

The Eugeniusz Geppert Academy of Art and Design in Wrocław

Doctoral School

Theory of Everything.

**Raw material, technical and technological research
in the field of ceramics as a starting point
for artistic work inspired by scientific theories.**

Doctoral thesis in the field of arts in the discipline of fine arts and art
conservation

Dawid Żynda

Supervisor:

Assoc. Prof. Dr. hab. Joanna Teper

Wrocław 2024



THE EUGENIUSZ GEPPERT
ACADEMY OF ART AND DESIGN
IN WROCLAW

TABLE OF CONTENTS

INTRODUCTION2

Chapter I: The Theory of Everything.

Science as a Source of Inspiration in Artistic Creation4

- 1.2. Time4
- 1.3. Gravity9
- 1.4. Outer Space14
 - 1.4.1. Dark Energy and Dark Matter14
 - 1.4.2. Human at the Center.
The Anthropic Principle and the Fine-Tuned Universe16
 - 1.4.3. String Theory - Unified Theory19
- 1.5. AI/AGI21
- 1.6. Math.random()23

Chapter II: The Construction of a Hybrid Prototype

Kiln for Firing Large-Format Ceramic Slabs27

- 2.1. Why?27
- 2.2. Gas Kilns29
- 2.3. Electric Kilns29
- 2.4. Hybrid Kilns31
 - 2.5.1. Reducing Atmosphere in Electric Kilns32
 - 2.5.2. Temperature Ranges34
 - 2.4.3. Controlled Heating34
 - 2.4.4. The First Prototype35
 - 2.4.5. Hybrid Kiln Designed for Large Surfaces37
- 2.5. Conclusions41

Chapter III: Research on Lesser-Known and Small Deposits of Raw Materials from the Lower Silesia Region.....	42
3.1. Basic Research	42
3.2. Raw Materials	48
3.2.1. Basalt from the Wilków Quarry	48
3.2.2. Wollastonite from Nowa Wieś Kłodzka	49
3.2.3. Halloysite and Kaolin from Dunin	50
 Chapter IV: Online Application for Creating Databases of Raw Materials, Glazes, and Ceramic Bodies	 51
 Chapter V: The Theory of Everything. Description of the Works Comprising the Doctoral Thesis	 58
5.1. Black Holes	58
5.2. Event Horizon	59
5.3. Dimensions Entwined	60
5.4. Space Debris	61
5.5. The Cosmos	63
5.6. !Gravity	64
5.7. Entropy	66
5.8. Summary	67
 INDEX OF WORKS INCLUDED IN THE DOCTORAL PROJECT	 68
 CONCLUSION	 95
 BIBLIOGRAPHY	 97
 LIST OF ILLUSTRATIONS	 100

To make an apple pie from scratch, you must first invent the Universe.¹

Carl Sagan

¹ An aphorism spoken by Carl Sagan during the ninth episode of his series *Cosmos: A Personal Voyage* from the 1980s.

INTRODUCTION

Currently, in physics, there are two main theories that define the universe. The first—*the theory of relativity*—deals with large-scale objects like planets, while the second—*quantum mechanics*—describes the small-scale world, such as atoms. However, there is a concept of a single, unified theory that could summarize and connect everything. If it is ever discovered, it would become *the Theory of Everything*.

The apparent similarity of gravitational forces and electrical forces, for example, in that they both follow inverse-square laws, which every kid can understand, made every one of these “kids” dream that when he grew up, he would find the way of geometrizing electrodynamics. Thus a generation of physicists worked trying to make a so-called unified field theory, which would have unified gravitation and electrodynamics into a single thing¹.

At times, I also feel like a child, trying to understand everything at once—only in the realm of ceramics. As such, I am involved not only in strictly artistic work but also in building kilns, creating glazes and clay bodies, and developing my own techniques in each of these areas. As a researcher should, I try to maintain both an experimental and scientific approach to the field I analyze and practice. It seems quite natural to move from such activities to exploring physics and back again—attempting to translate issues derived directly from it into my own creative work. Taking a broader view of the phenomena that encompass me and my actions, I am trying to understand myself from the ground up, but to do so, I must first comprehend the universe.

Therefore, my doctoral dissertation, in keeping with the nature of my work, is a bit of everything. As part of it, I create series of works inspired by the world of science, seeking visual interpretations of concepts such as black holes, string theory, or the phenomenon of entropy. All stages of the work are personally developed by me—I acquire and analyze the raw materials needed to create glazes, I create my own clay body mixtures, I build a kiln for hybrid electric-gas firings, and I experiment with throwing techniques, reversing the gravity of the tool. I complement this set of activities with the development of an application for composing glazes.

¹ R. Feynman, *Lectures on Gravitation*, Londyn 1999, s. 2.

The doctoral collection, inspired by the *Theory of Everything*, thus becomes a particularly important space for me, where everything ultimately converges, creating a new, unique quality. The entirety of my research reaches its goal—the creation of an artistic reinterpretation inspired by science—from the unearthed raw material subjected to analysis, which ends up in the clay body and the glaze that covers it, to its materialization in the form of planned spatial compositions. Somewhere in between, I try to understand my motivations, reflecting on my tendency to reject decision-making in favor of (nevertheless seemingly!) randomness. It may seem that the areas I try to explore are a collection of random topics, but everything stems from my life experiences as an artist, ceramist, technician, programmer—Dawid.

Chapter I: The Theory of Everything. Science as a Source of Inspiration in Artistic Creation

1.2. TIME

One of the first definitions of time according to the Polish language dictionary by PWN is "an uninterrupted sequence of moments."¹ This rather poetic explanation reflects the difficulty in clearly naming and encapsulating this intriguing dimension in just a few words. In summing up his reflections on its nature, the eminent humanist Krzysztof Pomian writes: "As a class of relations, time is not a stream. It does not flow, it does not pass, it does not escape, and it cannot be likened to a river. The notion of time as a stream stems from its unjustified identification with change."² Contrary to the deep-rooted cultural conceptions that Pomian describes, Salvador Dali, in his famous painting *The Persistence of Memory* (1931), uses melting clocks to depict the surreal and elusive nature of time, suspended between fluidity and permanence.

Although it is not change itself, time is inextricably linked to it.

Imagine a cup of water falling off a table and shattering into pieces upon hitting the floor. If someone filmed the event, we would easily be able to tell if the film was being played in reverse. (...) It is easy to tell the film is running backward because such behavior never happens in reality, (...) it would violate the second law of thermodynamics. This law states that the disorder, or entropy, of any closed system always increases³.

These words by Stephen Hawking once helped me understand the nature of entropy, inextricably connected with time, and enabled me to begin my work on its own interpretation. Wanting to visualize closed systems with varying levels of entropy, I developed and created a ceramic diptych, *Entropy*, composed of repetitive elements, with only the level of their organization changing. The transitions between the objects aim to allow both a linear perspective on the process of increasing entropy and a tempting possibility of returning to what has passed. The inevitability of ordered systems moving toward chaos, and ultimately to disintegration, parallels

¹ *Time*, SJP PWN, Accessed: 20 sierpnia 2024, <https://sjp.pwn.pl/sjp/czas;2450266.html>.

² K. Pomian, *The Order of Time*, Gdańsk 2014, str. 335.

³ S.W. Hawking, *A Brief History of Time: From the Big Bang to Black Holes*, Warszawa 1990, s. 134.

our aging and death. This is why narratives that defy the laws of entropy and allow us to dream of time travel, especially backward, become so intriguing to people.

I, too, once experienced a sort of time travel—toward the future. As a child, I visited an open-air museum with my parents, where pottery techniques on a wheel were demonstrated. At one point, the instructor asked the group: "Who would like to try?" I jumped up and quickly sat at the wheel. I remember clearly that I was utterly convinced I knew how to do it.

Everyone is likely familiar with such iconic works as the American film series *Back to the Future* by Robert Zemeckis from the 1980s, or the British TV series *Doctor Who*, produced since 1963. They used time travel as a narrative tool, enriching their stories. Jumps backward allowed encounters with famous figures from the past or the correction of previous mistakes. The American writer Kurt Vonnegut creates a completely different take on time travel in *Timequake*, where after the titular event, the entire world is sent back from 2001 to 1991 and has to relive everything, minute by minute, in exactly the same way. The novel becomes, among other things, a pretext for reflecting on free will—*this time, the universe, not humans, had a hiccup, and it was responsible for all actions. People might have thought they were in control, but it was not true*⁴.

Let's return, however, to established—perhaps only seemingly—knowledge about reality. Time has been measured since antiquity. The Sumerians and Egyptians were among the first to create devices for observing the passage of time through the movement of the sun. Sundials evolved into more advanced tools, such as water clocks, and ultimately into mechanical clocks in medieval Europe. Today, we measure time in seconds, minutes, hours, and years, but we can also find systems based on less obvious units, such as the blink of an eye (*nimesha*), described in the sacred Hindu texts. There, too, time is perceived as a cosmic cycle of creation and destruction—a repeating sequence of vast epochs called *yuga*. In contrast, Christianity views time linearly, with a clearly defined beginning (Creation) and end (Judgment Day). Meanwhile, some indigenous cultures, such as Native Americans or Australian Aborigines, perceive time as a series of natural cycles, rejecting linear progression. Despite these cultural interpretations, time in physics remains unidirectional, aligned with the arrow of time⁵, running from the past to the future.

⁴ K. Vonnegut, *Trzęsienie czasu*, Warszawa 2000, s. 91-92.

⁵ The arrow of time indicating the direction of its flow.

The most accurate time-measuring devices today are atomic clocks, which count time based on the vibrations of cesium atoms. In 1971, scientists Joseph Hafele and Richard Keating⁶ arranged for such clocks to be flown on airlines, and the results of their experiment confirmed the thesis derived from Einstein's theory of relativity—that time moves slower for an object in motion than for one at rest. However, this experiment has been questioned for various reasons, one being the influence of gravity on time. In a stronger gravitational field, closer to massive objects like Earth, time moves more slowly.

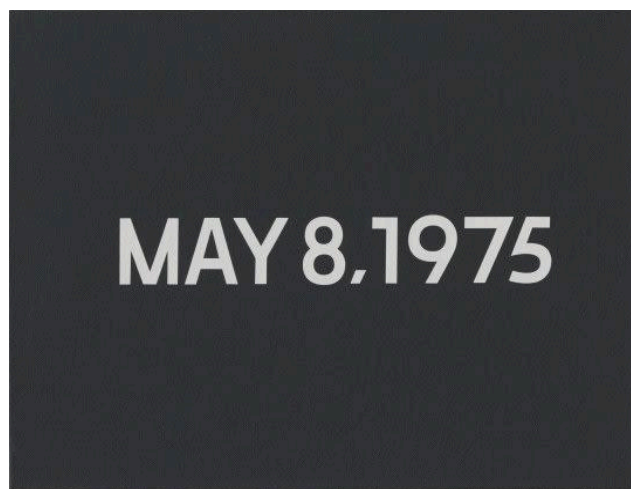


Illustration 1.1. On Kawara, *May 8, 1975*, 1975

Nevertheless, this thesis has found reflection in many works of culture. In 1961, Stanisław Lem published *Return from the Stars*, in which the protagonist, Hal Bregg, returns from a ten-year space mission to an Earth transformed over nearly a century:

“(…) that started and ended once and for all, and this was new. No remnants, no ruins to question my biological age; I could forget about its earthly conversion, so contrary to nature—until an incredible chance brought me together with someone I had left behind as a small child (…). Had I not flown, I would no longer be alive⁷.”

⁶ J.C. Hafele, R.E. Keating, 1972. *Around-the-World Atomic Clocks: Predicted Relativistic Time Gains*, Science, Accessed: 30 sierpnia 2024, <https://www.science.org/doi/10.1126/science.177.4044.166>, [tłum.własne].

⁷ S. Lem, *Return from the Stars*, Warszawa 2008, s. 79-80.

Just as the protagonist in *Interstellar* (2014), who meets his 80-year-old daughter while still being under forty, Hal experiences something that humanity has yet to encounter, but we grapple with the consequences in our imagination, drawing proposals for the future.

The future, however, brings with it an end, turning time into precious capital. It is materialized by artists such as the Japanese-born On Kawara, who gave form to the passage of time over his long career. His works *One Hundred Years Calendars* (1984–2012) and *One Million Years* (1970–98) consist of leather-bound volumes filled with numbers representing years written backward from the date of the work's creation. In contrast, in *Today* (1966–2013), a series of around 2,000 paintings, he recorded single dates in acrylic paint on the canvases, depicting the days the paintings were created [Illustration 1.1.]. The Polish artist Roman Opalka devoted nearly his entire life to the idea of painting time, creating a series of *Counted Paintings*⁸, which, starting with the first canvas depicting white numbers from 1 to 36,327 on a black background,

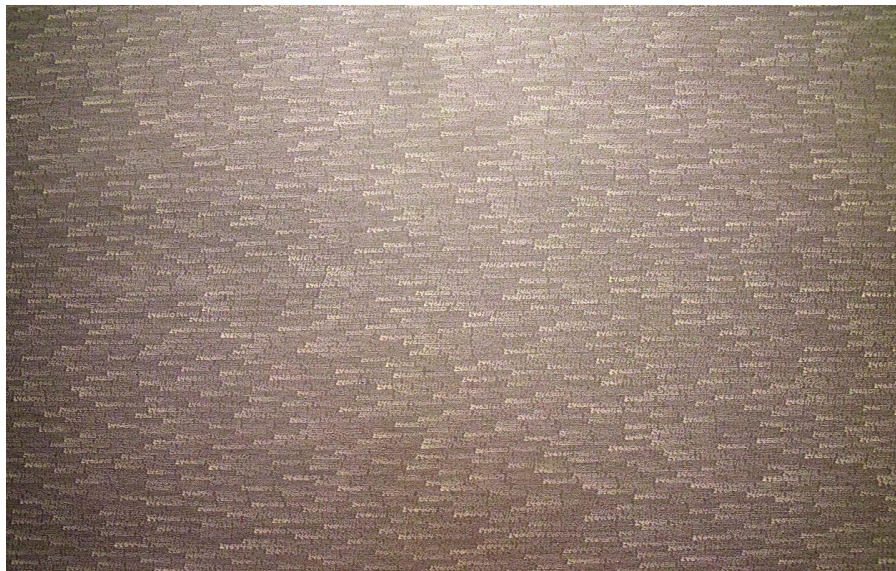


Illustration 1.2. Roman Opalka, *Counted Painting. 1965/1 to ∞ Detail 2450737-2473067*, 20th century.

he gradually brightened [Illustration 1.2.]. The series was interrupted by the artist's death in 2011, and the final painting shows a seemingly uniform white surface, with the counting ending

⁸ Roman Opalka's *Counted Painting at the National Museum*, Accessed: September 13 2024, <https://www.radiokrakow.pl/kultura/obraz-liczony-romana-opalki-w-muzeum-narodowym/>.

at 5,607,249. All these works, by giving material form to segments of time, engage in an interesting dialogue with the physicist Carlo Rovelli, who argues in his publication *The Order of Time*: “The universe is not a collection of things but of events⁹.”

The inevitability of passing time is confronted by the American-Swedish artist Christian Marclay in *The Clock* (2010), a 24-hour montage of clips from television and films in which a clock face appears, showing the actual time of day. Thanks to the endless looping of the entire piece, the viewer of the installation can enter and leave at any moment, all while knowing that time will continue to flow after they leave.

As a ceramist, time is incredibly important to me. My current research focuses on firing processes, which depend on precise timing. Meticulous record-keeping of firing curves¹⁰ is crucial to achieving consistent results in subsequent trials. The methods for measuring temperature changes over time vary depending on the technique used. When firing with wood and other natural methods, one relies heavily on human experience, without which it would be impossible to maintain the proper temperature. In contrast, electric kilns use PID controllers and SSRs (solid-state relays) to regulate the heating of coils, ensuring a more controlled and repeatable process.

However, to produce the item that will be placed in the kiln, many time-consuming stages of work must first be completed. When preparing ceramic clay independently, the extracted clay needs to undergo processing, which is most beneficial if its maturation cycle also takes place in winter (and only comes once a year!). After the processes of purification, mixing in necessary additives, and de-airing, we can move on to the creative work. It is important to remember that the formed clay body must dry at an appropriate (slow!) pace. Otherwise, it is prone to cracking and warping, inconsistent with the original plan of the artist. Considering the fact that each subsequent stage of a ceramist’s work carries a high risk of failure, I can confidently state that this occupation requires a great deal of patience and TIME.

⁹ C. Rovelli, *The Order of Time*, Łódź 2019, s. 93.

¹⁰ Graphs depicting the temperature rise over time, also accounting for additional actions, such as the activation of specific burners in gas kilns or the opening and closing of the chimney in both gas-fired and wood-fired kiln constructions.

1.3. GRAVITY

The formulation of Newton's law of universal gravitation was a groundbreaking moment in science, but even in antiquity, gravitational forces binding the cosmos were symbolically depicted by figures such as the Titan Atlas, who carried the celestial vault. Our artistic and more mundane, everyday experiences constantly remind us of what gravity is, and Newton's assertion that two bodies are attracted to each other is more than sufficient to explain this phenomenon.

However, there is a more precise definition of this fundamental force of nature. According to Einstein's general theory of relativity, it is described as the way matter perceives distortions in spacetime, better understood in the form of the astrophysicist John Wheeler's aphorism: "Space tells matter how to move, and matter tells space how to curve¹¹." Using the mathematics of this theory, Einstein was able to calculate the hypothetical existence of gravitational waves in the cosmos. However, it took a century before their discovery. In 2015, the American LIGO Laboratory observed their actual existence. By repeatedly verifying the accuracy of Einstein's calculations, scientists also allow for the possibility of repulsive gravity, and, as a result, anti-gravity. I hope that we will not have to wait another hundred years for confirmation of this. Until 1971, black holes (interestingly, a term coined by the aforementioned John Wheeler) existed only in theory. The discovery of the first one, in the Cygnus X-1 system, was yet another validation of Einstein's calculations.

When I first delved into *A Brief History of Time* by Stephen Hawking, it was black holes with their intense gravitational forces that sparked my imagination the most. Due to their colossal density, directly influencing the strength of gravity, they can engulf another object and stretch it in a process known as spaghettification, or the "noodle effect¹²." The closer an object is to the black hole, the stronger the gravitational pull, meaning that the closer part of the body is attracted more forcefully than the farther part. As Hawking writes: "If a black hole has a mass several times that of our Sun, you would be turned into spaghetti before reaching the event horizon."

¹¹ K.W. Ford, J.A. Wheeler, *Geons, Black Holes and Quantum Foam: A Life in Physics*, Nowy Jork 1998, s. 228, .

¹² K. Mazur, 2021, *Hawking's Famous Black Hole Theory Confirmed*, National Geographic Polska, Accessed: August 10, 2024, <https://www.national-geographic.pl/artukul/slyнна-teoria-hawkinga-o-czarnych-dziurach-potwierdzona>.

This horizon, known as the event horizon, is the spherical boundary marking the surface of the black hole.¹³



Illustration 1.3. *Quantum Field Theory in Curved Space - Black Holes*, 2021

Some of my early works related to black holes stemmed from the event in 2019, when Katie Bouman’s team at Caltech¹⁴ captured the first-ever image of one. Despite its blurriness and few visual stimuli, the image added tangibility to this phenomenon, as if pulled from a science-fiction story. The project I completed in 2020, *Quantum Field Theory in Curved Spacetime*, was an attempt to spatially relate to black holes, where the plane formed by cutting clay off the pottery wheel became the event horizon, and the resulting soft deformations in shape suggested my interpretation of its depth. To reflect the dynamic nature of the phenomenon, I introduced the pit fire¹⁵ technique, which through reduction in sawdust and wood, emphasized the texture of

¹³ K. Mazur, 2021, *Hawking's Famous Black Hole Theory Confirmed*, National Geographic Polska, Accessed: August 10 2024, <https://www.national-geographic.pl/artykul/slynn-teoria-hawkinga-o-czarnych-dziurach-potwierdzona>.

¹⁴ California Institute of Technology – a prestigious private university in Pasadena..

¹⁵ Alternative firing, which involves smoking the pieces by burning materials like sawdust, with limited oxygen supply.

ceramic surfaces and gave the objects colors that expressed the mysterious and awe-inspiring nature of black holes [Illustration 1.3.].

In the realm of art, particularly in sculpture and ceramics, gravity is both a limitation and an ally. The artist must account for the weight of materials to prevent works from cracking and collapsing under their own weight. In ceramics, gravitational pull during firing can cause glazes to run and drip or lead to the total disintegration of kiln contents if the clay body used is not carefully prepared and fired at the appropriate temperature.



Illustration 1.4. Peter Christian Johnson, *The Hollow Men*, 2016

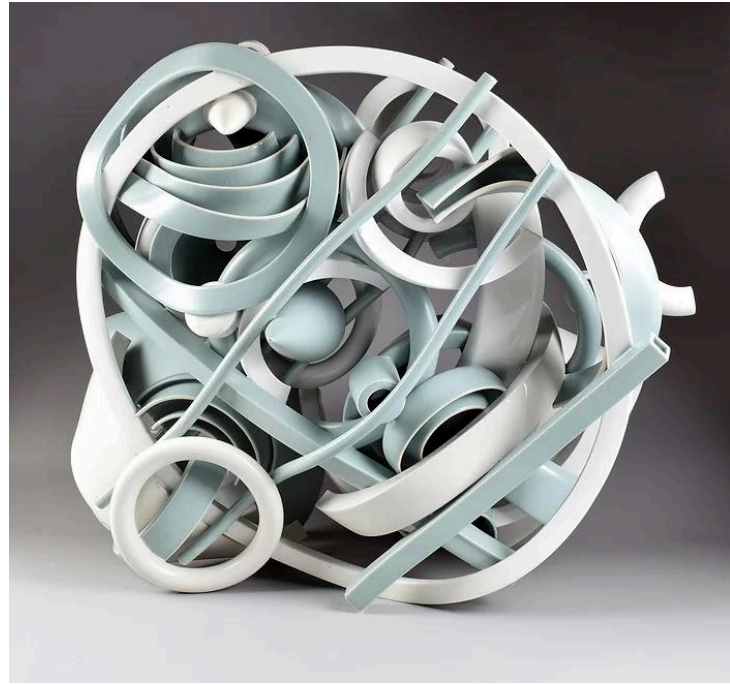
However, in the hands of a talented artist, these gravitational challenges can transform into creative techniques. One of the ceramists experimenting in this field is the American Peter Christian Johnson, who in his work meditates on entropy. "Most of my works," as he writes, "involve creating complex porcelain structures that I force to deform and collapse under the strain of firing"¹⁶ [Illustration 1.4.]. Similarly, Estonian sculptor Anne Turn collaborates with gravity in creating her light objects made of porcelain and glass, as seen in her installation *Tsoon* (Estonian for "zone") [Illustration 1.5.]. The artist controls the process in which molten glass,

¹⁶ P.C. Johnson, *Statement*, Accessed: September 25 2024, <https://www.peterchristianjohnson.com/statement> [tłum. własne].

guided by gravitational pull, creates visual effects that transcend the static nature of the material. Meanwhile, American artist Ryan LaBar uses ceramic materials to create the impression of forms caught in a moment of graceful resistance to gravity, with porcelain shapes spinning and stretching in apparent motion [Illustration 1.6.].



Il. 1. 5. Anne Turn, *Tsoon*, 2022



Il. 1.6. Ryan LaBar, *A point of unstable equilibrium*, 2019

These artists highlight the beauty of embracing the unexpected. Their work reflects the idea that the same force that can cause material to fail also becomes a source of inspiration, shaping a unique creative language. The interplay between the artist's intent and the inevitability of gravitational effects influences the creative process and the final result, making the works as much a product of the laws of physics as of human expression.

One of my projects that dealt directly with gravity was a performance created as part of my solo exhibition during the second year of my studies at the Doctoral School. The project was born from the dream of becoming the first ceramic artist to create in outer space or on another planet, such as Mars, which scientists envision colonizing in the future¹⁷.

¹⁷ On June 25, 2023, in Houston, Texas, one of the series of CHAPEA missions—The Crew Health and Performance Exploration Analog—began, which aims to simulate a mission to Mars on Earth.

To simulate the challenges of working in conditions so different from those on Earth, I created a personal training program that involved throwing clay upside down. This exercise allowed me to experience the difficulty of controlling the stretching of clay and the challenge of using water to soften the clay while working under reversed gravity.

The central piece of the performance was a wooden structure with an upside-down pottery wheel mounted at the top [Illustration 1.7.]. I titled the process appropriately *!Gravity*. The exclamation mark symbol, in many programming languages, reverses the value of the expression that follows it.



Illustration 1.7. *!Gravity Performance*, June 25, 2023

1.4. OUTER SPACE

1.4.1. Dark Energy and Dark Matter

Since the 1920s, scientists believed that the universe was expanding, but at a decreasing rate, as gravity was pulling everything back together¹⁸. The discovery of the accelerating expansion of the universe was the result of research by American astrophysicists in the 1990s, and it was awarded the Nobel Prize in Physics in 2011¹⁹. Through the observation of distant supernovae, it was proven that the opposite is true.



II.1.8. Jarosław Grulkowski, *Built a new world 2m*, 2021

From Einstein's theory of relativity, the aforementioned conclusions about this repulsive gravitational force, believed to have originated from the Big Bang, can be derived. The Big Bang was triggered by the accumulation and unification of a large amount of energy, which underwent

¹⁸ J. Rogan (Host), (2020, February 19), Brian Greene (No. 1428) [Video podcast episode], *Joe Rogan Experience*, Youtube.com, Accessed: July 25. 2024

<https://www.youtube.com/watch?v=r4wQsmAtZoc&t=2312s>, [tłum. własne].

¹⁹ *The Nobel Prize in Physics 2011*, Accessed: September 20. 2024, <https://www.nobelprize.org/prizes/physics/2011/summary/>, [tłum. własne].

a sudden and immensely intense expansion²⁰. Dark energy—an invisible force evenly filling cosmic space—is the ongoing cause of acceleration, exerting an expansive pressure on the structure of spacetime.

An artistic representation of similar processes can be seen in *Build a New World 2M* (2021) by Jarosław Grulkowski, which, through a regular grid of lines, suggests the existence of an overarching order. The symbolic depiction of matter in the form of dark spheres (in other drawings by the artist, referred to as molecules) simply conveys a powerful image of the creation of the world [Fig. 1.8.]. Their light-absorbing darkness can even evoke associations with black holes or dark matter.

His Dark Materials, a fictional trilogy by Sir Philip Pullman, presents an extraordinary approach to the subject of dark matter, which, in literary fantasy, becomes a self-aware entity capable of indicating the course of future events when using appropriate apparatus. In parallel realities, one of which is our real world, dark matter, also known as Dust, becomes the initiator of many natural processes and even a forbidden object of study, the exploration of which is considered synonymous with sin.

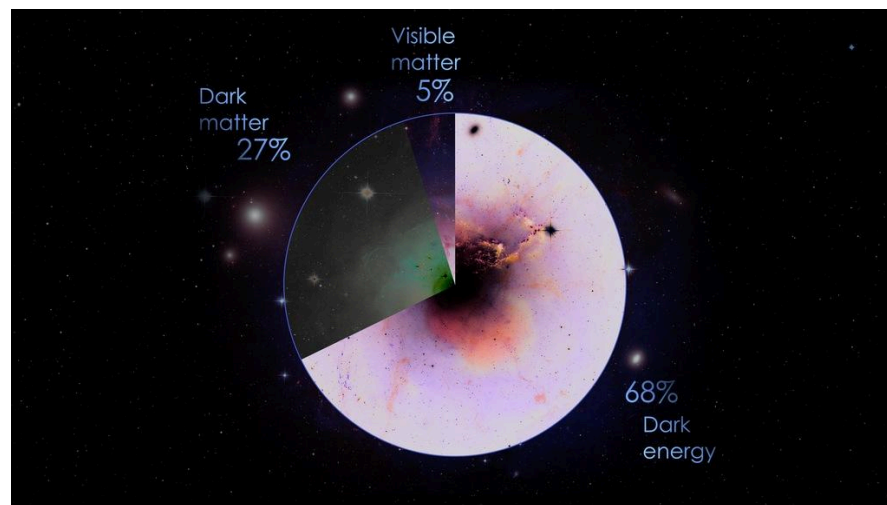


Illustration.1.9. Graph illustrating the percentage composition of visible matter, dark matter, and dark energy in the Universe.

²⁰ J. Rogan (Host), (2020, February 19), Brian Greene (No. 1428) [Video podcast episode], *Joe Rogan Experience*, Youtube.com, Accessed: July 25, 2024 <https://www.youtube.com/watch?v=r4wQsmAtZoc&t=2312s>,

Dark matter, which is about five times more abundant than visible matter [Illustration 1.9.], along with dark energy that fills most of the universe, represents the most elusive parts of reality. How far are we from a complete understanding when we have only discovered dark matter indirectly? It revealed itself through its gravity, which curves spacetime and thus influences the visual observations of distant corners of the universe, carried out by tools such as the Hubble telescope²¹.

1.4.2. Humanity at the Center – The Anthropic Principle and the Fine-Tuned Universe

In the face of this mysterious vastness, humans can feel proportionally small and insignificant, especially when such a large part of reality escapes our limited ability to comprehend the world. The feeling of insignificance is masterfully depicted by Arkady and Boris Strugatsky in their novella *Roadside Picnic*, where our planet seems to be just a "picnic stop," where an incomprehensible civilization left some of its bizarre trash, permanently altering the reality of an abandoned Earth. Yet, we have reasons for consolation. According to John Wheeler's participatory anthropic principle, derived from one interpretation of quantum mechanics, an "observer" is necessary to give the universe meaning, as no phenomenon can be deemed to exist until it is observed²².

One can also take this a step further—to the concept of the *fine-tuned universe*, which suggests that if almost any of the universe's fundamental properties, from the characteristics of atoms to the distribution of galaxies, were different, life would likely be impossible²³. In other words, everything seems to have converged to create a self-aware form of life—us. This view of reality seeks to explain why certain constants and measurable properties of what surrounds us are as they are, and not otherwise. Of course, these are all hypotheses. Despite advanced research equipment, we may still, as humanity, find ourselves in *Flammarion's engraving*²⁴ [Illustration

²¹ A. Balzer, K. Carpenter, E. Henderson, J. Jeletic, M. Marosy, J. Wiseman,, *Hubble Focus: Dark Universe*, National Aeronautics and Space Administration, 2024, s. 15-16, [tłum.własne].

²² *Forms of the anthropic principle*, Dostęp: 15 sierpnia 2024, <https://www.britannica.com/science/anthropic-principle/Forms-of-the-anthropic-principle#ref1078377>,

²³ P.C.W. Davies, *Cosmic jackpot: why our universe is just right for life*, Boston, 2007, s. 2,

²⁴Illustration by an unknown author, likely styled to appear older than it actually is; the year of creation is unknown. It was first published in 1888 by the French astronomer Camille Flammarion.

1.10.]—we have peeked beyond the celestial sphere and barely understand where we are. We must remain humble in the face of reality to be able to envision things that are still unimaginable. Who²⁵ could have imagined the Internet before it came into existence? In 1928, physicist and Nobel laureate Max Born told a group visiting the University of Göttingen: "Physics, as we know it today, will end in six months."²⁶ At that time, it was not yet suspected that protons would turn out to be divisible elements of our reality. In fact, the existence of neutrons had not even been discovered.

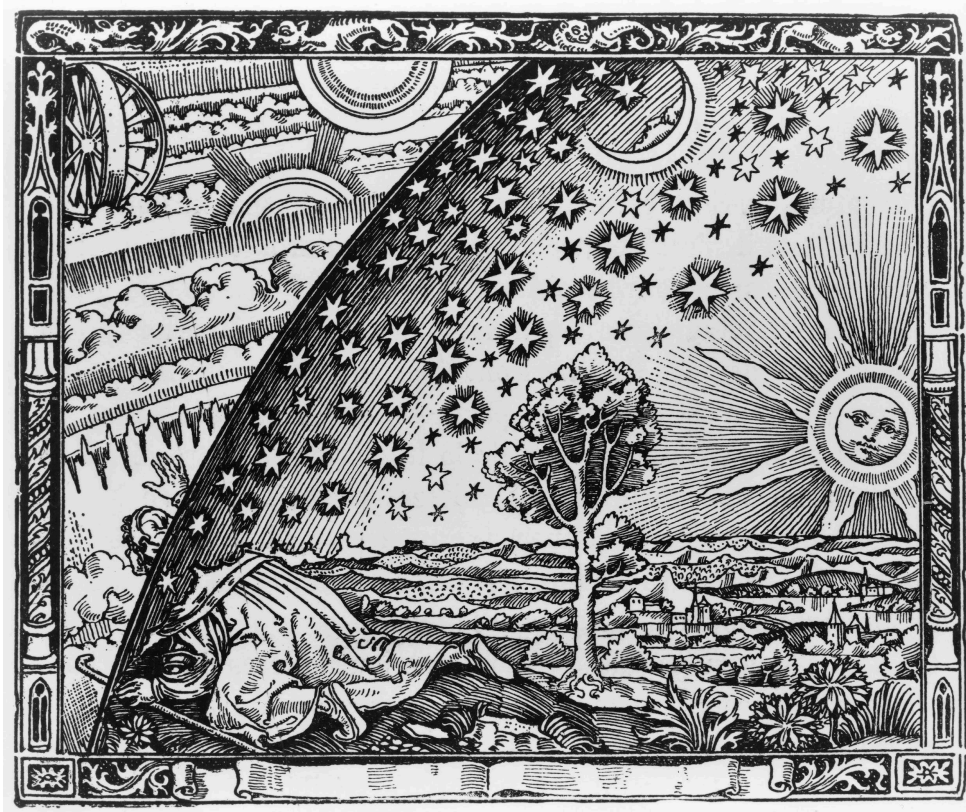


Illustration 1.10. The so-called Flammarion engraving.

Questions about the nature of the universe, observed only through the lens of our senses, have long been a fruitful area of artistic exploration. In his frequently exhibited installation *Solar*

²⁵ Marshall McLuhan in his 1962 publication *The Gutenberg Galaxy*, Marshall McLuhan predicted the rise of the Internet, describing the concept of a global village of the future.

²⁶ S.S.W. Hawking, *A Brief History of Time: From the Big Bang to Black Holes*, Warsaw 1990, p. 146.

Equation (2010), Mexican-Canadian artist Rafael Lozano-Hemmer [Illustration 1.11.] invites us to experience the human scale in relation to the vastness of the cosmos. As he himself says, "It is very important to (...) remain humble in the face of the fact that when we take something like the sun and reduce it 200 million times, it fits under the vault of a church, giving us perspective on our own scale. If we were to reduce Earth by the same factor, it would be the size of a small pea²⁷."



Il.1.11. Rafael Lozano-Hemmer, *Solar Equation*, 2010

In the *Cosmos* series, I also focused on working with scale. In the ceramic surfaces, I aimed to capture not only the enigmatic, visual nature of spacetime but also to build a relationship between everyday ceramic practices and the vastness of the universe. I created enlarged²⁸ glaze tests, portraying my imagined depictions of the cosmos. Through the use of light, much like in the observation of distant galaxies with the Hubble telescope, I can reveal the depth of the material—glaze—and suggest to the viewer the immensity of the depicted, imagined point in the universe, extracting its own "sample."

²⁷ R. Lozano-Hemmer, *Solar Equation*. *Relational Architecture* 16, Dostęp: 5 września 2024, https://lozano-hemmer.com/solar_equation.php,

²⁸ In relation to the commonly accepted sizes, which are not standardized but derive from ceramic practice, they usually, regardless of location, adopt similar values.

1.4.3. String Theory – A Unified Theory

Our size invariably makes us feel small in the face of the vastness of the cosmos. The claims that move us away from this feeling are usually associated with past eras, shifts in worldview, most profoundly expressed in the abandonment of geocentrism. String theory, which might be the gateway to finding *the theory of everything*, still seems to be tailored to humanity, as a three-dimensional, self-aware being. String theory, whose origins date back to the 1960s and 70s, only experienced its breakthrough in 1984. Since then, many eminent scholars, including Edward Witten²⁹, have worked on it. Witten declares that there is no other path for the development of physics³⁰. The basic objects in this theory are not particles occupying single points in space but objects that have only length (...); they resemble infinitely thin pieces of string³¹. The construction of this theory has sparked hope for explaining the properties of real particles³².

So, where does the humanistic aspect come into this complex discovery? Once again, it seems necessary to extensively quote Stephen Hawking:

"It seems that [string theories – author's note] make sense only if spacetime has 10 or 26 dimensions, not just 4 as usual!? (...) Why do we see only three spatial dimensions and one time dimension? The explanation goes as follows: In the extra dimensions, space is very tightly curved, so its size is extremely small—about a millionth of a billionth of a billionth of a billionth of a centimeter. It is so tiny that we simply do not notice these dimensions (...). However, a new question arises immediately—why have some, but not all, of the dimensions become so tightly curved? (...) In searching for an answer to this question, we may turn to the weak anthropic principle. Two spatial dimensions seem to be too few to allow the development of complex beings like us³³."

The encounter with the theoretical inevitability of more than four dimensions inspired me to create the installation *Entangled Dimensions*. This work is an attempt to spatially represent the realities that

²⁹ The multiple award-winning professor at the Institute of Advanced Study in Princeton.

³⁰ G. Farmelo (Host), (2019, 2 September), *Edward Witten interviewed by Graham Farmelo* (nr 5), , *The Universe Speaks in Numbers*, SoundCloud.com, Dostęp: 25 lipca 2024, <https://www.youtube.com/watch?v=r4wQsmAtZoc&t=2312s>

³¹ S.W. Hawking, *A Brief History of Time: From the Big Bang to Black Holes*, Warszawa 1990, s. 150.

³² *Ibid*, s. 150.

³³ *Ibid*, s. 152-153.

exist simultaneously and overlap, where objects from one dimension move into others through reflection in the planes of their boundaries—transparent plexiglass panels.

I have the impression that the creators of the opening sequence for the television adaptation of *His Dark Materials*—Clarissa Donlevy and Yongsub Song—also drew inspiration from string theory, particularly from its visual interpretations. This BAFTA³⁴-winning clip shows coexisting parallel realities, which, as the animation progresses, are soon revealed as vibrating, luminous strings [Illustration 1.12].



Illustration 1.12. Stills from the opening sequence of the series *His Dark Materials*, 2019.

String theory seems to conform to the necessity of fitting within our existence, but it's possible that this is merely a flaw caused by the fact that we, limited and not yet wise enough³⁵, are the ones creating the theories. Given that we are (only/also) humans, it's difficult to adopt a different perspective on reality, especially since we haven't been able to communicate with any other self-aware form of life whose perspective we could take as a contrast to our own.

³⁴ The shortened name of the British Academy of Film and Television Arts Award (BAFTA).

³⁵ Hawking assumes the possibility that we will find a unified theory when we become sufficiently wise.

1.5. AI / AGI³⁶

When asked to write two sentences about itself, ChatGPT responded:

"AI, or artificial intelligence, is a field of computer science focused on creating systems that can perform tasks requiring human intelligence, such as understanding language, recognizing images, or making decisions. AI is based on algorithms and models that learn from data, allowing them to improve their performance without direct programming."

We are indeed getting closer to creating a conscious machine, but we still don't know the path that could lead us there. According to Yann LeCun, chief scientist for AI at Meta, who openly criticizes grim predictions labeling AGI as a fatal threat, AI lacks the ability to understand the physical world, the capacity to memorize and recall things, long-term memory, and the capability to plan and reason³⁷ to become truly intelligent.

The currently widespread and commonly used form of artificial intelligence is large language models (LLMs), such as ChatGPT. There are also more specialized models, such as Bible Chat (which answers questions about the Bible) or blueJ, focused on taxes. Listening to a recent conversation with Sam Altman, CEO of OpenAI and responsible for the series of GPT models, one can get the impression that we won't have to wait long for GPT-5, which will eclipse all previous achievements in this field. Elon Musk's xAI is also joining the race, with Grok2 currently surpassing GPT-4 Turbo in many aspects.

In the course of educational activities conducted in the Studio of Technology and Ceramic Techniques in Painting and Sculpture, I decided to explore the potential of AI. Students were tasked with "passing" a chosen two-dimensional visual material, such as a photo, drawing, or painting, through a specific AI model they selected, and using personalized prompts³⁸ to process

³⁶ AGI (ang. *artificial general intelligence*).

³⁷ L. Fridman (Gospodarz), (2024, 7 marca), *Yann LeCun: Meta AI, Open Source, Limits of LLMs, AGI& the Future of AI* (nr 416), *Lex Fridman Podcast*, Youtube.com, Accessed: September 5 2024, <https://www.youtube.com/watch?v=5t1vTLU7s40>.

³⁸ A set of commands given to artificial intelligence.

it. Sam Altman mentioned a similar process: "One thing I've been using it for lately is as a sort of brainstorming partner. And there's a glimpse of something amazing in that (...)"³⁹.

A similar impression can be created by the visualizations of ceramic objects generated by artificial intelligence, presented in the article *Clay Meets Code* by British artist Elena Howard [Illustration 1.13.]. While analyzing the early encounters between the worlds of ceramics and AI, the sculptor doesn't yet find direct examples of applying this innovative tool to ceramic materials but discusses the ethical issues associated with it and presents her own attempts at generating images.

In the context of my artistic and interplanetary aspirations, it was wonderful to discover a series (though what exactly is it a series of, if it was generated by AI?) by American ceramic artist and experimenter Stephen Creech. Playing with the prompt "tools aliens use to make pottery in space," he created intriguing sets of objects, almost ready-made projects for a three-dimensional installation under the same title [Illustration 1.14.].



Il.1.13. Stephen Creech, *Tools Aliens Use To Make Pottery In Space*, 2023



Il.1.14. Elena Howard, AI generated ceramic idea, 2024

³⁹ L. Fridman (Gospodarz), (2024, 18 marca), *Sam Altman: OpenAI, GPT-5, Sora, Board Saga, Elon Musk, Ilya, Power & AGI* (nr 419), [Podcast video], *Lex Fridman Podcast*, Youtube.com, Accessed: September 5 2024, <https://www.youtube.com/watch?v=jvqFAi7vkBc>.

1.6. `Math.random()`⁴⁰

My interactions with randomness, or more specifically with pseudorandomness, during my five years working as a frontend developer⁴¹, have given me a unique perspective on decision-making processes, both trivial and significant. The tasks assigned to me often required the use of pseudorandom number generators (PRNGs)—algorithms used in data processing to create sequences of numbers that appear random. However, these sequences are entirely deterministic, initiated by a starting value, known as a seed. Knowing the seed and the algorithm allows all subsequent values generated by the PRNG to be predicted.

This deterministic nature of pseudorandom functions interestingly corresponds to decision-making processes in both daily life and art. One of my earliest programs was a simple coin toss simulator, which resolved small dilemmas—choosing between coffee and tea, or deciding what to eat for breakfast that day. This application used a PRNG to answer the question of "heads or tails," providing quick relief from indecision, which often hindered such mundane decisions.

The idea of using randomness in decision-making became even more intriguing to me when I started applying it to more meaningful aspects of life, such as my artistic endeavors. The use of chance in art is well-known, particularly in the work of Jackson Pollock. The painter employed techniques like dripping and splashing paint in ways that appeared random, almost manifesting a renunciation of control over the process. Yet, when Pollock was asked by William Wright on WERI radio in 1950 about the level of control he had over the stick he used for painting, he replied: "(...) *with experience, it is possible to control the flow of paint to a large extent, and I don't use—don't use chance because I deny chance*⁴²." His methods, despite everything, seem to contrast sharply with the inherent predictability of programming, but they are not so far removed. Randomness in art, like pseudorandomness in programming, is often not devoid of predictable

⁴⁰ A wordplay based on the function written as `'random()'`, which generates floating-point numbers within the range (0,1], with each number having an equal probability of appearing (as per Miłka Sokół, University of Warsaw <https://skrypty.biol.uw.edu.pl/strona-glowna/python-dla-biologow/python-podstawowe-operacje/liczby-i-obi-ekty-losowe/>).

⁴¹ A role focused on working with user interactions with a product (application, website).

⁴² P. Karmel, *Jackson Pollock: interviews, articles and reviews*, Nowy Jork 1999, s. 22.

patterns. In both fields, something that appears random is often the result of a complex relationship between controlled processes and initial conditions.

Such reflections led me to find certain parallels between the organized world of programming and the seemingly carefree, unrestrained nature of artistic creation. Both fields use elements of chance to generate unique, often unexpected, effects. However, delving deeper into the mechanism of PRNGs and the methodology of various artistic approaches, it becomes clear that nothing is truly random. As Carl Sagan once stated, "If you wish to make an apple pie from scratch, you must first invent the universe"—there exists a compelling network of interconnectedness and hidden order even where there initially seems to be only chaos and randomness. Whether analyzing a brushstroke on a canvas or the deterministic nature of PRNG sequences, the source and influences lead to a result that is anything but purely random—they are the outcome of a complex, yet detectable, set of rules and conditions.

Before I began working on the *Theory of Everything*, I was deeply engrossed in the *Fiszbinowce* series, consisting of porcelain sculptures created using plaster molds. The process of making them was highly intricate and required a great deal of patience. From the finished molds, which, due to the nature of slip-casting, represent the negative of the final object, I scraped away layers of plaster using metal brushes and power tools. This was a particular challenge because, by working only on the negative space, I couldn't see the final shape of the sculpture until the first casting was made. I perceived this as a process that would result in a random outcome, as the final appearance of the form being created in this way remained a mystery until the very end. The texture created by the strokes of the metal brush reminded me of whale baleen, which is where the series drew its name from. I believed that this reliance on a tangible pattern added an interesting dimension to the works. Because, in a sense, I couldn't see what I was doing, it felt as if someone else was creating the pieces. I even had the surprising feeling that the whales themselves were helping me make these sculptures. However, I later realized that this was simply a reflection of the difficulty I had in making decisions about my work. The method I used allowed me to relinquish responsibility, letting chance play a significant role in determining the final form.

A similar approach was visible in the next series of vessels I created, *Organic*. Instead of designing the shape from scratch, I looked for objects that could serve as models. I mainly focused on wood, and the first element I used was a piece of wood found in my parents' woodshed. This lucky discovery marked the beginning of the series. From that point on, every time I visited a place that had personal significance, I searched for pieces of wood that could serve as future models. In creating this series, I was responsible for transforming the wood into porcelain vessels, but I left the initial form to chance. I liked this mix of control and randomness because it allowed each object to be connected to its origin story. In this way, each vessel gained a unique and personal dimension, making both the process and the final product much closer to me.

Currently, I continue to experiment with incorporating elements of chance into my art, but my current work focuses on the effects achieved through the use of the pottery wheel. Rather than relying solely on the process of throwing, I deform the pieces after shaping them. I shake and collide the thrown forms, sometimes joining two or more parts to create larger compositions. As a result, dynamically deformed objects are created, which refer to the idea of black holes, with the deforming and compressing process evoking the concept of spaghettification. Through this process, I create entire galaxies of sculptures. In each case, the randomness and physicality of the deformation give the works a unique character. All the elements become part of a larger cosmic narrative, with their own story and meaning.

In summary, my journey from the *Fiszbinowce* series, through the *Organic* vessels, to my current work on the pottery wheel has been marked by constant testing and building relationships between control and randomness. The time spent on this research allowed me to develop a unique creative method, effectively combining decisions about what is orderly and structured with what is appropriately random. Random situations often bring an element of surprise, which we artists seek so eagerly. In ceramics, this may seem difficult to implement, but bridging the gap from the initial intention to the result with some unpredictable, random factor is more interesting and engages me in a longer, more complex process. With my personality and the predictability that comes with it, creative activities become too boring for me to continue. Finding this necessary balance has allowed me to create exceptional works that resonate with a personal theme while also advancing artistic innovation.

Chapter II: Construction of a Prototype Hybrid Kiln for Firing Large Ceramic Tiles

2.1. WHY?

I think I should start by explaining why I decided to build my own kiln instead of focusing solely on artistic creation. I believe that by shaping our environment and creating our own tools, we can make our art truly unique. It's important to remember that the same tools tend to leave similar marks, and as a result, they standardize—more or less—the character of the work. Even an Adobe Photoshop user has only as many algorithms as the creator who wrote the code has provided. Therefore, artists unsatisfied with standard solutions create their own accessories and equipment, seeing it as a critical part of the creative process and a path to achieving original effects.

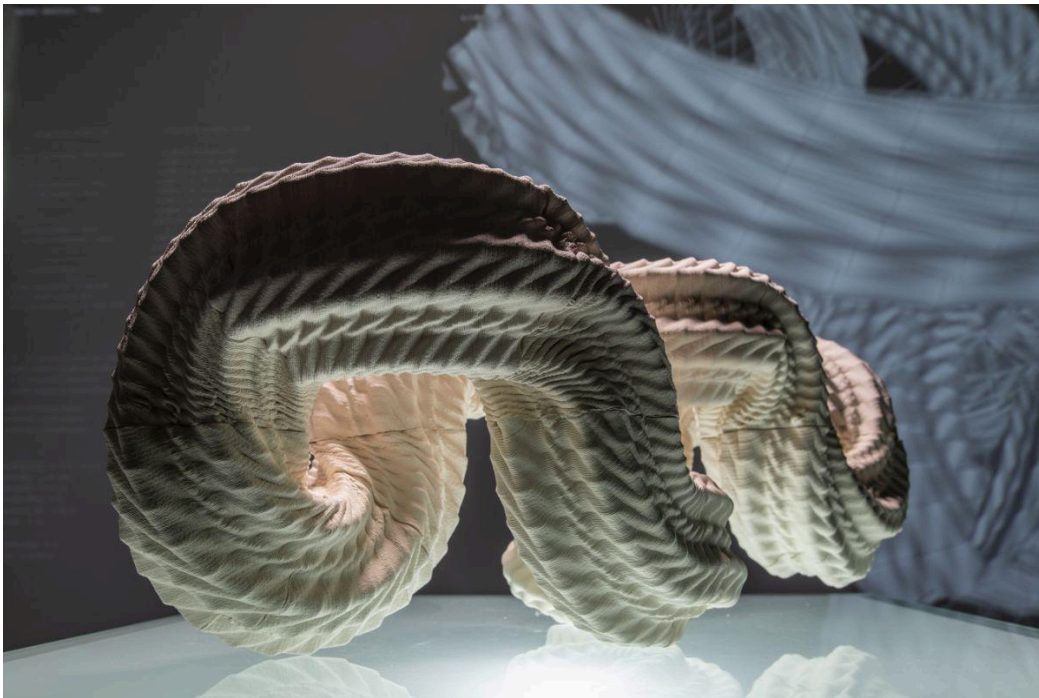


Illustration 2.1. Adam Abel, *Cyberboros*, 2020-2021

A great example of an academic breaking away from the standard programs is Wrocław-based ceramicist, Dr. Adam Abel, who wrote his own application within the Processing platform to generate spatial forms, which he later transfers to reality using 3D printers [Illustration 2.1.]. As he writes about one of his works, the authoring of the program allows it to become an integral

part of both the creative process and its outcome: "I extract the original skeleton of their construction, which reflects the algorithm that created it. Its strong traces left on the surface reveal the internal mechanism of form-building, which, from thousands of points, edges, and sections, composes a digital organism inscribed in the shape of a loop¹."

In the opening scene of the award-winning documentary *It Might Get Loud* (2008), Jack White, known for his involvement in bands such as The White Stripes, Dead Weather, and The Raconteurs, builds an instrument from an old plank and a Coca-Cola bottle. After plugging it into an amplifier and playing it, he says: "And who said you have to buy a guitar?" While he may not take such an uncompromising approach in all his creative choices, too much simplicity could be limiting. In 2019-2020, with the help of Fender Custom Shop, White designed and adapted his guitar, creating the Three-Wheel-Motion Low Rider Telecaster², a name that doesn't fully capture the numerous additional functions White added to personalize its sound.

I believe that the examples provided successfully demonstrate the value of such actions. The process of creating tools—whether analog or digital—becomes part of the artistic journey and allows for greater control and individualized expression. Over the course of my career, I have built many kiln constructions, both gas and electric, but I am aware that the project planned within my doctorate surpasses anything I have done before. In this way, I challenge myself both in terms of the scale of the construction and the complexity of the firing process. I hope to create a unique technique that will place me among artists experimenting with process and tools.

¹ A. Abel, *Chryssalis*, Accessed: September 11 września 2024, <https://www.adamabel.com/pages/digitalchrysalis.html>.

² The name refers to three knobs mounted on the guitar, alluding to a maneuver performed by low-rider cars, where during a sharp turn, one wheel lifts off the ground while the remaining three stay in motion (three-wheel motion); Telecaster is the name of a guitar model produced by Fender.

2.2. GAS KILNS

My first construction was a simple, handmade kiln of my own design, powered by gas. It consisted of a roofing torch, a metal barrel, and a piece of kiln insulation. It was inexpensive but allowed for higher temperature firings than the electric kilns available to me at the time. Additionally, it provided the possibility of reduction firing—it allowed for creating an atmosphere inside the kiln where there was more fuel than could be burned at once. These conditions removed oxygen from the clay body and glazes, often changing their colors. For example, green copper glazes could turn red, and porcelain glazes with a bit of iron could produce a celadon effect³.

My kiln had many advantages, except for the extreme difficulty in precisely reaching the planned temperature or controlling its rise. These difficulties were especially acute during the first firing attempts. Even if the achieved temperature matched the plan and the firing curve was carefully controlled, some pieces still cracked or overheated due to direct contact with the burner's flame. Moreover, overseeing the entire process was very time-consuming—during the first firings, I spent almost all my time next to the kiln, learning to control it as effectively as possible.

2.3. ELECTRIC KILNS

An electric kiln is the most difficult to build. Designing and constructing the kiln chamber are the easiest tasks. However, controlling the kiln's power is the hardest part. Calculations involving wire diameter, resistance, element length, and other factors depend on so many variables and direct experience that it's difficult to establish definitive rules. Considering all this, it's hard to beat the price and reliability of industrially built kilns⁴.

These words by Frederick L. Olsen summarize the chapter on electric kilns in his book on kiln construction, and it's hard to disagree with him. In the same chapter, he also states that the electric kiln is a product of the 20th century and may turn out to be the fourth most important

³A type of ceramics originating in China, characterized by a celadon-colored glaze, which results from a reduction firing process that reduces iron(III) oxide to iron(II) oxide.

⁴ F. L. Olsen, *The Kiln Book, materials, specifications & construction*, Iola 2001, s. 222

innovation in kiln construction history⁵. Despite the enormity of this challenge, and with Olsen's book possibly feeding my fear of failure, I decided to devote part of my career to understanding how electric kilns function.

My experiences with electric kilns were completely different from those with gas kilns. I didn't start by building my own kilns but by repairing my own and those of fellow ceramists. Over time, I began to notice recurring flaws in the construction of certain brands, while others occurred independently of the manufacturer. However, in most cases, I managed to find solutions. These custom improvements convinced me that I was ready to design my first original construction. It was a small, 20-liter kiln with a regular polygonal base, loaded from the top. The designed kiln used the maximum power of a single-phase installation, i.e., 3.6 kW, and worked flawlessly, even at temperatures of up to 1250°C.

The success of this construction motivated me to design and build a kiln with a much larger chamber and greater power. Unfortunately, with the next prototype, I found that the number of problems grew dramatically with the kiln's size. This time, a 100-liter construction, also with a polygonal base and loaded from the top, despite the assumption of an eight-hour firing to 1200°C, heated to just 800°C after several hours.

Returning to Olsen—perhaps the greatest authority on kiln construction—he presents two methods for calculating a kiln's power requirements. The first method is based on the volume of the kiln chamber and a coefficient of 1.5 kW/CF (cubic feet)⁶.

Olsen's example:

$$2 \times 2 \times 2 = 8 \text{ ft.}^3$$

$$8 \times 1.5 = 12 \text{ kW}$$

As the author notes, this method is not very accurate for small kilns. Trying to apply this method to a 20-liter kiln yields only 1.059 kW. Even increasing the coefficient to 2.07 kW/CF—Olsen's recommendation—gives only 1.46 kW.

⁵ *Ibid.*, s. 207

⁶ *Ibid.*, s. 215

$$20 \text{ cm}^3 = 0.706 \text{ ft.}^3$$

$$0.706 \times 1.5 = 1.059 \text{ kW}$$

The second method, based on the sum of the kiln's internal surface areas, works much better here. The coefficient in this case is 5 to 7 W/in² (inch), which, when converted to centimeters, gives us 1.085 W/cm².

$$3,456^* \times 1.085 = 3,749 \text{ W} = 3.749 \text{ kW}$$

(*sum of the internal wall surfaces of my 20-liter kiln, expressed in cm²)

Using this method and the same coefficient to adjust the mentioned 100-liter kiln, I calculated the power requirement at 7 kW. After replacing the heating elements to match this calculation, the kiln worked flawlessly, reaching a maximum temperature of 1200°C. These experiences were crucial in designing and building my hybrid kilns.

2.4. HYBRID KILNS

I use the term "hybrid kiln" to refer to a device that uses two different fuel sources for firing. In the case of my construction, it is an electric and gas kiln combined. There are four reasons why I decided to build such a kiln. The first is to achieve stable and fully controlled heating of the workpieces to the desired temperature using electricity. The second is the ease of igniting the gas burners by taking advantage of the temperature already accumulated in the kiln chamber. The propane gas used in firing spontaneously ignites at temperatures above 470°C, which could serve as the lower limit for switching to gas. The third reason is the ease of reaching high temperatures above 1250°C with gas. It also allows for stable and repeatable creation of a reduction atmosphere (even at high temperatures), which is the fourth argument for the proposed construction.

2.4.1 Reduction Atmosphere in Electric Kilns

The last argument presented above has an alternative solution for electric kilns. Pravoslav Rada, a Czech ceramicist and authority in ceramic technology, defines reduction firing (commonly referred to simply as "reduction") *as firing ceramics with insufficient oxygen supply; the carbon monoxide present in the atmosphere removes oxygen from metal oxides, thereby reducing them to pure metal*⁷. According to this definition, it is enough to "take away" oxygen from the kiln chamber to change the firing atmosphere. This can be done by adding or placing material in the kiln that will burn in the closed chamber. A popular method used at the Department of Ceramics at the Academy of Fine Arts in Wrocław is pouring cooking oil into the kiln during cooling. Depending on personal experience, ceramists practicing this method introduce additional fuel into the chamber at temperatures between 800°C and 600°C. Pouring oil into the kiln above 800°C can be not only ineffective—the oil may burn completely before the reduction effect is fixed—but also very dangerous. Above this temperature, rapid combustion of the oil can occur, resulting in an explosion.

To perform such a reduction, the kiln needs to be properly adapted. A hole is necessary for pouring the oil, into which a metal pipe functioning as a funnel can be inserted. Inside the kiln, below the pipe's outlet, an open container made of material resistant to thermal shock is placed. This prevents the oil from spreading freely throughout the kiln chamber. The entire procedure must be carried out during the free cooling of the kiln, meaning the kiln can no longer be heated by its elements. Multiple oil applications are necessary to fix the effect on the work surface, avoiding overfilling the container. Unfortunately, this forces the creator to return to the smoky kiln room at regular intervals to repeat the required task. It is not only cumbersome but also hazardous to health due to the carbon monoxide released during the process.

An alternative solution is the method used at the Academy of Fine Arts in Gdańsk. The academics there achieve a reduction atmosphere using wood. Personally, I consider this method

⁷ P. Rada, *Techniques of Artistic Ceramics*, Warszawa 1993, s. 196.

much easier to perform, even though it requires opening the kiln within a similar temperature range to the oil reduction and placing a well-dried piece of wood in a pre-designated spot. The primary advantage of this method is user safety. Here, a single "loading" of wood into the kiln is sufficient due to its slow burning [Illustration 2.2.].



Illustration 2.2. Loading wood into the kiln

Illustration 2.3. Reduction effect using wood with traces of ash

Interestingly, the reduction does not always succeed. There are kilns where it never works, usually due to their extremely tight construction. This can be explained by referring to Olsen, who claims that to achieve a reduction atmosphere, an excess of fuel is not enough; draft is also necessary⁸. It seems that older kilns, where parts of the insulation around the mechanical

⁸ F. L. Olsen, *The Kiln Book...*, *op.cit.*, s. 212.

components, such as doors and covers, have worn out, or simply less airtight kilns due to their design, are easier to "reduce" because the leaks create the necessary draft.

In conclusion, reduction firing is possible in electric kilns. However, it is difficult to execute, can be hazardous to health, and has limited capabilities, as reducing during cooling and below 800°C is not sufficient for reducing porcelain or celadon glazes.

2.4.2 Temperature Ranges

The third argument for building a hybrid kiln is the ease of achieving high temperatures. While it is possible to reach temperatures above 1250°C in electric kilns, it requires the use of special materials for the heating elements. The commercial name for this type of wire is Kanthal ATM, which is several times more expensive than the more commonly used Kanthal A-1. This means that replacing such elements is very costly, especially considering that heating elements wear out more quickly when operating at higher temperatures. Additionally, Kanthal ATM requires greater power. In section 2.3, I discussed how difficult it can be to correctly estimate a kiln's power requirements. A further challenge for the user may be that some electrical systems cannot support such high demand.

2.4.3 Controlled Heating

The first reason I provided—achieving stable and fully controlled heating of workpieces to the desired temperature using electricity—stems from the limitations of gas kilns. In comparison to electric kilns, it is much more difficult to achieve slow and even heating in gas kilns. Even fully automated kilns, equipped with specialized controllers, turn the burners on at full power for short intervals. This firing pattern creates the risk of "overheating" or even cracking pieces that are positioned close to the flame. Additionally, some glazes, especially raw ones, tend to overheat at lower temperatures⁹, which can cause them to run or detach from the clay body.

⁹ Glaze that is heated too quickly begins to crack and separate from the body, which in the subsequent stages of sintering can cause it to completely detach or form what is known as "crawling."

2.4.4 The First Prototype

The first hybrid kiln prototype I built had dimensions of 40x40x40 cm, resulting in a volume of 64 liters. It was a small kiln in which I wanted to test the above-discussed ideas. One of the key issues was the kiln's power, and consequently, the placement of the heating elements. To calculate the power, I referred again to Olsen's formula:

$$40 \times 40 \times 4 \times 1.085 = 6944 \text{ W} = 6.944 \text{ kW}$$

Despite the calculated requirement of nearly 7 kW, I decided to initially conduct tests using a single-phase 3.6 kW heating element, as the electric heating element was only intended to provide slow pre-heating and heating up to the self-ignition temperature of propane gas (470°C). A significant consequence of reducing the kiln's power was simplifying the electrical installation and ensuring greater safety when working simultaneously with high voltage and fire. It also made the placement of the heating elements easier since, in this case, they only had to be installed in the kiln's floor. Placing the elements there would also prolong their lifespan by preventing direct contact with the gas burner flame.

The kiln was also intended for electric bisque firings, so I aimed to test its ability to reach 900°C using electricity. Therefore, I did not connect the gas burners, even after exceeding 470°C (the self-ignition temperature of propane). Unfortunately, after the first test, I found that the maximum temperature I could reach using electricity was around 750°C. My goal was to heat the kiln chamber to 1000°C within six hours, but I encountered difficulties in evenly distributing the heat, as it concentrated in the lower parts of the kiln.

Although I still needed to cautiously heat the kiln using the burner, the temperature was sufficient to switch to gas and continue heating to 1380°C. Upon reaching 1200°C, I induced a reduction atmosphere by increasing the amount of gas supplied beyond the level required for temperature rise. Most of the test materials fired during this process were made of porcelain. I managed to achieve the desired level of reduction, resulting in a cool-toned white porcelain.

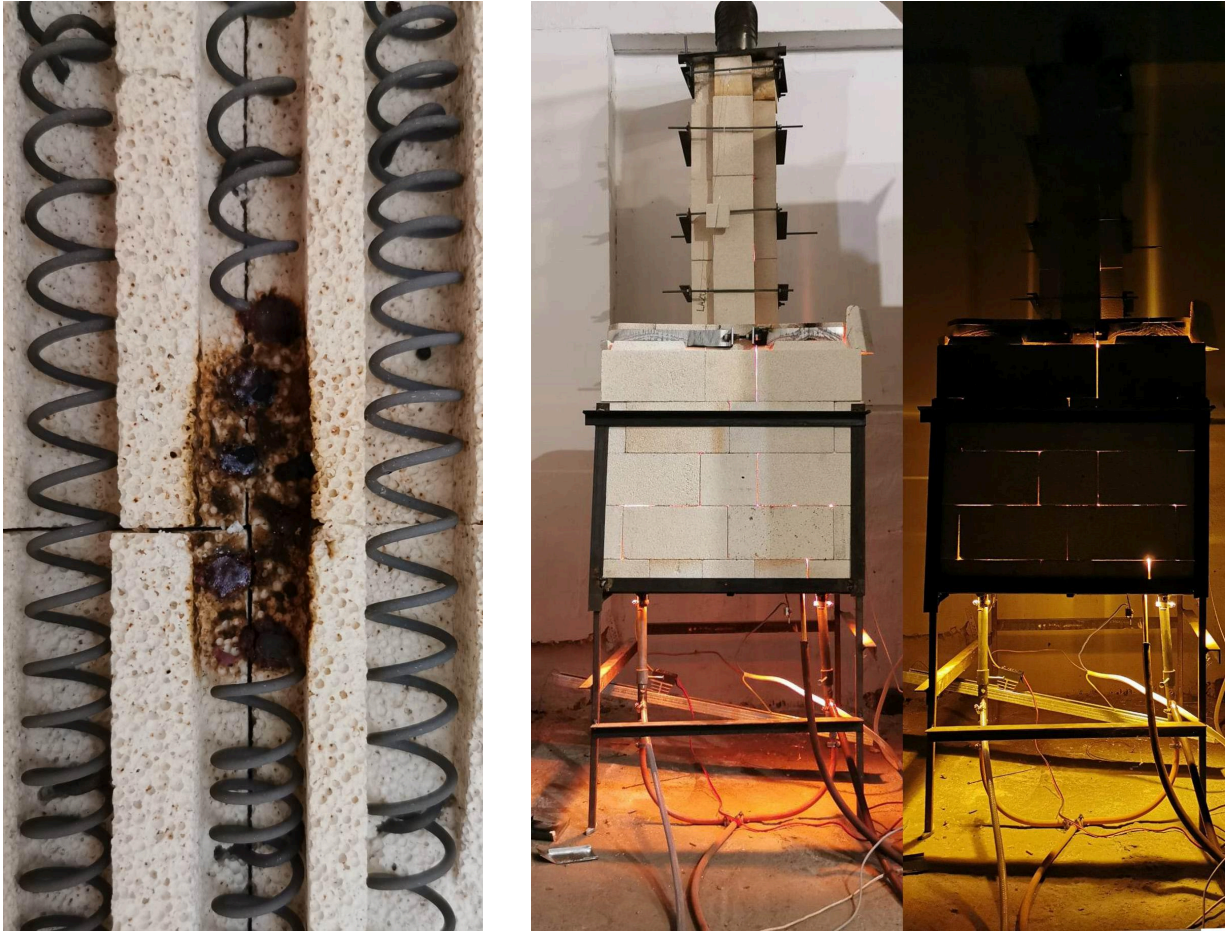


Illustration 2.4. Place where the heating element burned out Illustration 2.5. Prototype kiln structure without external insulation during firing

Unfortunately, after the firing described above, the heating element burned out [Illustration 2.4.], meaning it had to be replaced. This time, using Kanthal ATM wire, I was able to increase the kiln's power to a value close to the result of Olsen's formula. I also changed the connection from single-phase to three-phase. This time, using electric power, I successfully reached a temperature of 1000°C, and the heating element survived 14 more firings at temperatures ranging from 1300°C to 1350°C.

2.4.5 Hybrid Kiln for Large Surfaces

The next hybrid kiln construction was intended to meet very specific and unusual tasks for a ceramic kiln—firing single large-format surfaces. I also wanted the kiln to be adaptable in size each time the size of the fired surface changed. The challenge was that theory suggests the best shape for a kiln is a cube or a shape close to a cube¹⁰.

I began the design process by solving the problem of a modular and adjustable-size construction made of bricks, with particular emphasis on a movable kiln lid. The module used was a heat-resistant insulating brick, L26, with dimensions of 230x115x65 mm. Using 182 bricks, I built a lid measuring 1610x1690 mm. To avoid gluing the bricks together, which would negate modularity and could cause cracking during uneven heating and cooling, I designed metal corners fastened together with threaded rods. Four corners, properly fastened together, act as a clamp that holds the lid intact. The key to this design was positioning the threaded rods far enough from the kiln so that the metal structure would not heat up and expand [Illustration 2.6].



Illustration 2.6. Kiln lid using metal corners

¹⁰ F. L. Olsen, *The Kiln Book*..., *op.cit.*, s. 207.

As seen in the illustration, two sets of threaded rods on each side of the lid were necessary. The further rods hold the lid together, while the rods near the lid stabilize the metal corners. The weight of the lid, of course, prevents manual lifting. To address this, I constructed a frame around the kiln for a chain hoist. The specific nature of working with large surfaces, especially after firing, requires free access to the kiln chamber from all sides, which is why the kiln walls consist only of loosely arranged bricks that can be quickly dismantled after firing. The final maximum dimensions of the kiln were 1610x1690x65 mm, providing a volume of 177 liters.

Another critical element is, of course, calculating the power requirement. Referring once again to Olsen's formula, I arrived at a result of just 4 kW. It was clear to me that calculating power based on the wall surface area for a kiln of such an unusual shape would be inaccurate. Keeping similar principles in mind, I modified the formula to account for all the internal surfaces of the kiln, not just the walls. Using the parameters of existing, tested constructions, I calculated a coefficient that allowed me to estimate the new kiln's power requirement at 18 kW.

Modularity had to also be reflected in the way the heating elements were installed in the kiln floor. Therefore, I divided the kiln floor into sections, without preparing separate grooves for the heating elements as is commonly seen in factory-built kilns. There, the elements are often placed in carved channels in the kiln walls. Here, they lay freely on the floor, separated by spacers made from the same material as the L26 bricks [Illustration 2.7].

The final important element to discuss is the base on which the large surfaces rest during firing. Using large kiln shelves could cause the work to crack where it sits directly over the shelf joints. Therefore, I decided to use small fireclay tiles measuring 250x125x20 mm. Reducing the size of the tiles was intended to balance any thermal stresses occurring between the shelves and the large surfaces being fired. With such a large number of divisions in the base, the movement of the parts due to heat expansion should distribute evenly across the entire structure. In contrast, using two or four large kiln shelves would result in significant stress at a few connection points [Illustration 2.8].

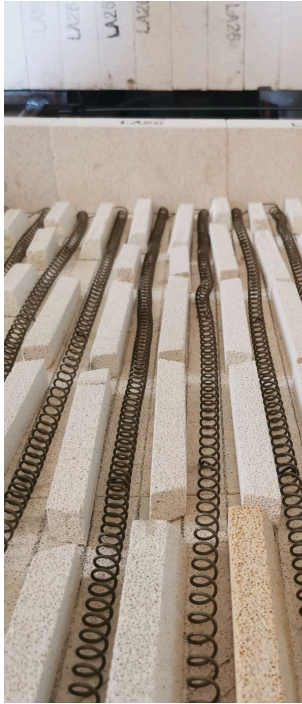


Illustration 2.7. Arrangement of heating elements



Illustration 2.8. Kiln floor

After attempting to fire the first piece, I found that the electrical installation in my studio could not support such powerful heating elements. As a result, I had to reevaluate the functionality of the construction assumptions that were supposed to ensure the kiln's modularity. The system I designed turned out to be highly efficient, and the reconstruction did not take long. I simply reduced the internal dimensions of the kiln chamber to 1000x1000x70 mm and simultaneously lowered the power requirement to 11 kW. After this update, I was ready for another test.

Similar to the previous hybrid construction, the firing plan involved slowly heating to 900°C using electricity and then switching to gas. This time, the final planned temperature was 1100°C—sufficient for firing the applied glazes. Unfortunately, after the firing, it became apparent that I had not achieved the desired reduction atmosphere, or at least not to the extent I had intended.

For the next firing, I followed the same plan. This time, to improve reduction, I reduced the diameter of the chimney outlet, which resulted in a satisfactory glaze appearance.

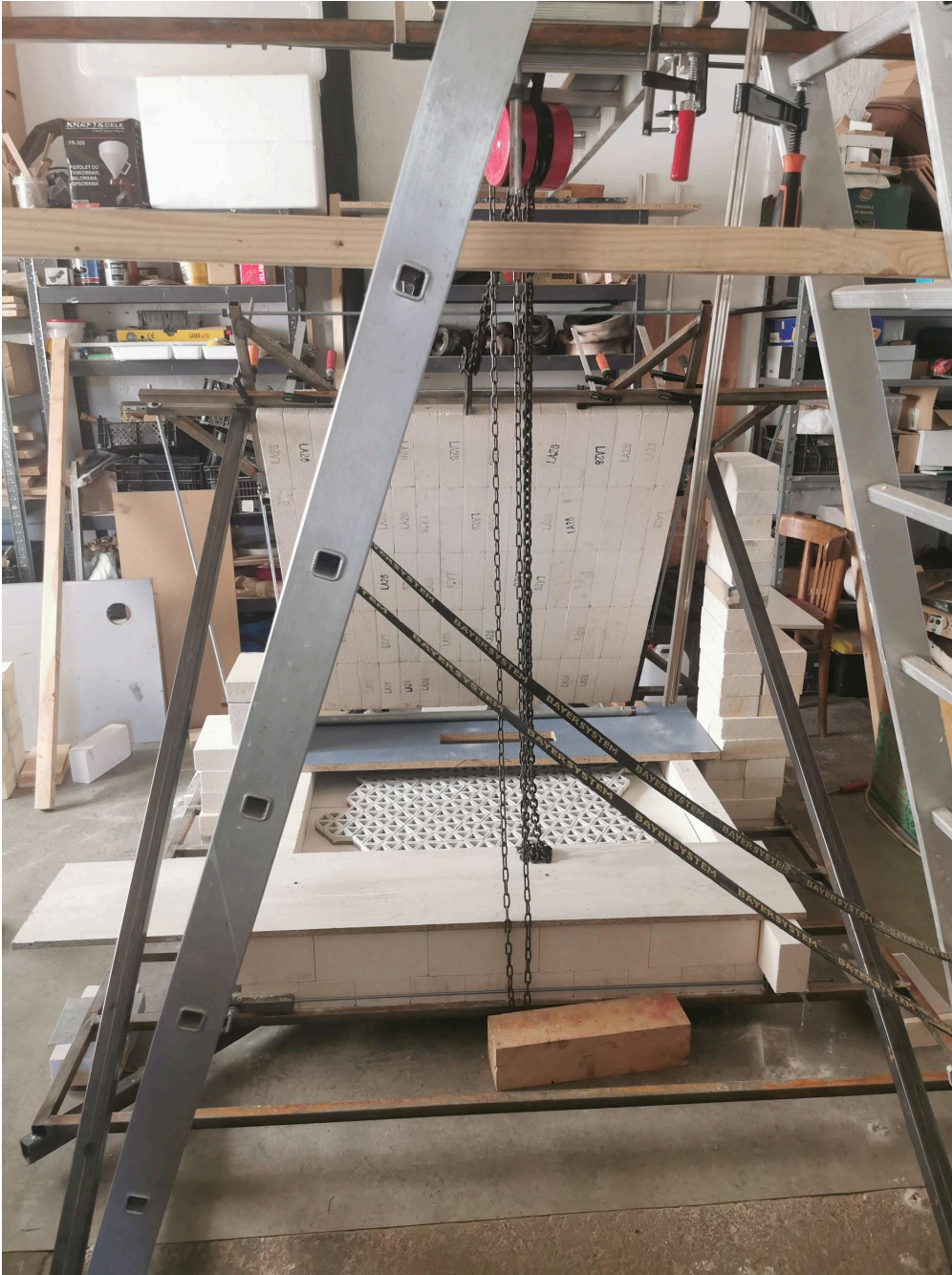


Illustration 2.9. Opening the kiln after firing

2.5 Conclusions

To sum up, building my own kilns, despite being time-consuming, provides me with a unique perspective on my creative process. I gain deep insight into how both electric and gas kilns work, allowing me to manipulate the processes within them to achieve specific artistic outcomes. This knowledge currently enables me to exploit the advantages of each kiln type, combining their functions innovatively and creating opportunities for firing with unusual results reflected in my work.

One of the first gas kilns I constructed produced a snow-white version of the "Organic" vase due to its strong reduction atmosphere. This piece was appreciated and exhibited in Munich at the Talente 2015 exhibition, Internationale Handwerksmesse Munich. In 2018, a celadon tea bowl fired in one of my kilns won the national competition for ceramic tea bowls, "Czarka z essencyą." My biggest success was the "Fiszbinowce" series, which has been showcased in over 20 exhibitions in Poland and abroad. Works made of hard porcelain, fired in my kiln at 1350°C, have been presented at significant ceramic exhibitions, such as the 2019 Korean International Ceramic Biennale, the 2019 Taiwan Ceramics Biennale, and the 2020 61st Faenza Prize, International Competition of Contemporary Ceramic Art.

The time and effort invested in creating my own tools pay off in spades—not only through recognition but also through enhanced creativity, personalization, and artistic cohesion that these tools bring to my work.

Chapter III: Research on Lesser-Known and Small Raw Material Deposits in Lower Silesia

3.1. Basic Research

In 2015, I completed a month-long internship at the Institute of Ceramics and Building Materials in the Experimental Department of Decorative Materials in Warsaw. Although the structure of the Institute has undergone minor changes, the Decorative Materials Section continues its research in the broad field of ceramic technology. My time at this prestigious institution, a place I had dreamed of for years, allowed me to observe and apply a scientific approach to raw material research and the development of glaze recipes. The Institute is equipped with tools and devices capable of precisely determining the parameters of glazes and raw materials, offering any ceramic artist an ideal technological workspace.

Even artists who stick to pre-packaged products need to adjust the ceramic body to the applied glaze (or at least they should!). However, operating such equipment is often complicated and time-consuming, not to mention the high costs associated with purchasing similar laboratory equipment. In a ceramic artist's workshop, we often lack both the time and space for complex research, but simpler methods exist to analyze the properties of ceramic materials outside of a laboratory setting.

During my three years in the doctoral program, I aimed to gather several methods for determining the basic, essential knowledge of raw materials, glazes, and clays. I compared these methods with those used at the Institute, always seeking a cheaper and simpler alternative for conducting tests, fully aware of the reduced precision and repeatability of the results. Several of these methods were necessary for the work described in this dissertation, which I will outline below.

In my work with new raw materials, often lacking extensive documentation, I frequently began from scratch. The first step after acquiring a raw material is to clean it of organic impurities—assuming, of course, that the material didn't come from a ceramic supply store. In

such cases, the product sheet provided by the manufacturer typically includes the necessary basic information. However, if I dug up clay from a garden or found an unidentified material, I soaked the raw material in water for at least 24 hours [Illustration 3.1]. Afterward, I poured the suspension through a sieve with 992 holes per square centimeter, which I determined through experimentation to be the most optimal sieve for my original recipes.

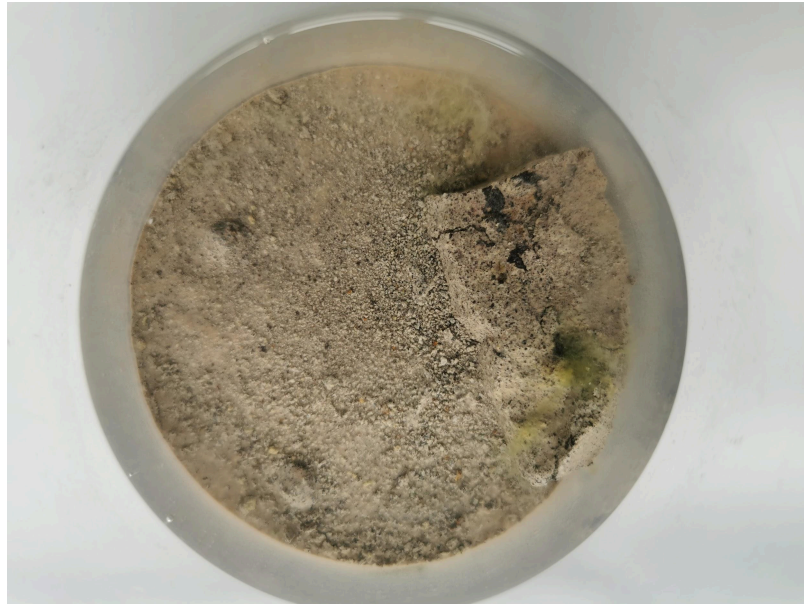


Illustration 3.1: Soaking halloysite from the Dunino mine

Once cleaned, each material is fired individually on pre-bisqued tiles to determine the most critical information for me—its melting point. At the Institute, this is done using a device that can be simplified as a very small kiln with a thermal imaging camera, through which you can observe the material sample during firing and thus determine its melting point with an accuracy of one degree Celsius. In my art studio, the equivalent test involves determining the melting point through a series of firings in a test kiln [Illustration 3.2].

Usually, I start by firing a small amount of material at 1200°C and, after this introductory firing, I classify its condition into one of three categories: underfired, overfired, or properly fired. Underfired samples are fired again at a higher temperature. Depending on the degree of

underfiring, this could be an additional 10°C or 20°C, with a maximum firing temperature of 1410°C—the highest I can achieve in my kilns. Similarly, for samples identified as overfired, I prepare new tiles and lower the temperature with each firing until the melting point is determined.

The next step is to assign each raw material to a category: colorant, flux, stabilizer, or glass-forming substance. This designation is not strictly necessary, especially in an artistic studio, but it can be useful in preparing more stable utility glazes¹.



Illustration 3.2: Raw material samples before firing

¹When preparing such a glaze, it is necessary to use raw materials from three groups: fluxes, stabilizers, and glass-forming substances. Failing to follow this principle could result in a "runny" glaze if an insufficient amount of stabilizers is included in the mixture. On the other hand, if we are aware of such behavior, we can use the recipe as a base for crystalline glazes. In the artist-ceramicist's workshop, these seemingly "faulty" recipes can find excellent applications. The most important thing is to properly prepare the kiln for possible glaze overflow if using these intentionally "runny" glazes. It is recommended, for example, to use broken kiln shelves and apply a thick layer of kiln wash on every shelf. Securing the kiln in this way ensures it is ready for any experiment.

Another essential test I perform is evaluating the impact of a given raw material on the CTE (Coefficient of Thermal Expansion). This is crucial because some raw materials, when combined with certain clay bodies, may be incompatible in terms of CTE, leading to glaze cracking or, in extreme cases, the cracking of the ceramic body itself. Testing the coefficient of thermal expansion was particularly important for the "Entropy" project, where the glaze needed to match the clay body not only decoratively but also structurally, acting as a binding agent between the body and the glaze.

At the Institute, this test is conducted with specialized equipment. However, a simpler method is suggested by Pravoslav Rada:

"From the clay body we want to test, we make thin strips and glaze them on one side with the available glazes. The strips are hung in the kiln and fired. The appropriate glaze will not cause the strip to bend. However, if the glaze has a higher shrinkage than the body, the strip will bend towards the glaze, and if it has lower shrinkage, the strip will bend in the opposite direction²."



Illustration 3.3: Longitudinal sample from the ceramic body. The top part should have a hole to allow hanging during firing. The bisque-fired sample should be glazed by pouring and fired in the appropriate temperature on a stand that allows it to hang without touching anything.

² P. Rada, *Techniques of Artistic Ceramics*, Warsaw 1993, p. 69.

By regularly testing every raw material in my studio and its impact on the CTE, I was able to experimentally determine the degree of deviation from the flat plane in millimeters. This allows me to easily visualize the effect of adding a raw material to a base glaze and how it influences the deformation of the body and glaze cracking. This distortion on thin samples is far more pronounced than on larger objects [Illustration 3.4]. It's possible that on some works, this effect won't be visible at all. However, being aware of how a glaze influences the body is crucial, particularly when working on complex projects prone to increased deformation.

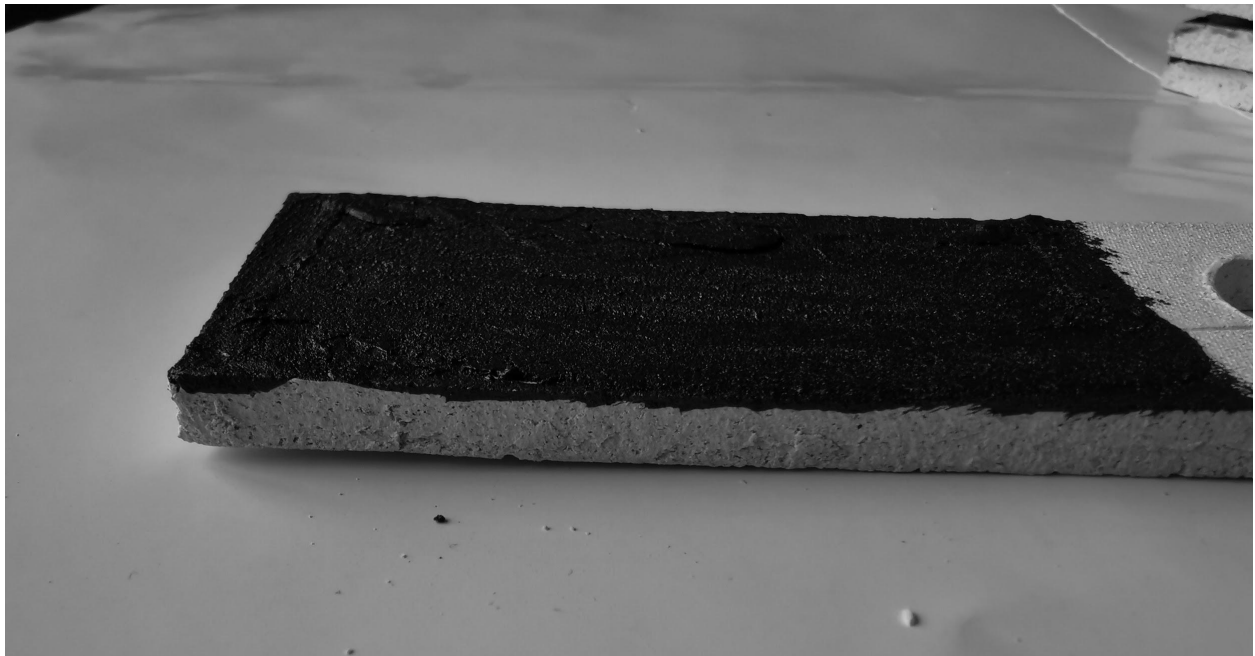


Illustration 3.4: Deviation of the sample from the flat plane

Another crucial property of glazes that I aim to determine in my research is their density. A significant number of glazes provide a similar, if not identical, result regardless of density. However, there are glazes for which the desired final effect depends heavily on the precise measurement of the amount of water added to the mixture of raw materials. Various methods are used to determine the required value. Among ceramists, the use of a hydrometer is popular, though it is somewhat imprecise. In my opinion, a better tool for testing suspensions, such as glazes, is a pycnometer. It consists of a vessel and a lid or stopper and measures a very precise volume, allowing it to be weighed [Illustration 3.5]. I opted for a 100 mL container, partly for

convenience and because it aligns with the common notation used in the Decorative Materials Section—Xg/100mL. After filling the pycnometer with glaze, placing the lid on, and wiping off the excess glaze, you weigh it to obtain the desired parameter, for example, 150g/100mL.



Illustration 3.5: Pycnometer on a scale

If testing raw material for use in ceramic bodies, it is important to conduct shrinkage and water absorption tests. These are very popular methods, also described in detail in Pravoslav Rada's book, which I've cited multiple times. I always perform these tests following his instructions without introducing my own modifications, so there is no need to elaborate further here.

A particularly important property when creating ceramic slabs is testing the resistance of the ceramic body to thermal shock, which is related to thermal expansion. For this, I heat a previously prepared sample point-by-point for 2 minutes using a gas burner, then rapidly cool it in water at room temperature. This is a single test cycle. Most ceramic bodies containing grog, which shows greater durability, withstand between one and three of these cycles.

3.2. Raw Materials

3.2.1. Basalt from the Wilków Quarry

In my initial studies of raw materials from Lower Silesia, I analyzed basalt from the Wilków quarry. This volcanic rock has a melting point I experimentally determined to be 1100°C. According to Pravoslav Rada, *stoneware glazes matte well when ground volcanic rocks such as basalt³ are added*. Inspired by my melting point studies, where I fire raw materials without any additives, I decided to use basalt with three different particle sizes in an unusual way, sprinkling it over wet, freshly glazed works. This resulted in matte melts of varying sizes on the glaze surface. I discuss these experiments in more detail in subchapter 5.5. I also tested this material as an ingredient in ceramic bodies for the "Black Holes" series and in black slips, which proved ideal as bases for reduction glazes [Illustrations 3.6-7].



Illustration 3.6: Black slip No. 1 with 5% basalt added

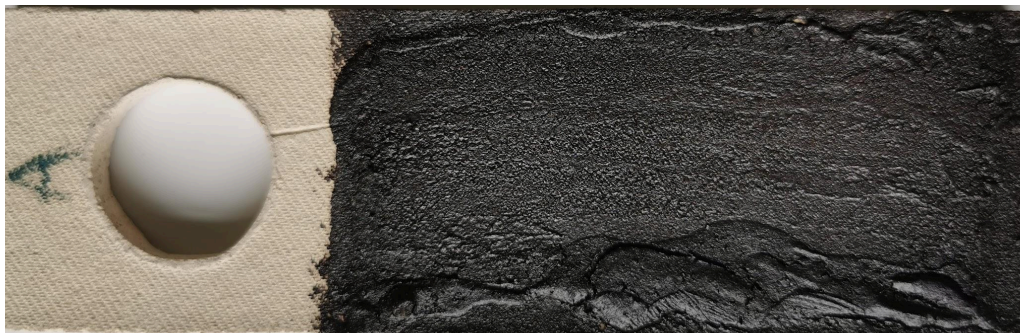


Illustration 3.7: Black slip No. 2 with 10% basalt added

³ P. Rada, *Techniques of Artistic Ceramics*, Warsaw 1993, p. 72.

3.2.2. Wollastonite from Nowa Wieś Kłodzka

The second interesting material I used in my artistic work is wollastonite, CaSiO_3 (calcium silicate), from Nowa Wieś Kłodzka. *Wollastonite helps reduce the formation of crazing in glazes and increases their resistance to temperature changes*⁴. As an additive to the ceramic body, *by introducing calcium and silicon, it helps lower thermal expansion and enhances the strength of the fired clay*⁵. Although it has no impact on color effects, these properties proved very beneficial in the context of research on larger ceramic slabs.

To assess the suitability of the wollastonite for use in ceramic bodies, I conducted tests on five samples of clay without wollastonite and five samples⁶ with a 15% addition of it. The samples with wollastonite endured 6–7 cycles of the previously described thermal shock tests, indicating increased resistance to sudden temperature changes and, consequently, reduced thermal expansion. Despite its high melting point of 1540°C , I decided, after prior testing, to use wollastonite as a frit—sprinkling it over freshly glazed works from the "Cosmos" series, achieving characteristic speckling after firing [Illustration 3.8].

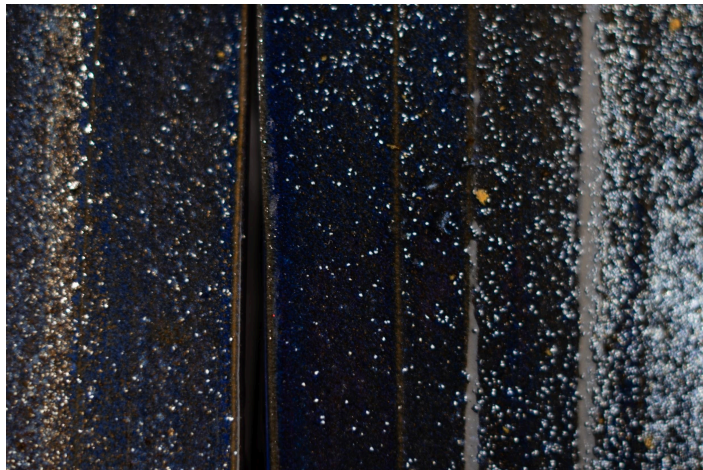


Illustration 3.8: Effect of using wollastonite on the surface of the work

⁴ Ibid, p. 44.

⁵ J. Kaplan, 2015, *Techno File: Clay Body Building*, *Ceramics Monthly*, Accessed: July 23 2024, <https://ceramicartsnetwork.org/ceramics-monthly/ceramics-monthly-article/Technofile-Clay-Body-Building#>

⁶ I performed five identical tests to eliminate false results (caused, for example, by improper mixing of the material) and to average the conclusions.

3.3.3. Halloysite and Kaolin from Dunino

The next three raw materials I obtained through the courtesy of Dominika Kulczyńska, a doctoral student, and Aleksander Glich, a graduate of ceramics art and design, both associated with the Wrocław Academy of Fine Arts. The materials come from Dunino [Illustration 3.9], particularly from a halloysite mine, one of only three in the world. The other two are located in the United States and New Zealand.

The accumulation of halloysite near Dunino is a result of weathering. What weathered? Basalts, or rather basaltic pyroclastic breccias—rocks formed from the debris expelled during an eruption in the form of ash, bombs, or lapilli⁷. The halloysite and kaolin samples I received were tested primarily for their suitability as components of ceramic bodies and stabilizers in glazes. Halloysite, which is a hydrated aluminum silicate ($\text{Al}_4\text{Si}_4\text{O}_{10}\cdot 4\text{H}_2\text{O}$), is excellent for this purpose. Due to its origin, it also serves as an interesting alternative to quartz sand and kaolin, commonly used by ceramists as glass-forming substances and stabilizers.

The use of halloysite and kaolin from this region results in interesting effects in glazes, mainly due to the chemical impurities present in these raw materials. Analyzing the fired samples containing halloysite, I can identify fragments of basalt and local iron impurities, which I infer from the reddish tint in the ceramic body that became visible after firing.



Illustration 3.9: Raw material samples after firing

⁷ T. Pawlik, *Haloizyt i wstyd Francuza, czyli atrakcje Dunina z kurzym wampirem w tle*, Dostęp: 10 sierpnia 2024, <https://agatowcy.com.pl/2018/06/01/haloizyt-dunino/>..

Chapter IV: An Online Application for Creating Databases of Raw Materials, Glazes, and Ceramic Bodies

In 2012, I participated in the "Ceramic Glaze Recipes (CGR)" seminar as part of the European Leonardo Da Vinci project¹. During this event at the Institute of Ceramics and Building Materials in Warsaw, I was introduced to an online application for creating glaze recipes. The seminar presented the capabilities of the application and provided the necessary skills to use it. The tool was quite complex and required knowledge of the unity method, i.e., the Seger² method, for calculating glaze recipes.

At that time, I recognized the potential of such software, but the time-consuming process of entering recipes into the database discouraged me from using the application regularly. Today, that particular application is no longer available online, but a new, widely popular alternative has emerged—the glazy.org platform. This application operates much like a social networking site, where ceramists from around the world share experiences, glaze recipes, firing curves, and knowledge about ceramic materials.

Despite its many advantages, Glazy didn't provide the option to store research results conducted on specific raw materials. While I could enter data such as melting temperature, shrinkage, absorption, or effects on CTE (Coefficient of Thermal Expansion) as a description, these were not the type of information the program could actively utilize in creating glaze recipes. Therefore, I decided to develop my own application that could offer such functionality. I also aimed to simplify the glaze composition process by eliminating the Seger method and introducing a much simpler approach based on weighted averages.

I had previously written about this method in my master's thesis, *Nature of the Vessel – Firing Techniques, Bodies, and Glaze Recipes Based on My Experience*. This method is a simple

¹ The Leonardo da Vinci Program was part of the European Union's Lifelong Learning Programme, implemented from January 1, 2007, to the end of December 2013. The program aimed to promote workforce mobility within the European labor market and to implement innovative educational solutions to enhance professional qualifications.

² *The primary use of the Seger method is that it provides a simple way to control the balance between the three groups (fluxes, stabilizers, and glass formers) and the composition of the flux group. This is crucial in determining the properties of the glaze [own translation from M. Cardew, Pioneer Pottery, New York 1971, p. 134].*

formula that determines the final temperature of combined raw materials based on the melting points of individual ingredients and their percentage in the final mixture:

$$x = \frac{x_1 \cdot w_1 + x_2 \cdot w_2 + x_3 \cdot w_3 + \dots + x_n \cdot w_n}{w_1 + w_2 + w_3 + \dots + w_n}$$

Here's an example set:

Nazwa	Temperatura topnienia[°C]	Zawartość w zestawie[%]
Kreda	1000	30
Nefelin Sjenit	1125	50
Kaolin	1550	20

$$\frac{1000 \cdot 30 + 1125 \cdot 50 + 1550 \cdot 20}{30 + 50 + 20} = 1172,5$$

The calculated temperature of this mixture is: 1172,5°C.

I am not alone in my desire to abandon the Seger method. *Some ceramic artists, particularly in England, believe that calculating glazes using the Seger method is a waste of time and that the method is unhelpful in creating aesthetically interesting glazes. They argue that calculations involving abstract quantities like atomic mass, which must be checked in textbooks, are nonsensical given the artist's temperament*³.

The application I designed performs calculations for the user, whose only task is to prepare an appropriate database of raw materials, similar to the information shown in the example table. One essential principle to follow is using ingredients from three groups necessary

³ M. Cardew, *Pioneer Pottery*, New York 1971, p. 130.

for the proper composition of a functional glaze: glass formers, stabilizers, and fluxes. The foundation for preparing such a database could be the table found in *Artistic Ceramics Techniques* by Pravoslav Rada, which lists properties typical of ceramic raw materials, including their melting points⁴.

Nowy materiał

Nazwa:

ID:

Temperatura (°C):

Gęstość (g/100 ml):

Typ:

Qr code:

Zdjęcie:

Opis:

Receptura

Nazwa: <input type="text" value="Kaolin"/>	Ilość (%): <input type="text" value="25"/>	<input type="button" value="Usuń"/>
Nazwa: <input type="text" value="Nefelin sjenit"/>	Ilość (%): <input type="text" value="25"/>	<input type="button" value="Usuń"/>

SUMA: 50%

Zakres temperatur:

Sugerowana temperatura: 1350.00 °C

Illustration 4.1: Form for a new material entry in the library

When getting familiar with the tool I designed, the first steps involve creating a personal materials library. The user can also opt to use the materials already available in the application.

⁴ P. Rada, *Techniques of Artistic Ceramics*, Warsaw 1993, p. 60-62 .

For me, preparing this part of the system was especially important because it allows documenting raw materials about which we initially know nothing, or for which our knowledge is limited.

By using the research methods I detailed in the previous chapter, users can independently determine the basic properties of each material. In the materials library [Illustration 4.1], each material can be assigned values such as name, melting point, group affiliation (glass formers, stabilizers, fluxes, or colorants⁵), and application. The application also provides space for a longer description, allowing creators to freely take notes. Every material is assigned a unique numerical identifier and a QR code, making it easier to find or identify the ingredient on their studio shelves. Therefore, the label on a container doesn't need to include all the information; it can be easily retrieved in the application by scanning the QR code [Illustration 4.2].



Illustration 4.2: Mobile version of the app, accessible after scanning the QR code with a smartphone

⁵ Colorants are not a key component of glaze, which is why they were not included in the previous listing.

The next essential step is creating personal glaze recipes. To do this, users select the required ingredients from the available materials list and specify their percentage in the mixture. Based on the entered data, the application informs users of the mixture's melting point and whether more ingredients need to be added.

Once the glaze recipe is saved, it receives a generated identifier and QR code, just like the raw materials. Users can then conduct a glaze firing test and, based on the results, edit the recipe, add photos, and define the preferred glaze density, expressed in g/100 mL⁶.

Nowy materiał

Nazwa:

ID:

Temperatura (°C):

Gęstość (g/100 mL):

Typ:

Qr code:

Zdjęcie:

Opis:

Receptura

Nazwa: Ilość (%):

Nazwa: Ilość (%):

SUMA: 100%

Zakres temperatur:

Sugerowana temperatura: 1227,50 °C

Illustration 4.3: Recipe generation after selecting the target melting point range for the mixture

⁶ It refers to the density of the glaze before it is applied to the ceramic body, after it has been mixed with water.

One of the most important features of the application is the ability to generate glaze recipes. It was created with beginner users in mind, who are just starting their journey with glazes. Thanks to my algorithm, users can choose from the available raw materials and select the desired final firing temperature range. The generator then randomly assigns percentage values to the individual components in such a way that the desired set temperature is achieved. This process uses random functions, which I described in more detail in subsection 1.6.

By generating and using different combinations of raw materials, novice users can gradually learn to build their own recipes by observing the relationships between similar glaze compositions and the appearance of fired samples. An additional advantage of this feature is its potential for future development. I plan to expand the glaze generator by connecting the user's database to artificial intelligence. A trained AI model, based on the accumulated information, would not only be able to generate new recipes but also predict the appearance of a glaze after firing by creating a visualization of the final sample. The actual firing would then serve only to confirm the AI-predicted outcome.

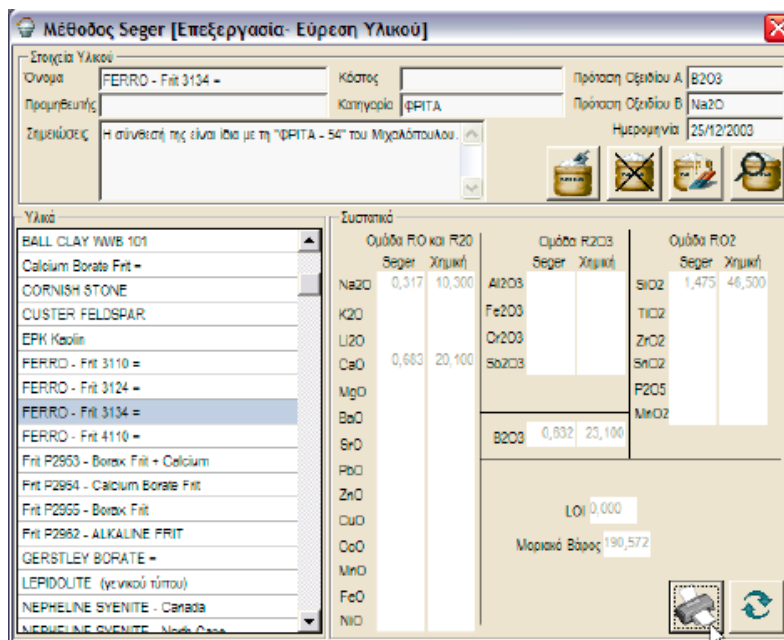


Illustration 4.4: Glaze creation form. Example of a Greek application with a complicated interface, partly due to the use of the unity method.

In summary, I decided to develop this application because I always struggled with the systematic creation and cataloging of glaze recipes. My goal was to create a simple tool, in Polish, that would be fast and easy to use. The simplicity lies in excluding the Seger method from necessary calculations, but also in significantly simplifying the user interface.

Given the nature of my doctoral project, the ability to create a database of raw materials sourced from small, unique sites was crucial to me. I also needed a tool that allowed me to quickly determine the characteristics of these materials and easily use them in my own recipes. There is also another key argument—the ownership of the database. I want users to feel confident that the materials they collect for personal use remain their property after entering them into the system. Despite the sense of community and openness felt on platforms like Glazy.org, all the data entered there becomes the property of its creator, Derek Au.

Currently, the prototype of the application is complete and ready in its basic form for the testing phase. However, I am keen to develop it further in the future. I plan to apply for funding from the Ministry of Science and Higher Education to make the development of the application and its refinement with AI possible. I would like to test the product with a group of users and later popularize a free version of the program among ceramists.

Chapter V: The Theory of Everything. Description of the works that make up the dissertation

The dissertation consists of seven cycles. They are groups of ceramic objects, installations and performance. The works are a form of personal journey to the heart of the mystery of the cosmos (wherever it is). What intrigues me in this creative process is not so much the search for answers, but the process of discovering and expressing the unknown through art.

5.1 BLACK HOLES

This is the first series that was created as part of the *Theory of Everything* project . I started working on it back in 2018 during the *Martison Award* symposium in Latvia. While packing for the trip, I took Stephan Hawking's book *A Brief History of Time*, which I quote here many times. It was supposed to be an inconspicuous read, meanwhile it has had and continues to have a huge impact on my artistic work. In the series in question, I try to build analogies between black holes and forms spun on a wheel. Much follows, for example, from Hawking's statement that *if a black hole is spinning, its interior may not contain a singularity in the usual sense (...). Instead, it may contain a ring-shaped singularity*. The spinning of a ceramic mass on a wheel, can be stopped in a turned spatial form, by means of the introduction of deformations, which arise directly from the nature of this movement. In turn, the deformations help to capture the mysteriousness of the interior of the black holes, preventing the viewer from simply looking inside the objects. The fact that rolling on a wheel generally presupposes the existence of a ring of matter, makes it possible to symbolically reflect both *the ring of singularities*, and to visualize a circular event horizon. The work on this series resulted in seven forms fired at 1250°C, varying in size, formation and color. I distinguished three of them by covering the surface of the symbolic event horizon with a colorful textile fiber. I turned the forms out of a dark mass, colored with the use of Wolf basalt, which forms a unique background for the reduction glazes used. For their juxtaposition, I used, among other things, boron frit, produced at the Institute of Ceramics and Building Materials, and firing was carried out in a reducing atmosphere, achieved by burning oil.

5.2 EVENT HORIZON

It was quite natural for me to move from my work on *Black Holes* to *Event Horizons*. They are a development of the former in both form and subject matter. In this series, I decided to combine ceramics and glass - materials that, for me, represent the contrasting nature of black holes: the known and the unknown. Ceramics form the solid, tangible base of each sculpture, while the glass that connects them embodies the intangible and intangible, in particular the event horizon - the point beyond which, it is impossible to escape the gravity of a black hole. Hawking writes: *the paths of light rays in the event horizon had always to be moving parallel to or away from, each other. Another way of seeing this is that the event horizon, the boundary of the black hole, is like the edge of a shadow - the shadow of impending doom*¹.

Work on the objects proceeded in cycles. First, I experimented with different sizes of glass. The result of these experiments is the work *Event Horizon Ω*, where I connect four ceramic elements with one sheet of glass, trying to capture the moment just before two black holes collide and merge. I then decided to work with recycled glass, which I cut to fit specific ceramic forms. This assumption led me to unexpected results. Because the used glass was scratched, I began to experiment with the clarity of their surfaces. At first I sanded them by hand using carborundum, but the changes were too irregular and I found it hard to control the intensity of the tarnishing. So I decided to use a belt sander, which allowed me to achieve a uniform surface, distorting the image on the other side of the glass. Here I was able to capture metaphorically the fact that the mass of black holes, due to its large gravitational field, curves the image of what we observe around and behind it. But why the rectangular and square panes? The universe has a certain tendency to regular shapes, caused by the laws of physics. The symmetry and formality of nature never ceases to amaze me, whether I observe its animate elements - the perfection of an iris of an eye, the structure of a leaf, or the effects of crystallization of minerals, the shape of sea waves. Absolute synthesis here leads me to regular quadrilaterals and parallelograms.

One of the works - *Event Horizon γ* I wanted to devote to Hawking radiation - one of his most important discoveries. For a long time, scientists claimed that black holes absolutely absorb everything, emitting nothing in return. However, when it was found that black holes have their

¹S. Hawking, *A Brief History of Time. From the big bang to the black holes*, London, 1988, p. 100.

own entropy, it became inevitable to assume, according to the second law of thermodynamics, that they also have temperature, and thus must emit radiation. *If an astronaut falls into a black hole, its mass will increase, but eventually the energy equivalent of that extra mass will be returned to the universe in the form of radiation. Thus, in a sense, the astronaut will be “recycled”*². With this observation, one can hope for further, more in-depth studies of black holes. If any information leaves them, it can be assumed that this will allow us to understand their interior. To visualize the idea described, I decided to place a light source in the object, which emits a bright beam in a darkened room.

In the series described here, I used proprietary glazes, fired at temperatures of 1020-1200°C, in an electric kiln using wood reduction. The chert was a mass made from recycled scraps.

5.3 BRAIDED DIMENSIONS

My artistic explorations related to string theory began by exploring the concept of an object called a tesseract - a four-dimensional hypercube. I wondered how I could represent it in the familiar three dimensions of space³. Carl Sagan is remarkably adept at familiarizing us with this kind of object⁴, by building an analogy between imaginary existences, living in two dimensions, which are unable to perceive and understand our third dimension, and us, caught in the trap of width, depth and height. Just as - decomposing a cube into a grid, we get an arrangement of squares in two dimensions, so, decomposing a tesseract, we get a grid consisting of interconnected three-dimensional cubes. Such explanations, however, did not bring me any closer to the visual concept of representing this solid.

I decided nevertheless to include the idea of the cube in my work, enclosing the projected composition *Dimensions intertwined* in a space of 1x1x1m. This installation is my personal interpretation of string theory, in which the Plexiglas sheets represent successive planes of extra dimensions, and the ceramic elements, intertwined between them, serve to visualize the strings of reality. Where do the extra dimensions come from? As I mentioned in subsection 1.4.3 - string

² S. Hawking, *A Brief History of Time. From the big bang to the black holes*, London, 1988, p. 112.

³ I would like to illustrate it here as well, but in two dimensions of paper, it would border on a miracle.

⁴ *Cosmos: A Personal Voyage* [documentary series], e. 10, dir. Adrian Malone, PBS, 1981.

theory requires, according to Hawking, the existence of at least 10 dimensions (9 spatial and time). The M-theory, announced in 1995 by the aforementioned Edward Witten, which is supposed to unite all superstring theories⁵, assumes one more additional dimension, giving us 10 dimensions of space and time⁶. With the help of seven transparent planes, I want to show these seven additional dimensions, escaping our cognition, which exist materially, but their colorlessness suggests that they are invisible to the human eye. I decided to roll the ribbons flowing through them out of the ceramic mass and, thanks to the natural behavior of the material as it is turned on the potter's wheel, to show at the same time the jitteriness and fluidity of the matter - the strings. The clay, fired at 1250°C, is clearly reflected in the subsequent sheets thanks to its dark hue. The reflections build up, revealing shimmering images of other dimensions.

I had the opportunity to present this composition as part of *the First International Conference: Methodological and Cognitive Aspects of Visual Arts* at the home Academy in September 2023, together with the first objects of the series *Cosmic Waste*. The exhibition was accompanied by a text created with the help of artificial intelligence - GPT Chat.

5.4. SPACE DEBRIS

Space debris from the perspective of Earth, does not seem to be a significant problem (after all, we can't see it in the sky!). So it was surprising to me to discover a special NASA program [II.5.1.] dedicated to measuring and preventing the negative effects of the presence of this debris in Earth's orbits. The status as of January 2022 showed nearly 9,000 tons of junk in orbital space, of which more than 25,000 are expected to be at least 10 cm in diameter⁷. Currently, the main source of trash in space is satellite debris. The incredible increase in their quantity due to the lack of regulation and selection makes it easy to collide, and it should be remembered that the amount of space in orbits is limited.

I first encountered this intriguing phenomenon in more detail, thanks to the documentary *Space Smash* (2018), which discussed, among other things, some of the largest debris of its kind - rocket fuel tanks [II.5.2.]. It is mainly to these massive forms that the objects of the *Space*

⁵ Superstring theory combines string theory with supersymmetry theory.

⁶ E. Witten, *String Theory Dynamics In Various Dimensions*, Nuclear Physics, Section B, vol. 443, nr 1-2 (1995) 1995 ; Vol. 443, No. 1-2 s. 85-126.

⁷ *Frequently asked Questions*, Access: September 2, 2024,, <https://orbitaldebris.jsc.nasa.gov/faq/>.

Debris series under discussion refer. The potter's wheel seems to be an ideal technique for depicting the transformation of a regular, manufactured form under the influence of heat or collision with other objects. In the works, I wanted to capture the dissolution of the material, mimicking the impact of entering the atmosphere and burning the object, but also being bruised by other debris or colliding with the Earth's surface. The flanges of the objects indicate, being only a part of a larger whole, the remaining traces of rivets and joints that have long since disintegrated. The scale of the spun forms is meant to affect the viewer's imagination - how is it possible that such massive objects are circling around us, and what should we feel knowing that they could fall on us at any moment? Emphasizing the weight of the objects with the choice of material is supposed to further influence the viewer, while remembering that the fuel tanks are even bigger!



Figure 5.1: NASA Orbital Debris Program Office logo



Figure 5.2: A fuel tank that went down in 1997 in Georgetown, Texas

I've thrown these works from waste matter. I collected the leftovers from other processes, so that I could eventually mix them to the consistency of a homogeneous mass and use the waste (apparently!) to create forms of space debris. I covered the objects with reduction glazes with the addition of raw materials from Lower Silesia and fired at temperatures of 1020-1200 °C.

5.5 COSMOS

The series was created as an expression of a new outlook on glaze samples. When making such shapes on a daily basis, I use a potter's wheel - a fast and convenient tool for realizing vertical, repeatable pieces. The turned samples retain the characteristic rolling marks and clay texture that affect the final glaze effect. Since I turn most of my work on the wheel, I want the samples to be a kind of miniature of the target work. The *Cosmos* series contradicts this proportion - the sample is enlarged and becomes a work in itself. In cross-section it retains the “L” shape, so important in analyzing the effect of gravity on the glaze during firing. At the same time, it streamlines the kiln packing process, since the planes of the work can be aligned vertically⁸. I pair the finished pieces with the bases to create extensive surfaces that bring the glaze I have put together to the forefront. It no longer complements the form, but becomes the most important element of the work.

In juxtaposing the glazes used, I had the opportunity to use in each of the four sets of planes, the results of my research on materials from Lower Silesia. I used basalt from the village of Wilków with different levels of fineness - from finely ground (up to a fraction of 0.5 mm), which influenced the uniform color of the glaze surface, to larger fractions, which allowed to obtain a spotting effect [Fig. X], as well as cases of “melting” [Fig. X], caused by high firing temperatures (1200-1250°C). As I describe in the chapter on materials research, the basalt I sourced melts as early as 1100°C, making it suitable for use as a flux in this temperature range. Pravoslav Rada also describes basalt as a glaze matting agent⁹. On the surface of the *Kosmos 3* work, I was able to achieve a matting effect just by using an admixture of basalt. The second, interesting material used in this series is wolastonite from Novaya Veselnitskaya, which on the surface of the planes of *Kosmos 4* allowed me to achieve a starry night effect, perfectly illustrating the character of the series.

When planning the color and texture of the glazes, I tried to capture both the superficial appearance and the incomprehensibility of outer space. The symbolic aspect that one must first

⁸ It is more convenient and advantageous to fire tall items of similar size with a small base than flat items with a small height and large surface area.

⁹ P. Rada, *Techniki ceramiki artystycznej*, Warszawa 1993, p. 72, [own translation].

explore the surface of one's own planet in order to portray the cosmos became an important thread in this creative process.

5.6 !GRAVITY

I want to become the first interplanetary ceramicist. Such an intention was once born in my mind. So I began preparations, and I hope that it is only a matter of time before humanity becomes an interplanetary species. After all, the 17th architectural exhibition of the Venice Biennale (2021) has already presented a lunar habitat as part of the *Life Beyond Earth*¹⁰ exhibition, which in consultation with retired astronaut, MIT¹¹ professor Jeffrey Hoffman, was planned as a settlement on the sunny South Pole of the Moon. Of course, it will be very difficult in the initial phase to adapt to the new environment and create structures that will sustain human life (the project presented in Venice envisioned only 300 days of comfortable existence¹²), but at some stage, on such a Mars (it is to be interplanetary!), art must appear. Art that will become part of culture already different from Earth's.

Being the first ceramic artist in space, or on the Moon, or at least on the International Space Station, means much more than just being that first. It would also testify that we have overcome so many difficulties, and that we are in a place and time when we can plan and carry out such a mission as turning on a potter's wheel. Both gravity and centrifugal force are the potter's worst enemies, hence I imagine that turning in space will be received with definite relief. The worst part, however, will be all that has to be done before I get there.

To get closer to the point where I'll be able to roll without gravity, I've decided to create my own exercise device. Of course, I can't simulate zero gravity on Earth, but I can attempt to work in an inverted gravitational field. The structure of the instrument is a wooden cube grid - a frame that holds a potter's wheel hung upside down. This position poses new challenges to the user, such as the clay stretching and disintegrating on its own. Even the simple act of adding

¹⁰ *Moon habitat blueprint at Venice Biennale*, Access: 10 September 2024, https://www.esa.int/Enabling_Support/Space_Engineering_Technology/Moon_habitat_blueprint_at_Venice_Biennale

¹¹ Massachusetts Institute of Technology

¹² *Moon habitat blueprint at Venice Biennale*, Access: 10 September 2024, https://www.esa.int/Enabling_Support/Space_Engineering_Technology/Moon_habitat_blueprint_at_Venice_Biennale

water becomes extremely difficult in reverse gravity. During the opening performance of the *!Gravity* exhibition on May 25, 2023¹³, I took advantage of the natural effect of these struggles by placing sheets of paper on the floor under the toque, thus recording my experience in the language of mud and traces of falling clay. I put on a white protective suit (how little is needed to create an evocative reference!), took off my shoes (without gravity it is impossible to accidentally step on a nail or glass) and rolled.

This experience opens me up to new solutions, putting some creative distance between me and turning, which, having practiced for at least 20 years, I already do often mechanically. Who knows what solutions, useful to ceramists, I might come up with by indulging in the experiment of turning upside down? After all, the drills and screwdrivers we know every day were, in the first place, equipment created by NASA for work in space! One of the first ideas that came out of the performance was to improve the control of the turning of the lathe. Admittedly, I was considering solutions to the problem, due to the hypothetical suspension in weightlessness, but eliminating the pedal that controls speed would also help on Earth for people who cannot use it for various reasons. One solution could be voice or thought control. We are not as far away from these solutions as it might seem. This year, the first patient was successfully implanted with a Neuralink implant, thanks to which he is able to think, control a computer cursor and play chess¹⁴. With the ability to transmit the signal directly from the brain to the toker, eliminating the delays caused by sending the signal to the leg (which usually operates the pedal), turning would become an even more integrated process in the creator. I hope I will still have a chance to discuss these ideas with Elon Musk himself. Admittedly, I am treating anecdotally the imminent prospect of such a meeting, but indeed at the aforementioned *First International Conference: Methodological and Cognitive Aspects of the Visual Arts*, I somehow received such an offer. After hearing my Pecha Kucha¹⁵ regarding the *!Gravity* project, American artist Amy Karle, being considered for a commercial spaceflight for artists, promised to write to Elon Musk on the matter. I am still waiting to this day. Even if inelegantly late, I will gladly accept this invitation.

¹³ The exhibition was presented in the gallery of the Eugeniusz Geppert Art Documentation Center at the Academy of Fine Arts in Wroclaw and lasted until June 6.

¹⁴ Neuralink [@neuralink], (March 20, 2024), [video], X, Access: September 14, 2024, <https://twitter.com/neuralink/status/1770563939413496146>.

¹⁵ A type of presentation, limited in time and visuals to 20 slides, each 20 seconds long.

5.7 ENTROPIA

One artist who inspires me with his interdisciplinary approach is Jakub Jernajczyk, PhD, who often explores concepts from mathematics and physics. In his works *Monument to Pi* (2019) or *Boundaries of the Circle* (2015), he explored issues related to geometry, while his works *n tropi a* (2018) and *Declination of Entropy* (2019), as the titles indicate, dealt, in a rather intriguing, because linguistic way, with entropy. In my work, I wanted to approach this issue in a strongly illustrative way, creating two contrasting works depicting high and low entropy by varying the ordering of repetitive compositional elements. I took the triangle as the basic module of the work, and multiplying the properly prepared form, I built two large-format compositions. To fire them I used the hybrid kiln constructed and described in subsection 2.4.5. There I describe in detail the firing process at 1100°C. In the course of solving the technological issues involved in this work, I was inevitably accompanied by a very poetic yet deeply scientific statement by physicist Carlo Rovelli: *the flame is a process that opens a channel through which wood can pass to a higher entropy state*¹⁶.

I treat the diptych *Entropy* not only as an artistic work, but also as a visualization of the impact of entropy on reality, as well as a reinforcement in our consciousness of its importance: *The world moves [...] forward not through sources of energy, but through sources of low entropy. Without low entropy, energy would dissipate into homogeneous heat and the universe would fall asleep in a state of thermal equilibrium - it would no longer be possible to distinguish the past from the future and nothing more would happen*¹⁷. Composition *Entropy small*, illustrates the high level of order of the elements of the system with the regularity of the arrangement of modules, while *Entropy large*, visualizes the chaos of a similar system, but after the passage of time and an increase in the level of disorder.

5.8 CONCLUSION

Over the course of the three-year project, each of my realizations underwent dynamic changes, depending on the effects of its various stages. For me, it was very significant that by exerting a certain influence on the activity, I received feedback (from the universe, as it were) and thus

¹⁶ C. Rovelli, *Tajemnica czasu*, Łódź 2019, p. 148, [own translation].

¹⁷ Ibidem, p. 146, [own translation].

developed the projects according to the nature of the feedback I received. I did not expect that the experiments would lead me to reduce the area of the hybrid furnace. Nor did I assume that I would rebuild it four times, let alone hundreds of repairs. It also fell short of my initial assumptions that in my first designs all *Event Horizons* were connected by clear panes of glass. All the activities, however, exceeded my expectations. As the series of objects grew, so did my skills in controlling controlled chance. I would like my realizations to find their place not only in art galleries, but to be able to exist in spaces related to the sciences, thus opening the gate for conversations about common ground full of experimentation and precisely controlled artistic freedom.

INDEX OF PIECES INCLUDED IN THE DISSERTATION

(Part of the dissertation is an appendix with a flash drive, containing all the photographic documentation)

Black holes

(8 objects)

Material: stoneware, engobe, textile fiber

Technique: objects turned on potter's wheel

Firing at 1200 °C in an electric kiln

Photo: Dawid Żynda



Black hole 01 | h:20 x 31 x 23 cm



Black hole 02 | h:26 x 24 x 19 cm



Black hole 03 | h:45 x 45 x 27 cm



Black hole 04 | h:14 x 15 x 18 cm



Black hole 05 | h:12 x 10 x 11 cm



Black hole 06 | h:48 x 44 x 38 cm



Black hole 07 | h:47 x 48 x 32 cm



Black hole 08 | h:48 x 46 x 50 cm

Event horizon

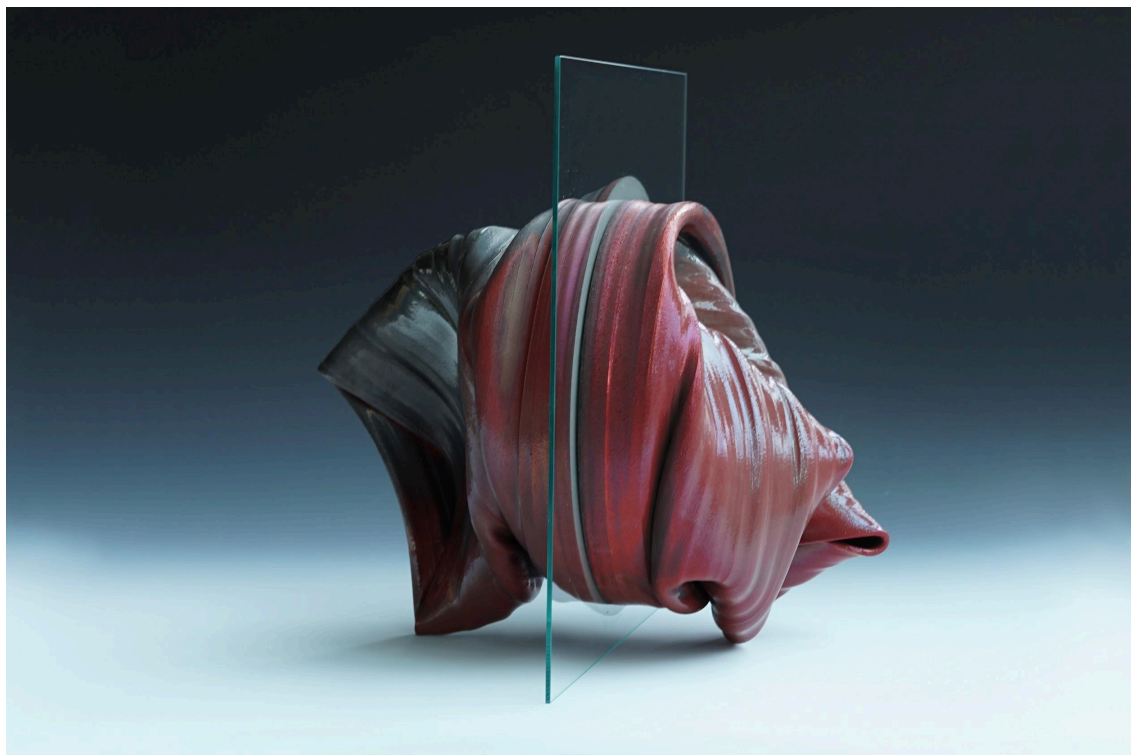
(11 objects)

Material: stoneware, upcycled glasses

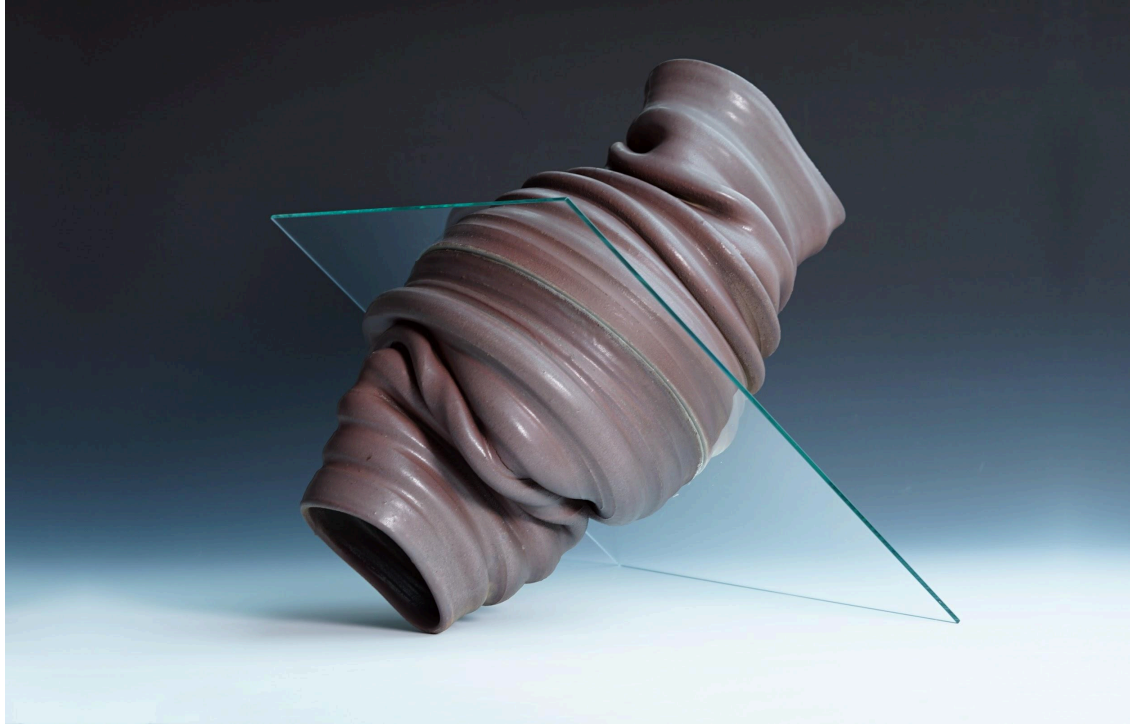
Technique: objects turned on a potter's wheel

Firing at 1200 °C in an electric kiln

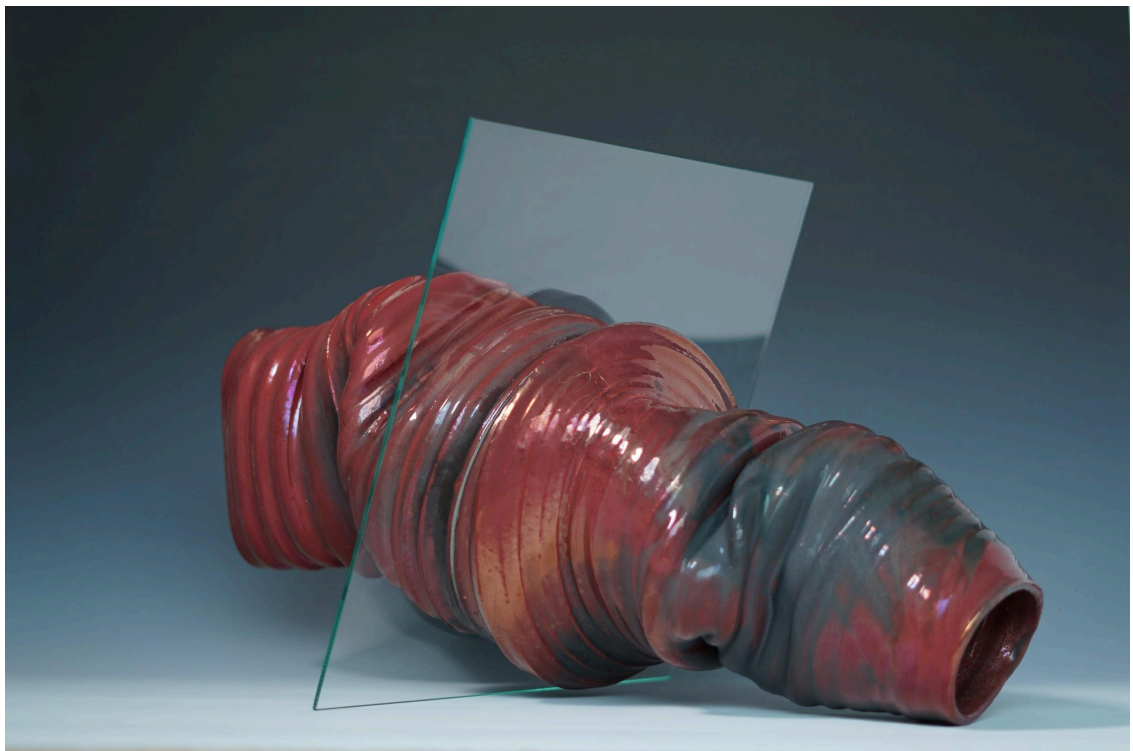
Photo: Dawid Żynda



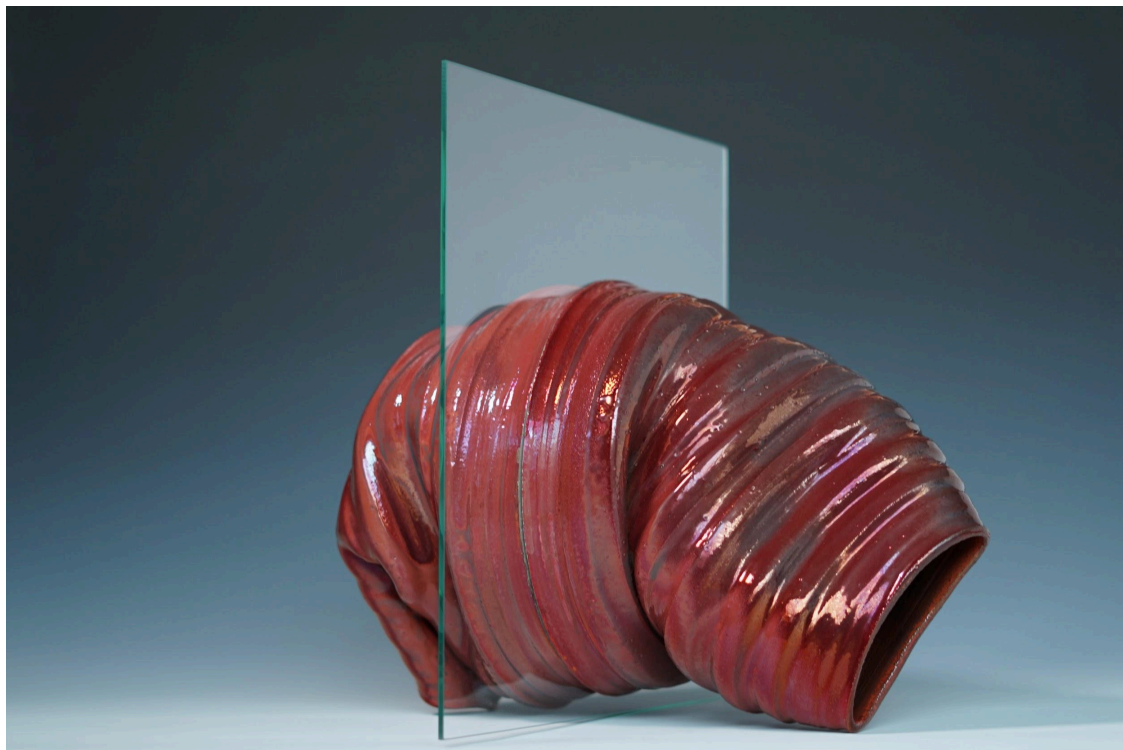
Event horizon 01 | h:45 x 45 x 38 cm



Event horizon 02 | h:47 x 45 x 55 cm



Event horizon 03 | h:45 x 45 x 60 cm



Event horizon γ | h:45 x 45 x 50 cm



Event horizon 05 | h:30 x 30 x 50 cm



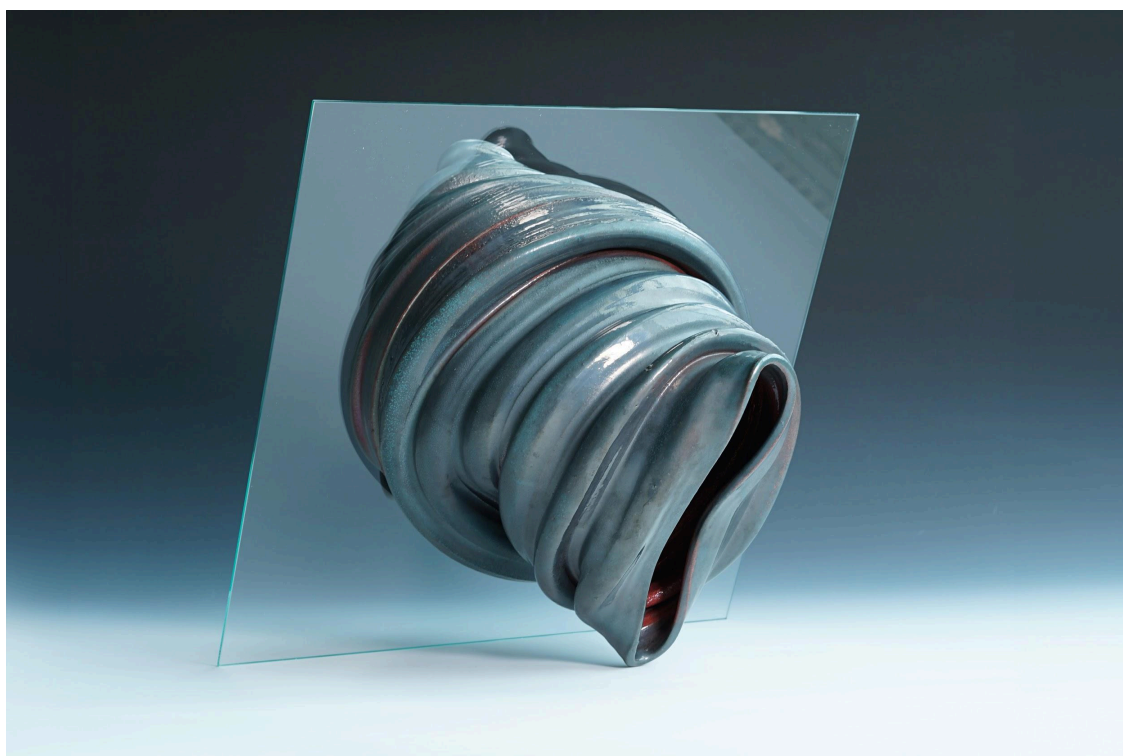
Event horizon 06 | h:32 x 30 x 47 cm



Event horizon 07 | h:50 x 48 x 54 cm



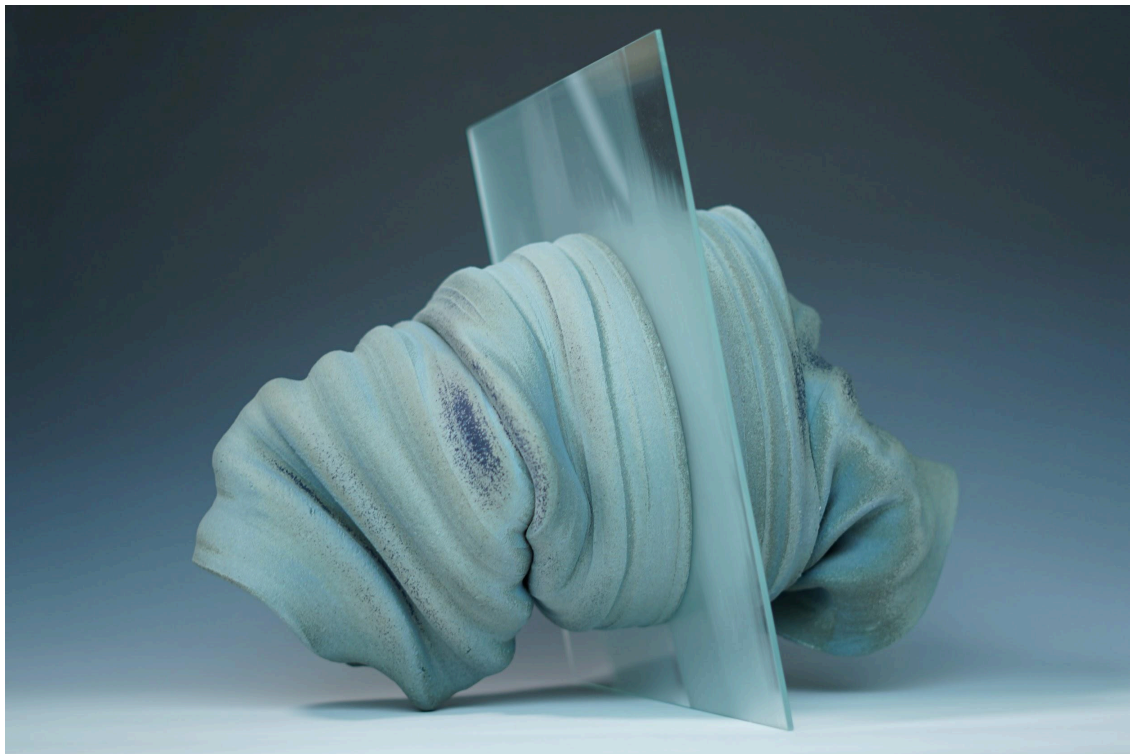
Event horizon Ω | h:30 x 60 x 35 cm



Event horizon 09 | h:45 x 45 x 47 cm



Event horizon 10 | h:45 x 45 x 57 cm



Event horizon 11 | h:45 x 45 x 56 cm

Dimensions entwined

Installation

Material: stoneware, 7 sheets of plexiglass, metal screws

Technique: objects turned on a potter's wheel

Firing at 1200 °C in an electric kiln

Dimensions [cm]:

h:100x100x100

Photo: Dawid Żynda





Space waste

(5 objects)

Material: stoneware, metal screws

Technique: objects turned on a potter's wheel

Firing at 1200 °C in an electric kiln

Photo: Dawid Żynda



Photo from the exhibition *Dimensions entwined*. In the background *Cosmic debris 01* and *Cosmic debris 02*



Photo from the exhibition *Dimensions entwined*

Cosmic debris 01 | h:55 x 55 x 42 cm

Cosmic debris 02 | h:55 x 55 x 35 cm



Cosmic debris 03 | h:32 x 32 x 36 cm



Cosmic debris 04 | h:55 x 55 x 50 cm



Cosmic debris 05 | h:32 x 32 x 37 cm

Cosmos

(4 objects)

Material: stoneware

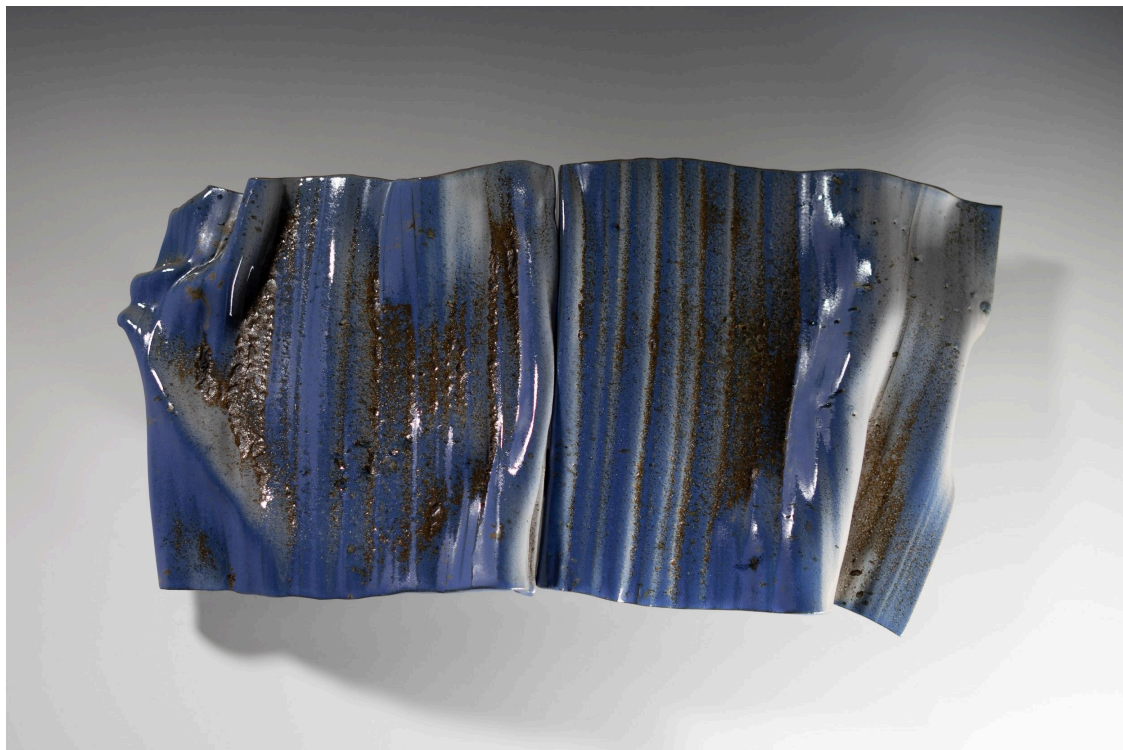
Technique: planes turned on a potter's wheel

Firing at 1200 °C in an electric kiln

Photo: Dawid Żynda



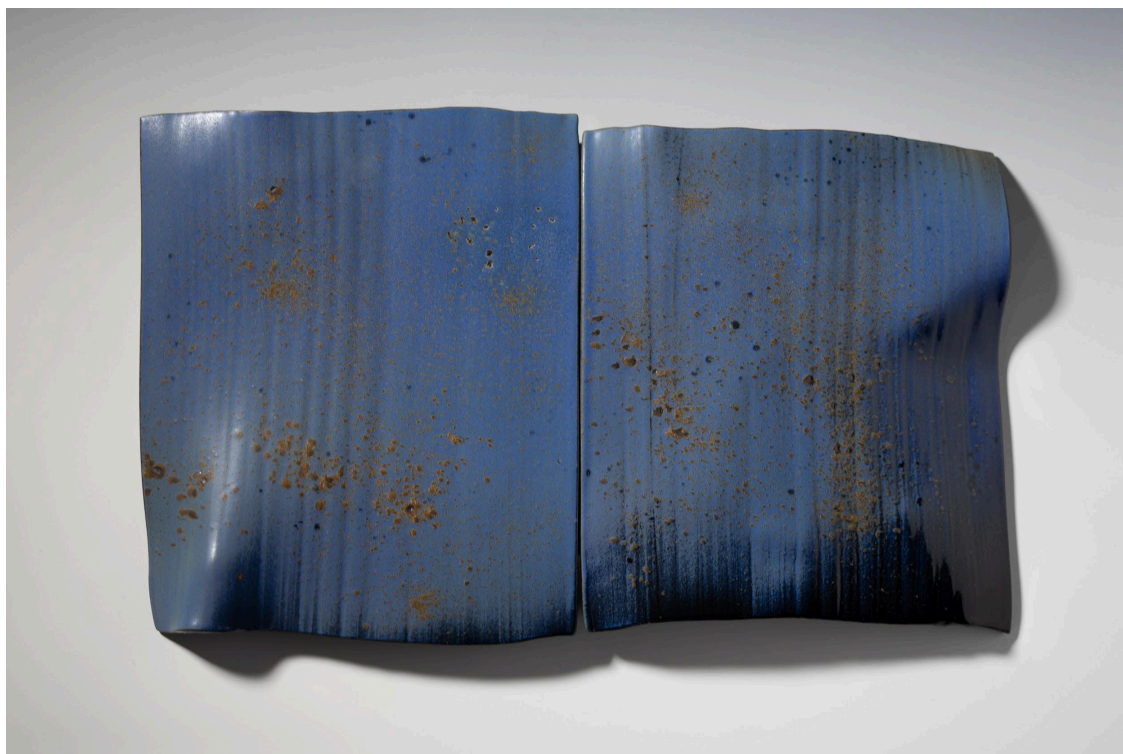
Cosmos 01 | h:40 x 44 x 5 cm



Cosmos 02 | h:38 x 58 x 7 cm



Cosmos 03 | h:46 x 62 x 5 cm



Cosmos 04 | h:40 x 67 x 4 cm

Gravity

Performance

(Video documentation included on flash drive)

Photo: Małgorzata Maternik, Weronika Lucińska





Entropy

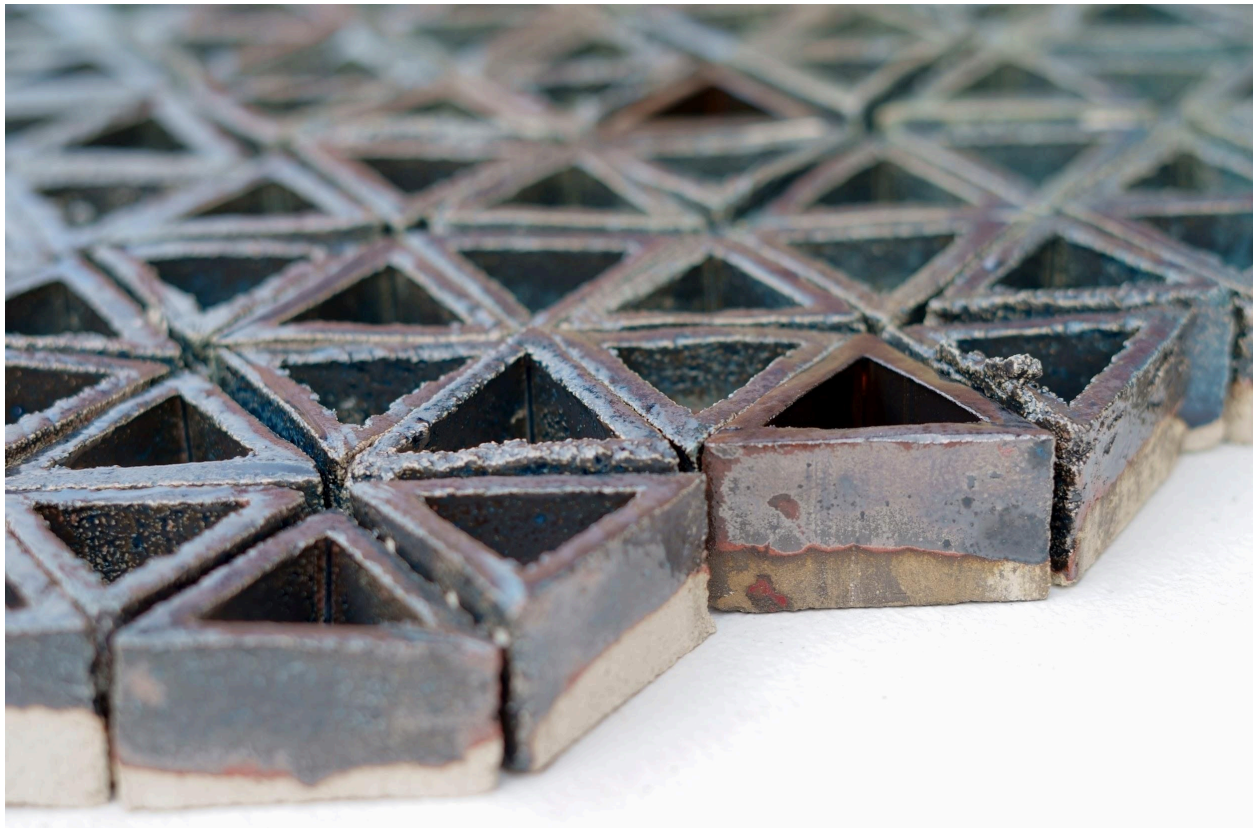
(2 objects)

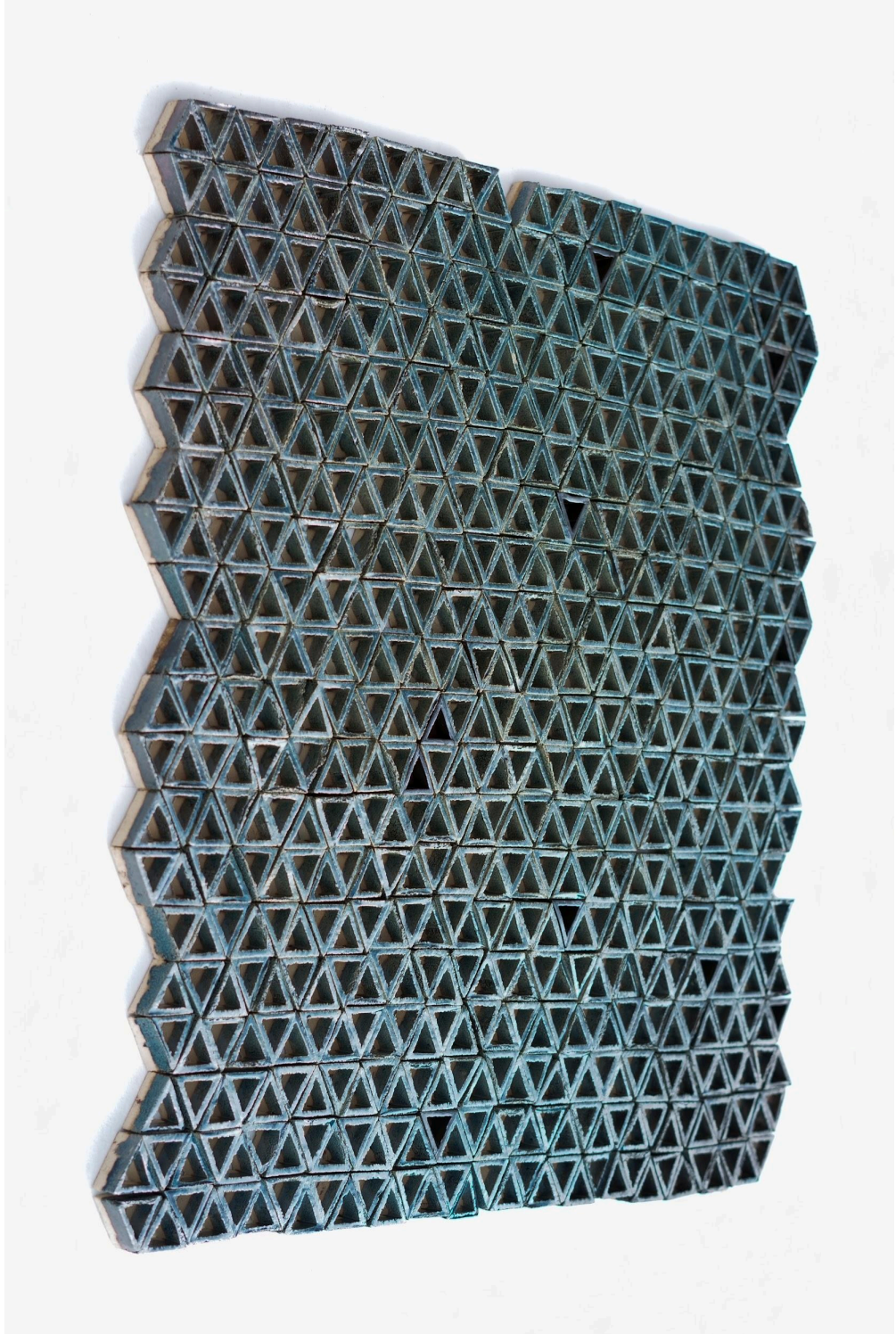
Material: stoneware

Technique: extruder

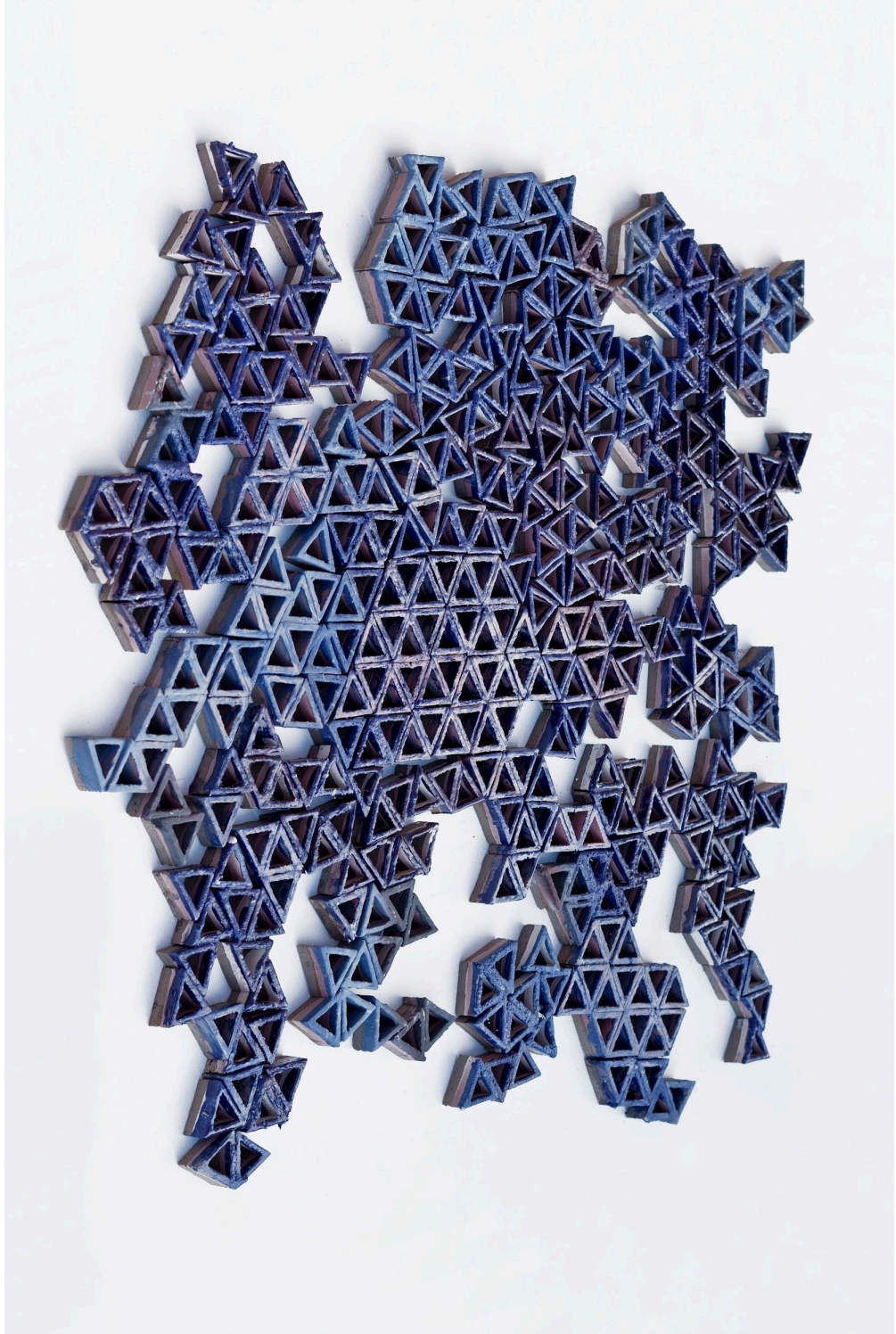
Firing at 1100 °C in a hybrid kiln

Photo: Dawid Żynda

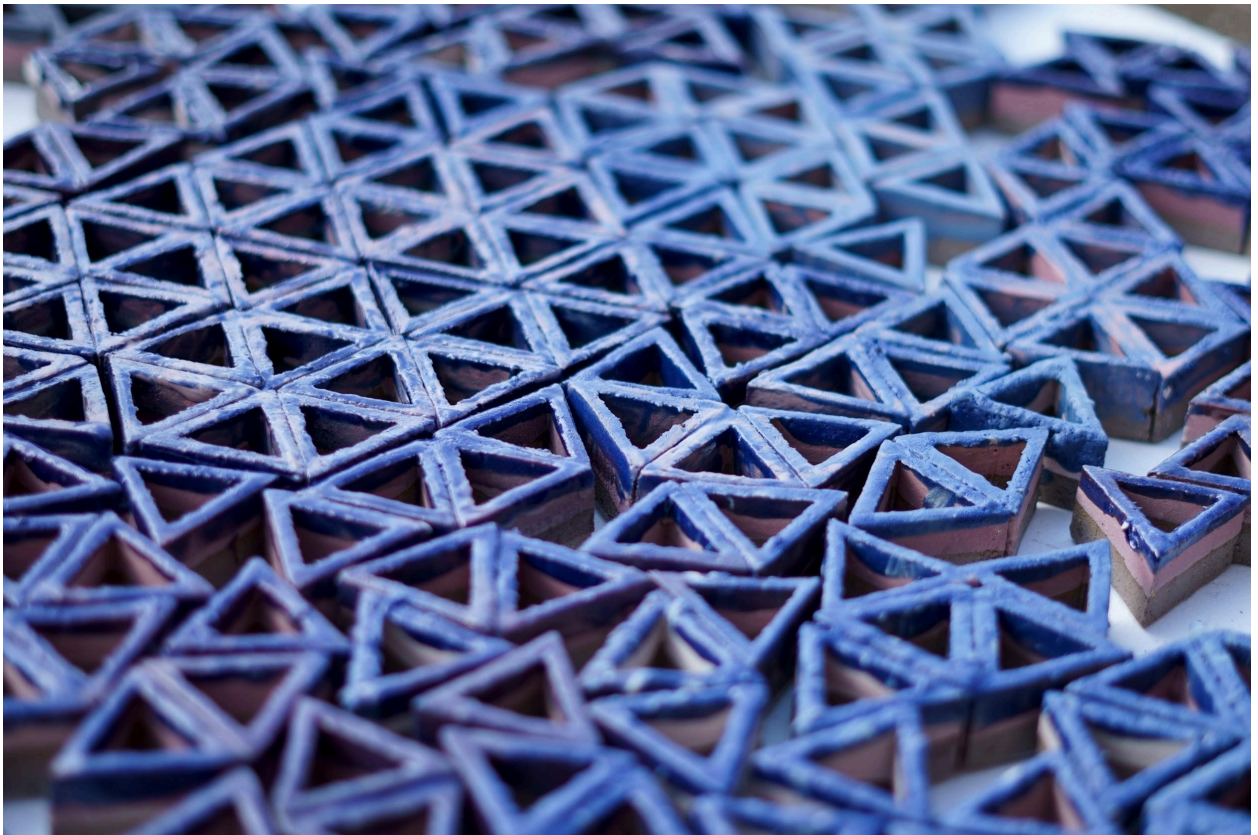




Low entropy | h:3 x 100 x 100 cm



High entropy | h:3 x 100 x 100 cm



Conclusion

All of the experiences of working on the doctorate, despite the breadth of the issues covered, seem, in retrospect, to be only a prelude to something larger. Within each of them, I feel a sense of insufficiency. I dare to assume that this is how physicists, seeking answers to the question of the Theory of Everything, may feel, still stuck in the process of investigation and discovery. The completion of the doctoral project does not mean the end of the search for me, quite the opposite. The initiation of these activities has developed new paths for me to explore in the area of designing and building kilns or applications for creating and cataloging glazes. Building a plane kiln proved to be a long process for me, full of problems and challenges. It's only after it's completed that new, fresh inspiration and new ideas for using this unusual design emerge. Above all, I am looking forward to realizing more art cycles.

I am also not abandoning my training program before flying into space to realize my dream of becoming the first ceramic artist to create on other planets. I decided to reassure myself of my assumptions and asked Chat GPT (one can assume all the specialists at once!) what are the chances of realizing this dream. Here is his answer:

It's hard to predict exactly, but the idea of working with ceramics on other planets is fascinating and not at all far away! With the rapid development of space exploration, especially in the context of plans to colonize the Moon and Mars, there may be an opportunity in the future for artists to contribute to the creation of space colonies. Ceramics, due to their insulating, building, as well as artistic properties, could play an important role in space habitats.

Being the "first" would depend on your ability to combine your knowledge of ceramics with space technology, space exploration or space mission projects. If you are interested in such a path, it would be worthwhile to stay in touch with space research and perhaps link your ceramic work to these fields - this could increase your chances!

Well- the goal is set!

The deeper goal of all my activities is a personal search for myself in the vastness of the universe. Referring to Sagan's apple pie - I am building my "ceramic universe" from the ground up to better understand my own work and ceramics in general. The creative process, inseparable from our tiny presence in the grand scheme of space and time, brings me deep peace and comfort - emotions that I hope resonate through my works and touch the audience, attracting them as intensely as only black holes could.

Bibliography

- Balzer A., Carpenter K., Henderson E., Jeletic J., Marosy M., Wiseman J., *Hubble Focus: Dark Universe*, National Aeronautics and Space Administration, 2024.
- Boch P., Niepce J., *Ceramic Materials. Processes, Properties and Applications*, ISTE, France 2001.
- Cardew M., *Pioneer Pottery*, Nowy Jork 1971.
- Czas, SJP PWN, Access: 20 August 2024, <https://sjp.pwn.pl/sjp/czas;2450266.html>.
- Cosmos: A personal Voyage* [series], e. 10, reż. Adrian Malone, PBS, 1981.
- Daly G., *Developing glazes*, Bloomsbury Plc, London 2013.
- Davies P.C.W., *Cosmic jackpot : why our universe is just right for life*, Boston, 2007.
- Doremus R.H., Shackelford J.F., *Ceramic and Glass Materials Structure, Properties and Processing*, Springer, New York 2008.
- Farmelo G. (Gospodarz), (2019, 2 September), *Edward Witten interviewed by Graham Farmelo* (nr 5), [Odcinek podcastu audio], *The Universe Speaks in Numbers*, SoundCloud.com, Access: 25 July 2024, <https://www.youtube.com/watch?v=r4wQsmAtZoc&t=2312s>.
- Feynman R. *Lectures on Gravitation*, Penguin Books, 1999.
- Ford K.W., Wheeler J.A., *Geons, Black Holes and Quantum Foam: A Life in Physics*, Nowy Jork 1998.
- Forms of the anthropic principle*, Britannica, Access: 15 August 2024, <https://www.britannica.com/science/anthropic-principle/Forms-of-the-anthropic-principle#ref1078377>.
- Fridman L. (Gospodarz), (2024, 7 marca), *Yann LeCun: Meta AI, Open Source, Limits of LLMs, AGI& the Future of AI* (nr 416), [podcast episode], *Lex Fridman Podcast*, Youtube.com, Access: 5 September 2024, <https://www.youtube.com/watch?v=5t1vTLU7s40>.
- Hafele J.C., Keating R.E., 1972. *Around-the-World Atomic Clocks: Predicted Relativistic Time Gains*, Science, Access: 30 August 2024, <https://www.science.org/doi/10.1126/science.177.4044.166>.
- Hawking S.W., *Black Holes: The Reith Lectures*, Transworld 2016.

Hawking S.W., *Krótką historia czasu. Od wielkiego wybuchu do czarnych dziur*, Warszawa 1990.

Johnson P.C., *Statement*, Access: 25 August 2024,
<https://www.peterchristianjohnson.com/statement>.

Karmel P., *Jackson Pollock: interviews, articles and reviews*, Nowy Jork 1999.

Kirkaldy J.F. *Minerals and Rocks*, Blandford press, Londyn 1968.

Lozano-Hemmer R., *Solar Equation.Relational Architecture 16*, Access: 5 September 2024,
https://lozano-hemmer.com/solar_equation.php.

Matthes W., *Keramiche Glasuren*, Hanusch, Verlag, Koblenz 2018.

Mazur K., 2021, *Słynna teoria Hawkinga o czarnych dziurach potwierdzona*, National Geographic Polska, Access: 10 sierpnia 2024,
<https://www.national-geographic.pl/artykul/slyнна-teoria-hawkinga-o-czarnych-dziurach-potwierdzona>.

Neuralink [@neuralink], (2024, 20 marca), [video], X, Access: 14 September 2024,
<https://twitter.com/neuralink/status/1770563939413496146>.

Obraz liczony Romana Opalki w Muzeum Narodowym, 2019, Radio Kraków, Access: 13 September 2024, <https://www.radiokrakow.pl/kultura/obraz-liczony-romana-opalki-w-muzeum-narodowym/>.

Olsen F. L., *The Kiln Book, materials, specifications & construction*, KRAUSE, Iola 2001.

Piech J., *Piece ceramiczne i szklarskie*, AGH UWND, Kraków 2001.

Pomian K., *Porządek czasu*, Gdańsk 2014.

Rada P., *Techniki ceramiki artystycznej*, Warszawa 1993.

Rogan J. (Gospodarz), (2020, 19 lutego), *Brian Greene* (nr 1428) [podcast episode], *Joe Rogan Experience*, Youtube.com, Access: 25 July 2024
<https://www.youtube.com/watch?v=r4wQsmAtZoc&t=2312s>
Rovelli C., *Tajemnica czasu*, Łódź 2019.

Space Smash [video], reż. Bertrand Loyer, Saint Thomas Productions 2018, Access: 3 sierpnia 2024,
https://www.youtube.com/watch?v=CQIDPNNGogg&ab_channel=SLICEFullDoc.

The Nobel Prize in Physics 2011, 2011, Access: 20 September 2024,
<https://www.nobelprize.org/prizes/physics/2011/summary/>.

Witten E., *String Theory Dynamics In Various Dimensions*, Nuclear Physics, Section B, vol. 443, nr 1-2 (1995) 1995 ; Vol. 443, No. 1-2 s. 85-126, Access: 20 September 2024, <https://ncatlab.org/nlab/show/M-theory>.

Interstellar [movie], reż. Ch. Nolan, Paramount Pictures, Warner Bros 2014.

Lem S., *Powrót z gwiazd*, Warszawa 2008.

Strugaccy A., B., *Piknik na skraju drogi*, Warszawa 2011.

Vonnegut K., *Trzęsienie czasu*, Warszawa 2000.

Doctor Who [series], twórcy: Newman S., Webber C. E., Wilson D., 1963-2024.

Powrót do przyszłości [movie], reż. Zemeckisa R., PL: Polfilm 1985.

Mroczne Materie [series], serason 1, twórca: Jack Thorne, BBC Studios, Bad Wolf, New Line Productions, Scholastic 2019.

List of Illustrations

Chapter I

II.1.1. On Kawara, May 8, 1975, 1975, Access: 30 July 2024

<https://www.artbasel.com/catalog/artwork/87818/On-Kawara-May-8-1975>.

II.1.2. Roman Opalka, Obraz liczony. 1965/1 do ∞ Detal 2450737-2473067, 20th century, Access: 15 September 2024

<https://lifeinkrakow.pl/w-planach/sztuka/894,wyjatkowy-obraz-do-ogladania-w-krakowie>.

II.1.3. Quantum Field Theory in Curved Space – Black Holes, 2021, personal photo

II.1.4. Peter Christian Johnson, The Hollow Men, 2016, Access: 3 April 2024

<https://www.peterchristianjohnson.com/qrqrbdzyiz6c57qmt4il64hpgdtgmn>.

II.1.5. Anne Turn, Tsoon, 2022, Access: 3 April 2024

https://issuu.com/tallinndesignfestival/docs/disainioo2022_kataloog_veeb.

II.1.6. Ryan LaBar, A Point of Unstable Equilibrium, 2019, Access: 2 September 2024

<https://www.ryanlabar.com/2018?lightbox=dataItem-jtlkqs8g>.

II.1.7. !Gravity Performance, June 25, 2023, photo by Małgorzata Maternik

II.1.8. Jarosław Grulkowski, Build a New World 2m, 2021, Access: 26 July 2024

<https://www.asp.wroc.pl/pl/pracownicy-dydaktyczni/grulkowski-jaroslaw>.

II.1.9. Graph illustrating the percentage of visible matter, dark matter, and dark energy in the Universe, Access: 2 September 2024

https://svs.gsfc.nasa.gov/vis/a010000/a012300/a012307/frame-000215_print.jpg.

II.1.10. The so-called Flammarion Engraving, Access: 4 August 2024

<https://publicdomainreview.org/collection/flammarion-engraving/>.

II.1.11. Rafael Lozano-Hemmer, Solar Equation, 2010, Access: 21 September 2024

https://lozano-hemmer.com/solar_equation.php.

II.1.12. Photos from the opening sequence of His Dark Materials, 2019, Access: 5 August 2024

<https://www.artofthetitle.com/title/his-dark-materials/>.

II.1.13. Stephen Creech, Tools Aliens Use to Make Pottery in Space, 2023, Access: 14 September 2024

<https://www.instagram.com/creechoftheeast/>.

II.1.14. *Elena Howard, AI generated ceramic idea, 2024*, Access: 2 September 2024, <https://www.ceramicreview.com/articles/clay-meets-code/>.

Chapter II

II.2.1. Adam Abel, Cyberboros, 2020-2021, Access: 10 September 2024

<https://www.adamabel.com/pages/cyberboros.html>.

II.2.2. Loading wood into the kiln, personal photo

II.2.3. Reduction effect with wood, ash traces visible, personal photo

II.2.4. Burnt heating element, personal photo

II.2.5. Prototype kiln construction without external insulation, during firing, personal photo

II.2.6. Kiln cover using metal corners, personal photo

II.2.7. Heating element arrangement, personal photo

II.2.8. Kiln floor, personal photo

II.2.9. Opening the kiln after firing, personal photo

Chapter III

II.3.1. Soaking halloysite from the Dunino mine, personal photo

II.3.2. Samples of raw materials before firing, personal photo

Il.3.3. Elongated sample from ceramic mass, showing how it should have a hole at the top for suspension during firing. After bisque firing, the sample should be glazed by pouring and then fired at the appropriate temperature on a stand that allows it to hang without touching anything, personal photo

Il.3.4. Deviation of the sample from the flat surface, personal photo

Il.3.5. Pycnometer standing on scales, personal photo

Il.3.6. Black engobe no. 1 with 5% basalt addition, personal photo

Il.3.7. Black engobe no. 2 with 10% basalt addition, personal photo

Il.3.8. Effect of using wollastonite on the surface of a work, personal photo

Il.3.9. Samples of described raw materials after firing, personal photo

Chapter IV

Il.4.X. Glaze creation card. Example of a Greek application with a complicated interface, caused in part by using the unity method, Access: 25 August 2024

Chapter V

Il.5.1. NASA Orbital Debris Program logo, Access: 20 September 2024

Il.5.2. *A fuel tank that went down in 1997 in Georgetown, Texas*, Access: 20 September 2024, https://www.esa.int/ESA_Multimedia/Images/2005/04/Two_large_fragments_of_a_Delta_second_stage.