)[127], New Kingdom, Amarna Period, Dynasty XVIII, c. 1353-1336 B.C., Height: 4,2 cm

[124] op. cit. Deleuze: 2003, p.94
[125]http://www.britishmuseum.org/research/collection_online/collection_object_details.aspx?objectId=121087&partId=1&searchText=relief+egypt&page=2
[126] http://www.tate.org.uk/art/artworks/bacon-seated-figure-t00459
[127] Exhibition catalogue, Köstlichkeiten aus Kairo!, Antikensmuseum Basel und Sammlung Ludwig und Museum August Kestner Hannover, 2008, p.107, no. 54b.
(at:) http://www.alaintruong.com/archives/2012/04/11/23983743.html





An important aspect in this research is to outline the transmission of glass-making tradition, and to highlight deliberate aesthetic preferences for devitrified[128] glass through glass-making history. In this respect, I refer to the extended linguistic and historical research of Dibombari Mbock who is the author of a number of scientific publications in the field of Egyptology; whereas the technological frame of glass references is '*Ancient Glass: An Interdisciplinary Exploration'* by Julian Henderson. The author is the Chair of Archaeological Science in the Department of Archaeology at the University of Nottingham and his interdisciplinary exploration of historical glass combines the study of its technological, historical, geographical, chemical and cultural aspects. These literature references were the basis for my material tests in glass completed at the Royal College of Art. Third contribution is '*Colour and Culture. Practice and Meaning from Antiquity to Abstraction'* by John Gage and particularly chapter four '*A Dionysian Aesthetic,*' where the art historian explains circumstances leading to transfer from the Early Christian tradition according to which a mosaic meant to embody the notion of divine luminosity, to the incipient Gothic of St-Denis where a stained glass window replaced it.

Each case study, undertaken to clearly demonstrate the research issue - in ancient Egypt, in Bohemia of the Baroque, and the Biedermeier period of the early 19th century influenced by the ideas of Romanticism – has been selected to incorporate contrasting symbolic, aesthetic or commercial attempts to attain glass quality similar to that of precious stones. Therefore, the focus is on glass-making traditions conditioned by the contrasting characteristics of societies, which influenced the way in which this vitreous material was considered, manufactured and used. The production, use and trade of ancient materials determined a complex link of interconnections. At the root of certain ideologies characteristic of specific societies, a range of facilities was established for an impressive scale of production.

[128] *Devitrify* (with reference to glass or vitreous rock) - become or make hard, opaque, and crystalline.

This control over production reflected complexity at the time, because the various phases of work demanded considerable development of well-organised structures in the form of an 'integrated operational chain' leading to the manufacture of glass artefacts characteristic of that society. Thus, most of the time, glass compositions are not homogenous, but vary with time and location of production.

Glass is among the most important discoveries of humankind and appeared due to the understanding of transformation processes experienced through lapidary carving of precious stones, metalworking, and most of all through contact with clay in ceramics. It was the latest of the three main technologies to appear before 3000 B.C. in Egypt – pottery, metal and glass. Glass was used early on as a vitreous component, and so there is some doubt about a probable shift in the development of ancient technology existed, that made glass a distinct material. According to Julian Henderson, access to ceramic materials or stone for constructing furnaces creates a link between the technologies.[129] Moreover, the same raw material - silica and plant ash - were used to make both faience and glass, so essentially the two technologies were related. The starting point for any reflection concerning the ancient world is the study of the movement and provenance of people and objects. This procedure sets out the basis of evidence for any further interpretations of a wide range of cultural and existential particularities. One of the crucial strands is the occurrence of trade in objects, which is determined by tracking down peoples' migrations and diasporas. This movement of objects through time and space allows us to perceive how value is acquired and expressed through exchange.

Apart from Libyan Desert glass (LDG or Great Sand Sea glass), which has been dated as having appeared about 26 million years ago, the first manufactured glass

[129] op. cit. Henderson: 2013, p.13

appeared c. 2500 B.C. in modern-day northern Syria and Iraq.[130] Although, in the latter half of the 2nd millennium BC, the Mesopotamians were already creating the first small glass vessels, it was the Egyptians who became the real glass masters of the ancient world. It is striking that in the eastern Sahara fragments of the desert glass LDG can be found over areas of tens of square kilometres. Its origin is still discussed by scholars, who include different explications such as meteoritic origins, impact features such as zircon-breakdown, vaporized quartz and meteoritic metals or an impact crater. It is a probable that the glass was created due to radioactive melting from meteoric large aerial bursts, making it similar to trinitite, also known as atomsite or Alamogordo glass, made from sand exposed to the thermal radiation of a nuclear explosion.[131]

According to some theory, the Pre-Dynastic era, before 3000 B.C. is seen as the beginning of glass production in Egypt, that was related and established after the invention of glaze, and mastered during the reign of the 18th Egyptian Dynasty, ca. 1500 B.C..[132] For Egyptians glass was 'iner en wedeh' or 'aat wedhet' - 'stone of the kind that flows'.[133] Specialist analyses agree with the suggestion that Egyptian soda glass was made from impure materials, and its composition resembles a mix of

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130 op. cit. Henderson: 2013, p.8

131 "Evidence for deposition of 10 million tonnes of impact spherules across four continents 12,800 years ago." (at:) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3677428/
C. S. Ross, Optical Properties of Glass from Alamogordo, New Mexico, U.S. Geological Survey, Washington, D.C.: « Trinitite, also known as atomsite or Alamogordo glass, is the glassy residue left on the desert after the plutonium-based Trinity nuclear bomb test on July 16, 1945, near Alamogordo, New Mexico. The explosion of the atomic bomb at Alamogordo, New Mexico, fused the immediate surface of the arkosic sands of the area. This produced two distinct types of glass, one derived from the feldspar clay fraction of the sands, and the other direct fusion of the quartz to silica glass. It is usually a light green, although color can vary."
(at:) http://www.minsocam.org/ammin/AM33/AM33_360.pdf
M. Williams : « The typical green color of trinitite is caused by iron impurities, likely the result of the vaporized tower on which the device was positioned. Red trinitite like this is considerably more rare, and is associated with copper impurities from the cable runs that connected the device to the diagnostic and control trailers trailers » as copper minerals are not evident in the original arkosic sand. (at:) https://www.flickr.com/photos/mouser-nerdbot/5484861256/in/photostream/

132 op. cit. Cooney: 1960, p.15

133 S. Davison, R.G. Newton, Conservation and Restoration of Glass, Routledge, London: 2008, p.19

fused quartz sand with natron,[134] or previously quartz sand with plant ashes. From c. 800 B.C. until about c. 800 A.D. in the West and Middle East, glass known as 'natron glass', was primarily produced from the minerals natron or trona.[135] Pliny the Elder states that natron was harvested directly as a salt mixture from dry lake beds. It produces the sodium silicate that gives glass more plasticity, rather than the ash plants with a high percentage of potassium, calcium, magnesium carbonates and phosphates. Therefore, it is probable that the principal source providing the Ancient Egyptians with a flux for glass making were the alkali lakes of Natron Valley (Wadi el-Natrun). Apart from being an essential ingredient for making a distinct colour called 'Egyptian blue', this mineral was also employed as a flux to solder precious metals together. It has been used for centuries as a preservative and was employed as a drying agent during mummification ceremonies, and in this context it was linked to the resurrection of Osiris. The ritual purification of Egyptian priest–glassmakers included the use of natron because the sea salt was understood as Seth's saliva, and as such was forbidden.

On the Egyptological side, the constancy in colour terms, and the repertory of colour, can be analysed on the basis of the wider, non-linguistic context of its attested Egyptian use and also of the linguistic comparison with existing Northwest African expressions. The formation of colour is revealed in the primacy of basic terms, which also have strong non-colour associations, in the linking of km(m) black with 'Egypt' (kmt)' or the colour of the soil, hd (white) with 'silver', and dsr red with 'desert (dsrt)'.[136] The prominence of Egyptian colour symbolism and the

[134] *Natron* is a naturally occurring mixture of sodium carbonate decahydrate ($Na_2CO_3 \cdot 10\ H2O$, a kind of soda ash) and around 17% sodium bicarbonate ($NaHCO_3$) along with small quantities of sodium chloride and sodium sulfate. Natron is white to colourless when pure, varying to gray or yellow with impurities. Natron deposits can be found in saline lake beds which arose in arid environments.

[135] op. cit., Henderson: 2013, p. 51

[136] W. Schenkel, Wozu die Agypter eine Schrift brauchten, 1963, (in:) Assmann A., Assmann J., Hardmeier Ch., Schrift und Gedächtnis. Archäologie der literarischen Kommunikation I, Munich: 1983, p.45-63

lack of complexity in its colour terminology may suggest a tacit sense of 'art', which continuously employed abstraction for ordering phenomena. The aetiological myths integrated metals, minerals and workable / plastic materials as representative elements of the universe. Internal self-sustaining discourse employs a religious analogy within this culture, which legitimates art, and the way in which artist-priests ideologically integrated affinities between mineral, vegetal and astral worlds. Taking possession of minerals, or metallic ores, equated with sharing divine power. Gold, silver, and minerals such as lapis lazuli, turquoise, green feldspar, red jasper and carnelian, guaranteed immortality thanks to the imposing character of the metaphor.

Furthermore, each material had magical significance linked to colour, which informed choices for sculptural bodies. The gods were said to have flesh of gold, bones of silver and hair of lapis lazuli. These precious, imperishable materials were further identified with the moon, sun, and sky, respectively rendering divine bodies as solidifications of essential light. The French scholar, Sydney Aufrère, examined materials, minerals, precious stones, and colour, which according to his theory were integral parts of the Egyptian decorative symbolism. Divine presence was seen manifested not only in the temple's architectural components, reinforcing the cosmological environment of the temple, but also in the mineral composition of the building materials. This particular approach allows us to perceive and refer to colour in terms of its natural origin, symbolism, and function when the traditional minerals were used as a touch-stone.

My investigation into Egyptian glass-making was dictated by a wish to reconstruct an idea behind the process of making, which influenced the development of advanced glass techniques. I based my investigation on the hypothesis that there is a link between the use of colour in glass by the Egyptians and their religious beliefs.

My methodology followed the conviction that glass was linked with the mineral world, and most of all on the basis of colour. Manifestation of colour in the natural world was interpreted as a spiritual presence of a god or goodness associated with a certain colour. The glass masters in Egypt were priests initiated into the sacred knowledge of the very nature of minerals. The fact that the first colour glass samples were made by melting together genuine minerals with glass matrix itself, may be taken as a guideline. The presence of rich metal ores in the region of Sinai allowed them to decide about a distinct colour by selecting a proper metal oxide ore.

Unlike gold, copper has a feeble presence in nature in its metallic state and so has to be produced artificially from its ores. And yet copper was one of the earliest metals known to man. Before gold, copper was particularly in use in ancient Egypt as long ago as Badarian and early Predynastic times.[137] The freshly formed surface of pure metallic copper is rose to orange coloured. I worked towards obtaining two coloured glasses of Egyptian type: 'Sang de boeuf[138]', scarlet or carmine red colour (kermes) and from Prussian or Paris blue to indigo colour (wadjet/keem). The ancient Egyptian word 'wadjet' signifies blue, blue-green, and green. The famous Egyptian blue pigment (hsbd iryt), in high favour in the Roman Empire, is also made out of a copper compound and according to F. Fouqué, it is calcium copper silicate (of the formula CaO*CuO*4SiO2)[139] or cuprorivaite. It is considered to be the first synthetic pigment and was known by the Romans as 'caeruleum' – from which the English word cerulean derives. This pigment is non-alkali and therefore resistant to weathering.

[137] op. cit. Lucas, Harris: 1962, p.228
[138] "*The Sang de Boeuf* – is a glaze that consists of several layers distinguished by their states of oxidation. Both metallic cooper and cuprous oxide probably participate in the production of the red colour." (in:) op. cit. Weyl: 2016, p.421
[139] Ibidem, p.433

In glass, Egyptian blue was produced at high temperatures and perhaps through repeated firings. Principally, it was made by heating together silica, copper alloy filings or crushed copper ore (e.g. malachite), calcium oxide with a fluxing material such as natron (or trona) or rarely potash. The glass inlays, used for decorative purpose like depicting parts of human figures, were first probably applied in the 14th century B.C. during the reign of Tutankhamun. Although excavated complete figures are rare, Ptolemaic glass production developed the technique to a very high standard of excellence. Inlays were found on wooden coffins, in furnishings and in religious shrines.

A considerable number of other factors are involved in order to produce coloured glass, ranging from the preparation of the glass batch itself, occurrence of transition metal ions, the gaseous atmosphere of the kiln, the presence of crystalline opacifiers, the chemical environment, and finally the nature of the heating cycle, with the maximum temperature achieved and the relevant annealing cycle.[140] In the right environment, copper transition metal ions can produce deep blue and turquoise blue colours in translucent and opaque glasses. The depth of the colour depends on their linear absorption coefficient (the relative strength of absorption), their concentration and their chemical environment.

Thoroughly mixing the glass batch in which the raw colourant material is present, preferably in a finely ground state, will reduce the amount of colour streaking. The gaseous atmosphere of the furnace, which may change at different points in the heating cycle, has a critical influence on the final colour of the glass that is produced. An oxidising atmosphere is one in which oxygen predominates, whereas a reducing atmosphere is oxygen-deficient (i.e. carbon dioxide and carbon monoxide predominate). It is also worth noting that Theophilus Presbiter in his '*De*

[140] J. Henderson, Ancient Glass: An Interdisciplinary Exploration, CUP, Cambridge, 2013, p.66

*diversis artibus*' or '*Schedula diversarum artium*'; in three books (date controversial but ca.1125) mentioned the deliberate addition of copper to produce turquoise blue, and under reducing conditions an opaque red colour ('Sang-de-Boeuf'). The presence of both manganese and iron oxides in 'naturally coloured' late Roman glasses, and Islamic, postmedieval, including *cristallo,* has led investigations to emphasise the importance of the gaseous atmosphere of the glass furnace was in determining the final colour of the glass.

Additionally, the atomic weight of the alkali present will affect the observed colour: the heavier the alkali, (in terms of its atomic number), the darker colour observed.[141] Today, we know that the use of cobalt ores in the Near and Far East is of a later date. The Egyptians were able, by means of only copper and iron, to produce deep blue glazes. And another copper-derived colour of great beauty and fame –the forementioned 'Sang-de-Boeuf' – a quest that pre-occupied European scientists and chemists for a long time. All blue and green glasses of this period contain copper oxide as a colourant (as proved by B. Neumann and G. Kotyga who found copper in the Egyptian glasses of Tell el Amarna, 1400 B.C.[142]). There is therefore an evident link in the use of copper as a colourant in faïence and glass. Under oxidising melting conditions, the Cu2+ ion is formed, under reducing conditions and at high temperatures, we may expect Cu+ as well as metallic Cu. The latter can occur in different forms which are known as copper ruby, hematinon and aventurine.

[141] C.R. Bamford, Colour Generation and Control in Glass, Elsevier Scientific Publishing, Amsterdam: 1977, p.125
[142] op. cit. Lucas, Harris: 1962, p.214

## 1.2. Pâte-de-verre technique and crystallisation in glass.

"For glasses of different viscosities to be compatible their expansions must be different. For instance, if the viscosity differences result in tension between the two glasses and the expansion differences result in an equal amount of compression between the two glasses, the two stresses cancel each other out."[143]

Based mostly in Nancy, in the Lorain region in France, Henri Cros, Albert Dammouse, Georges Despret, Amalric Walter, Emile Gallé, the brothers Daum and many others contributed to the popularization of the pâte-de-verre technique, which in French means literally 'paste of glass'[144] Their main interest lay in nature and the exploration of its evolutionary processes imbued with a distinctive vitality. By playing with subtle effects of the glass medium, startling colourations have been achieved with the introduction of metallic oxides and salts into the vitreous mass.[145]Infusions of iron or chrome oxides, cobalt and manganese produced smokiness, speckling, marbling and dichroism. Iridium and thallium were used to bring shadings to opaque colours. In 1884 Gallé introduced his imitation of hardstone glassware. A French commercial crystal manufacturer - Daum – has produced highly sculptural pieces in pâte-de-verre since the nineteenth century. This technique represents for me a 'modern' reference through which to reconstruct the mode of Egyptian glass-making.

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[143] op. cit. Schwoerer: January 2013
https://www.bullseyeglass.com/images/stories/bullseye/PDF/TechNotes/technotes_03.pdf

[144] *Pâte de verre* – a wide range of casting techniques based on covering a mould with the granular glass from fine flour-like to coarser grains like sat crystals. The 19th century pâte-de-verre was called also pâte de crystal as the lead content in it could reach up to 50% (lead crystal glass).

[145] The applied glass melting temperatures in a muffle kiln were relatively low (approximately around 775°C).

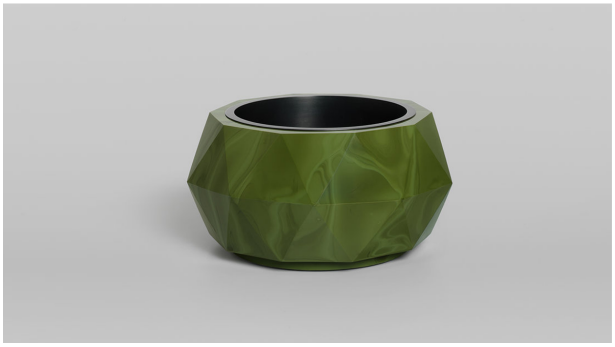
In order to describe the nature of glass flow, part of my methodology introduced a set of the material's resistance restrictions. The crystallisation of glass, or its devitrification (from latin: '*vitreus'* - glassy) is a process of crystal formation through natural or artificial transformation of the state of matter and therefore it was defined as a limiting state for amorphous glass flow. Multiples tests in glass blowing and kiln casting techniques, with particular attention to the pâte-de-verre technique, were undertaken in order to understand how to take control of the crystallisation process, which cannot be the same as spontaneous crystallization. In terms of glass blowing technique, the gestures employed were repeated in the same way, which, apart from almost constantly spinning a blowing pipe, included gathering coloured glass, glass powders and some modest quantities of chosen metal oxides such as cobalt, copper or iron. Some coloured layers were intermixed, and others divided one from another by a layer of clear glass. Sometimes a coloured pattern in glass could be 'cut' by the introduction of another colour or a clear glass layer that could pass across it. A great number of different effects were successfully developed in glasses, depending principally on time and temperature factors, but also from the way the raw material was prepared before melting it in the hot technique.

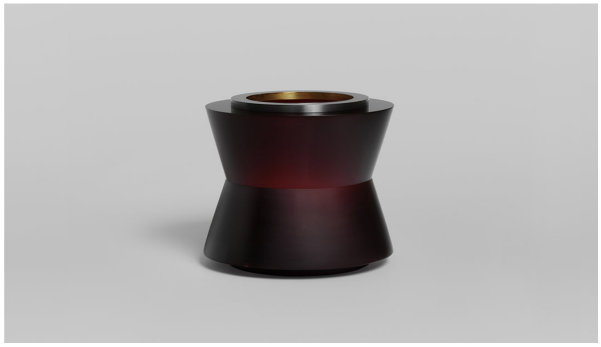
Furthermore, it was notable that a slight difference in an applied gesture has considerable importance for the process of making and its outcome, when it matters to get sufficiently comparable findings through each test. Therefore, a 'simplified' set of proceedings had to be introduced.

An important source for the practical research was the Royal College of Art doctoral thesis of 1979 called: "A research project to rediscover and reintroduce 'the lost art of pate de verre'" by Elaine J. Lewin. Her body of work consisted of critically comparing certain historical formulas for making the pâte-de-verre paste,

with others proposed by the artist. This paper with its scrupulous range of material tests offers a wide insight into the particularity of the technique.

Graduating from the Royal College of Art in 1985, Anna Dickinson has specialised in joining together glass and metal together in her artworks. Her vision and sensibility in understanding both materials make her work remarkable and inspiring. The time factor, perceptible in contact with artist' creations, probably plays an important role in the cold-working process in glass, when one focuses a mode of practice with the given material to extract from one's own experience from it.





*Figures 46 & 47:* Anna Dickinson, (from left:) Green Triangles, Glass and Copper, 13 x 26.5cm, Von Bartha Collection Basel, photo credit: Robert Hall[146]
Red Vessel 2015, Glass, steel and gold-plated copper, 18 x 19cm Private collection, Ariana Museum, Switzerland

[146] https://www.rca.ac.uk/more/staff/anna-dickinson/

*Figures 48 & 49:* Aurora, Izabela Dziepak, Glass, 2016, Royal College of Art

My work has been inspired also by the practice and philosophy of Bernard Dejonghe. Since 1977, the French artist lives and creates in Briançonnet, in the French Riviera, where he built a Japanese kiln which allows him to wood-fire his work. It seems that Dejonghe gains his inspiration through the observation of processes animating natural phenomena, while discovering his local flora, or while travelling the deserts of Mauritania, Algeria, Egypt, Chad, Sudan and Niger. He has been exploring their local geography and artefacts since 1989. His "Meules dormantes" are inspired by the cylindrical stones found in the desert. Dejonghe sees man as part of the mineral world, and challenges artists to interact with it, as a 'field of possibility' – un "champ de possible".[147]

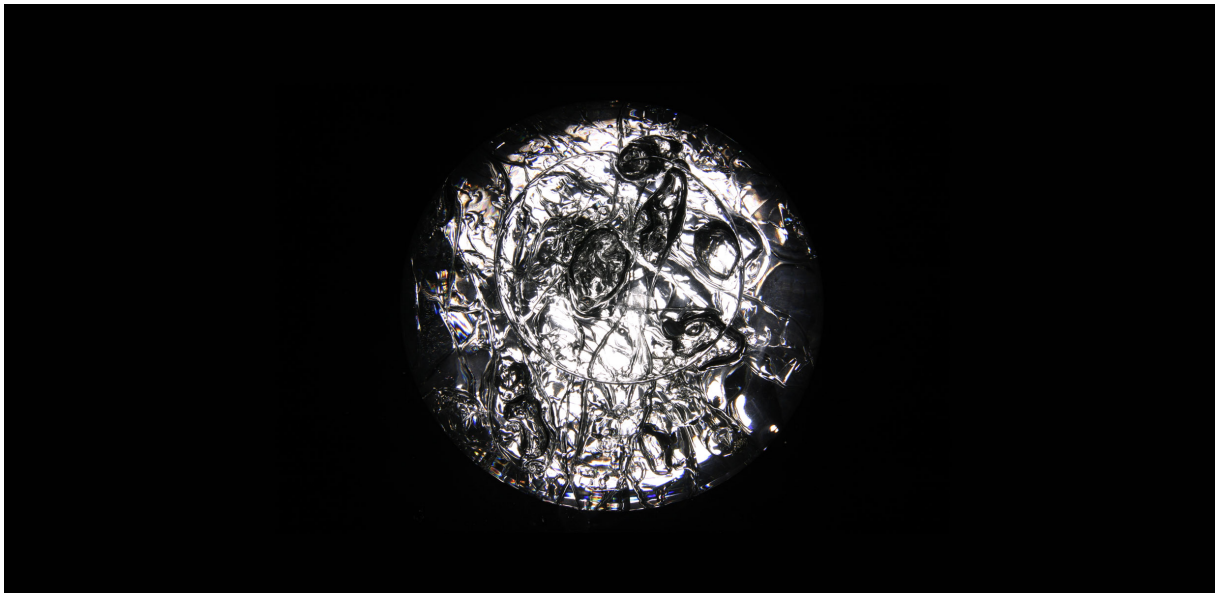
He thinks that an artist makes things linked with movement because nothing in the universe is stable. I share his conviction that a mineral, as manifested in glass and ceramic materials, is dealt with in its decomposed state - being further into fusion, and as such can become of a central focus of one's artistic practice.[148] This geological approach demands a constant verification of what exists in nature, and a sense for which of its processes might be repeated. Michel Onfray, the French philosopher and the creator of the free Université Populaire de Caen (Popular University of Caen), proposed in one of his radio discussions – "Faire Pleurer les Pierres*"* some philosophical concepts concerning stones, which he calls the "vitrified forces" or the "crystallisations of time".[149] Crystals, having a beginning and an end in their growing cycles, despite their long memory, are 'just' silent animated beings. As a historian, Onfray claims that an explication of a history can

[147] "J'ai toujours eu conscience de l'homme comme faisant partie de l'univers minéral. Depuis mes premiers travaux en terre en 1968, j'ai abordé le matériau comme un "champ de possible"",
https://www.galerie-capazza.com/fr/24_dejonghe-bernard
[148] https://www.galerie-capazza.com/fr/24_dejonghe-bernard
[149] 16. 07. 2017 radio conference: "Faire Pleurer les Pierres": "Les pierres sont une cristallisation du temps"
https://www.franceculture.fr/emissions/breve-encyclopedie-du-monde/faire-pleurer-les-pierres

be found by evaluating the soil and sub-soil.[150] Scientists who can extract data from the mineral world are able to explain facts concerning the universe. In my further research I intend to gain a deeper understanding of chosen processes that determine colour and shape in crystals, to render it more closely in glass. Dejonghe explicitly described deserts as responsible for revealing the living process of minerals in a longterm perspective. This helps him to gain a deeper understanding of his own practice: "J'aime les déserts par ce qu'ils nous montrent du vécu minéral dans la durée; ils me font comprendre ce que j'essaie de faire"[151]. The limits of such a quest to understand the animated nature of minerals is set in the mythical past by Orpheus, who once made stones cry through the powerful language of his music.

*Figure 50*: Triangle du Ténéré, Fusions, Bernard Dejonghe, solid optical glass, Dimensions: 28 x 29 x 23 cm, Catalogue du Musée de Dunkerque, Conversation avec Alain Macaire, Musée de Dunkerque, photo credit: François Goalec

150 "On pourrait faire une explication de l'histoire juste à partir des sols et des sous-sols. », op. cit. (at:) https://www.galerie-capazza.com/fr/24_dejonghe-bernard



*Figures 51 & 52* (from top): Sphere, Izabela Dziepak, Glass and water, 2005, Eugeniusz Geppert Academy of Fine Arts in Wroclaw, photo credit: Jędrzej Stelmaszek
Concave Glass Lens, Izabela Dziepak, Black and white analog photography, 1995

## CONCLUSION

My research, and reflection about the creative process, argues for improvements to be made in terms of technological and material development, innovative ways of exhibiting tactile art, as well as extending further expertise. Gilles Deleuze's concept of the fold helped me to understand how I can consider an object in the dimensional sense. Thus, enquiring into Ancient Egypt's pantheistic vision reflected European cultural change, which started from Homeric society, or rather from 'pre-Greek' civilisations[152]. The Egyptian 'frontal' way of depicting might be based on a mental image which is relevant to the stylistic mode alone, which, lacking foreshortening, may be faithful to a specific 'memory image' rather than to a perceived visual impression. Probably the aim behind this development was to render a purely objective depiction, deprived of a subjective viewpoint[153], or rather, as Esely Schäfer indicated, of a 'viewer-centred' position. How then might the intrinsic ability of glass to create an impression of depth have been perceived in ancient times? What was the role of glass in ancient Egypt? Was it used just as a substitute when lacking precious stones?

I looked for raw materials, which were chemically comparable with those that were in use in the ancient Egyptian glass-making formulas. The core of my interest was to define my glassmaking process in order to obtain more variety in the hues of blue without changing the formulaic compounds (fixed oxide amounts), but by regulating cullet size and time-temperature factors. However, my real interest lies more specifically in decoding the visual perception systems that might have been

[152] The term *'pre-Greek'* is employed in reference to its original definition proposed by Heinrich Schäfer (in:) Schäfer H., Principles of Egyptian Art, trans. Baines J., Griffith Institute, Oxford: 1986

[153] "E. Schäfer was rightly wary of the concept of a 'viewpoint', some of his objections to which are met by the more cautions formulation 'viewer-centred'. The problem of viewpoint and the general lack of them in Egyptian art remains central to his treatment; his detailed exposition shows how they are largely dispensable in the analysis of representation." (in:) J. Baines, Visual and Written Culture in Ancient Egypt, OUP Oxford: 2007, p.227

used in the past, to build up new thinking and subsequently to transfer it into making an original glass object.

This artistic research is enriched by the intercultural context where glass-making skills are discussed on a cultural basis. Social norms are sensory norms, and I consider it a vital issue to remain actively engaged in an exchange and transmission of values, which facilitate communication and make progress together possible. In the field of glass art, I wish to explore to a greater extent the technical solutions contributing to the protection of the natural environment by recycling glass, and manufacturing coloured glass in a glass studio. There is still a central issue of lowering the fuel costs for glass-making, which can be resolved by choosing alternative additional sources of power (i.e. solar and wind). Rooted in this thinking, innovation was pursued through discourse across disciplines and emerged as a unified spectrum of perspectives, from the scientific to the artistic, and certainly from the artistic to the scientific. With this in mind I wished to join an academic organism and linked my professional life with an art college, as it is an oasis of highly inspiring and creative exchanges, and a forum within which my research can be disseminated to a wider audience. I would like to share my knowledge and my practical skills with those who wish to advance seriously in the field.

Domination of our vision has never been stronger than in the current milieu of the technologically expanded eye and industrially mass-produced visual imagery. In consequence the strong desire to be drawn to the sensuous is present in the understanding that material culture, in conjunction with materializing social relations, and symbolizing the cosmos, gives human expression to a particular set of sensual relations. In response, there are researchers who have made it their mission to influence public institutions, such as museums, to allow tactile experience. This has been introduced in the form of educational projects in the British Museum. In

2008, Fiona Candlin and Raiford Guins edited '*The Object Reader*',[154] and two years later, Candlin specifically examined concepts and uses of touch within art museums and art history in '*Art, Museums and Touch*[155]'. Interested in the cultural construction of the senses, the study presents a counter-challenge to the museology and art history that has privileged visual experience. Through this original investigation, however, Professor Candlin contests the idea that touch is an easily accessible way of engaging people with museum collections. My wide-ranging enquiry convinced me to examine visual perception systems more closely in order to propose an appropriate and innovative way of exhibiting tactile art objects.

Furthermore, I found the process of ordering an amorphous glass matrix into a geometric crystalline structure highly challenging, because it meant that the molecular similarity between them makes the relation of resemblance even more explicit than the comparison based just on an aesthetic likeness. Hence, in this respect and following a great lapse of time, ancient Egyptian 'copies' of minerals do appear to have a powerful authenticity. Developing this conjoined project has become my next potential research challenge, as I continue the central enquiry into the capacities of viscous glass flow and the linear patterns generated by it. In consequence, my principal investigation is an on-going specialisation in the pâte-de-verre technique.

Compared to glass blowing technique, it allows control of the glass flow and its colour scheme with a greater precision, due to the extended time period, and the lower range of temperatures required for glass melting. I concluded that one of the major aspects to consider in using this technique is an annealing cycle, which when properly adapted may result in controlled crystallization. All these issues mentioned

[154] F. Candlin, Guins R., The Object Reader, Routledge, London: 2009
[155] F. Candlin, Art, Museums and Touch, Manchester University Press, Manchester: 2010

above demand further examination and a significant investment of time and effort with an innovative glass-making formula.[156]

The dominant aesthetic quality of this glass is its brittle character, and thus, handling these fragile objects requires particular care. Consequently the methodology of this practical research, with its interlinked theory, was extended to examine ways to make these sculptures solid, and the process has been further developed since. In this type of glass medium, I can exercise my 'painting while sculpting' technique of carving and polishing glass to achieve a deeply coloured, fine surface. Each of the coloured glass modules, used to build up a joined structure, captures a memory of a person and her or his treasured place (trying to tell the same story through minerals assembled together). Afterwards, this memory is transformed into a more intimate happening, a form of homage to that particular person by means of a portrait, little by little, a fold after a fold, until the object finds its centre-balance. This deeper focus, or rather contemplation, implants, by the reverse *processus*, the freshness of drawing the painterly coloured lines, thereby making myself a spectator in an adventurous combination of colour realm and form. The cutting wheel's profiles, while applied to a glass surface, are submerged in cooling water and for that period of time a glass object become a vessel, a container subjected to the same erosive forces as 'real' stones. The complexity of the process offers a variety of stimuli, drawing a response from the whole bodily system.

[156] In a studio-based environment, the temperature during the first phase of cooling can be controlled by adapting an innovative method of measuring the actual Delta T (expressed as Delta T > +/- 5°C) by the use of two thermocouples placed in a casting kiln. Recommended by Richard Whiteley, the Head of Glass Workshop School of Art in Australia and a pioneer of this method, it allows precise determining of the necessary time for an annealing cycle for a particular glass object (it is advised particularly for large and complex castings). (at:) http://richardwhiteley.com

Thus, my main aims have been oriented towards these stages of achievement: to create new sculptures using my own glass, and to deepen my knowledge of the controlled crystallisation of glass while creating coloured patterns. These I hope will be of use to subsequent researchers.

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**Author's declaration:**

During the period of registered study in which this thesis was prepared the author has not obtained any other academic award or qualification. The material included in this thesis has not been submitted wholly or in part for any academic award or qualification other than that for which it is now submitted.

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