Polar Aesthetics: Art of the Arctic and Antarctic

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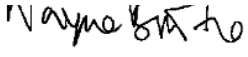
PhD (RCA)

Fine Art Research

Appendix B

Methods and Contextual Review

This thesis represents partial submission for the degree of Doctor of Philosophy at the Royal College of Art. I confirm that the work presented here is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis. During the period of registered study in which this thesis was prepared the author has not been registered for any other academic award or qualification. The material included in this thesis has not been submitted wholly or in part for any academic award or qualification other than that for which it is now submitted.

6th Aug 2023 

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Methods

Introduction

This section outlines what mixed methods were used, why these were the best methods for my practice-led research and states how collaborative knowledge sharing took place within it. The section highlights the philosophical/conceptual underpinnings of my research and discusses the specific design choices made, including a short concluding discussion of the methodological limitations.

While the independent methods explored at the RCA were externally supported by sustained dialogue and exchange with BAS and Arup science and engineering experts throughout the course of my research, Ice Floor and Polar Zero were large scale public exhibitions that originated from my own individual study and were produced within the integrated use of collaborative research methods. All other forms of writing and making articulated in this submission use methods authored by myself.

Research Methods Philosophy

As evidenced in the writings of Greek philosopher Thales, the idea of water as a vital affective power has a long and distinguished trajectory in the West. While many research philosophies exist, my own was specifically informed by two: positivism and interpretivism. Positivism is the underlying research philosophy in quantitative studies; it states that the researcher can observe reality objectively and that there is only one reality, which exists independent of the observer. Contrasted with this, interpretivism assumes that the researcher performs a role in observing the world around them and that reality is observed subjectively by the individual. My mixed method study involved investigating my research question in the exhibition setting. Integrating objective and subjective positions, the method philosophically considered the accumulation and release of ancient air from ice cores when dissolved in water as an experiential and emancipatory form of freezing and melting of polar history.

Research Methods Type

The mixed methods used throughout the study were inductive rather than deductive in design. Where deductive forms of research are confirmatory in approach, started with an established theory, my research was theoretically developed from the ground up (i.e., from the collected ice core scientific data) and was therefore exploratory in approach.

Research Methods Time Horizon

The data for my study was not collected at one point in time (i.e., cross-sectional) but rather at multiple points in time (i.e., longitudinal). This choice was dependent on my research aims, objectives and research questions. As I aimed to assess how notions of polar history change over time and place, I primarily adopted a longitudinal time horizon. However, PhD registration, funding, technical, logistical and exhibition deadline constraints also forced me to adopt a cross-sectional time horizon at specific points of the study.

Research Methods Strategy

The research used Patrick Dunleavy's seminal text Authoring a PhD (2003) as a central academic guide to structure the thinking and making of my practice-based research project. The text provided clear and effective strategies at both the macro and micro levels, which enabled me to shape and negotiate the many intellectual issues and practical difficulties of developing and completing the written thesis. The text also significantly helped me to refine and define my central research question, methods, aims and objectives around a critical intellectual problem:

What hidden histories written in polar ice can contemporary art reveal?

As discussed by Dunleavy, philosopher Robert Nozick defines an intellectual problem as being characterised by five interrelated components:

> The first is a goal or objective which can tell us how to judge outcomes, how to see that an improvement has been made. The second is an initial state, the starting situation and the resources available, in this case usually the existing literature review. A set of operations that can be used to change the initial state and resources forms the third component of an intellectual problem, including new data and a tool kit of research methods. Constraints are the fourth element, designating certain kinds of operations as inadmissible. The final element is an outcome. (Dunleavy: 2003:23)

The Arctic and Antarctic are remote, distant and conventionally out of reach for contemporary audiences. Attempting to collapse spatial and temporal distances of time and place, my **first methodological objective** and goal was to establish the exhibition format as an accessible and effective artistic framework through which to examine my central research question at the human and non-human, quantitative and qualitative levels.

I initially examined my research question through several formative exhibitions including Resonance of Water (2015) S:Future (2016) and Aqua Sulis (2017). These early exhibitions were directly informed by my primary case study (Library of Water) by artist Roni Horn. Horn's library, equally vibrant and animate, inert and dormant, offered a precisely calibrated invitation for an individual visitor to reconsider their emotional and intellectual relationship with the polar past in the present.

My visit to the Library of Water galvanised my artistic research making and thinking about how the exhibition format can be effectively explored as a powerful analytical and argumentative method. Horn's library seems to activate a primal space of collective discovery for the visitor through which to rethink and re-imagine our connection to the vanishing polar world. In this context, my visit directly shaped the artistic methods explored within my own subsequent exhibitions including Vapour Sculpture at Prior Park (2017), Solid, Liquid, Gas at the V&A Museum (2017) and Ice Manuscript at Arup (2019).

A second research method consisted of an expanded literature review of relevant polar explorers, historians, artists, curators and cross-cultural thinkers including Thales, Scott, Shackleton, Smithson, Holt, Bennett, Iberall, Bauman, Pallasmaa, Tanizaki, Ikeda, Deleuze, Eliasson, Boltanski and Paterson. The review was consolidated by readings of texts from the expanded fields of phenomenology, auto-ethnography, environmental aesthetics and contemporary art theory and practice.

It was specifically shaped by personal anecdotes, memories and oral testimonies of national and international scientists and experts at the BAS ice core laboratory whose lived experience of the Arctic and Antarctic situates a vital yet critically under-explored source of polar history. My literature review involved a comprehensive survey of written texts, scientific reports, catalogues, manuscripts, artefacts, personal diaries, letters, maps and photographs held in the respective archives and library collections of both the British Antarctic Survey and the Scott Polar Institute, University of Cambridge.

The British Antarctic Survey and the National Maritime Museum have long-established and closely tied links which can be observed at the new Polar Museum in Greenwich, including material instruments such as navigational chronometers, written texts, diaries, manuscripts, maps and telescopes which portray complimentary discoveries made in the fields of celestial, maritime and polar exploration.[1] **The third methodological component** of the research used a specific set of operations that involved using the transformative tools of engineering firm Arup to examine ice-core data from BAS. In counterpoint, I aligned data from BAS with data from the National Maritime Museum to examine and rethink the symmetry and correlation between the two strongly interconnected institutions. Here, the polarities of longitude and latitude, magnetic and geographic, north and south, in turn, directly shaped the speed and direction of the practical and written research produced at the RCA.

The fourth methodological component of the research involved analytical (solid, liquid, vapour) and argumentative (Arctic v Antarctic) constraints. Analysing concurrent states of chemical and societal phase change, both writing and making argued that Arctic and Antarctic history transform in equivalent and co-existent ways in which the polar world itself has solidified, liquified and vapourised over critical points of ancestral time and contemporary place. While the entire research methodology was conceptually underpinned by the conceptual/theoretical constraint of solid, liquid and vapour phase change at the macro level, each of the three integrated bodies of written and practical work was structured by specific phase changes at the micro level.

The first written chapter of the thesis examined the sublimation and deposition phase changes of the Arctic and Antarctic through a practical investigation of my Vapour Series of sound installations. The second written chapter of the thesis examined the condensation and evaporation phase changes of the Arctic and Antarctic through a through a practical investigation of my Liquid Series of paintings and photography. The third and final written chapter of the thesis examined the freezing and melting phase changes of the Arctic and Antarctic through a practical investigation of my Solid Series of glass sculpture.

The fifth methodological component involved a final research output Polar Zero, a collaborative research exhibition with BAS and Arup at COP26.

1 My film installation Dark Bubbles was permanently installed during the inaugural exhibition Poles Apart at the NMM Polar museum. July 2022. https://www.rmg.co.uk/stories/topics/wayne-binitie-art-climate-change

Fig.1 Antarctic ice.1,500 years old. British Antarctic Survey ice core laboratory

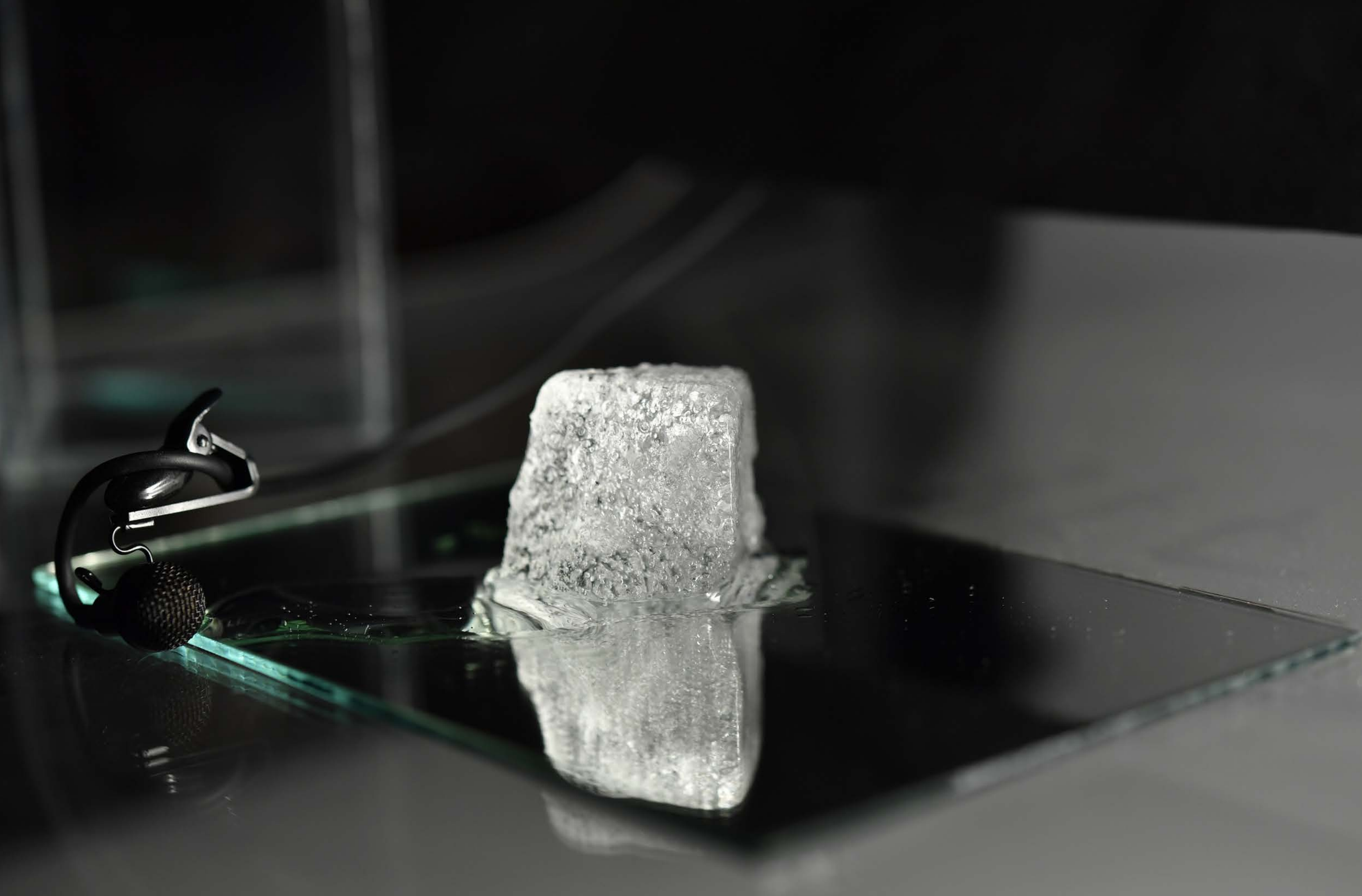


Fig.2 Antarctic ice. 1,500 years old. British Antarctic Survey ice core laboratory

Data collection methods at BAS

Over the course of six years, I was able to conduct audio-visual documentation and interpretation of a number of scientific methods of ice core analysis taking place at BAS including:

Inductively Coupled Plasma Mass Spectrometry (ICP-MS)

Elemental chemistry

Fast Ion Chromatography (FIC)

Major ion chemistry

Fluorescence detectors

Hydrogen peroxide, ammonium, calcium, nitrate

Gas analysers (Picarro and Zara) amm

Continuous methane and carbon monoxide

Led by Dr. Robert Mulvaney, the BAS ice core acquisition team locate, recover and analyse polar ice cores from up to 1000 m below the Antarctic surface. I made termly visits to their state-of-the-art laboratories in Cambridge in order to gain critical insight into the Arctic and Antarctic through audio-visual documentation and interpretation of the chemical, gas and stable isotope analyses carried out by the small group of glaciologists working at the laboratory.

The small bubbles of ancient air trapped inside ice cores are the most accurate climatic and atmospheric records found anywhere on Earth. As such, my visits to the BAS laboratory focussed on experimental ways to record and integrate the significance of this vibrant matter into my writing and making at the RCA. I found the visits fascinating and was occasionally overwhelmed by the range and depth of what I saw, heard and felt.

During my first year of study, Arup material lead Graham Dodd and I paid a visit to see Robert Mulvaney at the BAS laboratory. We began thinking about the idea of translating some of the long streams of data from ice cores into audible sounds to see what benefits might arise from being able to listen to the sets of data simultaneously through a period of glacial time, much like a multi-track recording. It struck us that the ice cores are like master tapes from an ancient recording studio, with multiple ‘tracks’ of information running over the years. The initial visit and subsequent conversations with experts at the Arup Sound Lab in London fired my imagination and directly led to the research formation of my Chapter One Vapour Series of sound installations.

What hidden histories written in polar ice can contemporary art reveal?

The research methods used in the study were aligned between what was practical and viable. To answer the research question posed, I aesthetically explored ice core samples (and the data contained therein) within the exhibition setting. However, at time of increased data saturation, I was aware that my material use of ice cores in the exhibition format situated both a potential and danger of falling into the ‘semantic trap’ outlined by Ivan Illich below:

> The world does not contain any information. It is as it is. Information about it is created in the organism [a human being] through its interaction with the world. To speak of the storage of information is to fall into a semantic trap. Books or computers are part of the world. They can yield information when they are looked upon. We move the problem of learning and cognition nicely into the blind spot of our intellectual vision if we confuse vehicles for potential information with information itself. (Ivan Illich in Dunleavy: 2003:29)

Within this context, my research sampling strategy at BAS considered positions found in discourse analysis. The term ‘discourse analysis’ conventionally indicates how verbal or written information is used to draw meaning. Anchored by my own experience of the Arctic and refined through my audio-visual recordings of Antarctic ice core data, Polar Aesthetics re-examined how the language of polar history is im/materially constructed and deconstructed at the chemical and societal levels by both humans and non-humans.

While the subject of climate change has now reach a point of saturated mediated ubiquity, the significance of the Arctic and Antarctic remains elusive, distant and difficult to grasp within the capitalist impulse of the modern world. The research explored an aesthetic form of discourse analysis in the exhibition format that aimed to assess how ice cores might be used to express differing viewpoints of polar history, including the positive and negative, the emotional and the intellectual. Moderated by the phase changes of matter, my specific use of polar ice in the exhibition space therefore aimed to avoid what many issue-based 21st century art does, namely, to employ complex statistical charts and visual graphs to attempt to tell what ‘the message is’. Ongoing exhibitions confirm that visitors strongly reject such an illustrative approach to polar matter.

The question of how polar history is ‘written’, ‘read’ and ‘erased’ is not limited within my research thinking and making to the literal meaning of written words and scientific facts but rather constitutes a materially discursive method of aesthetic enquiry that seeks to invite intellectual and imaginative encounter. Using probability and non-probability methods of data sampling, my audio-visual approach to ice cores therefore posits both a metaphorical and literal drilling into, and sampling of, polar history that operates at the chemical and societal levels yet strongly rejects any attempts to dictate how meaning should be formulated and experienced by the viewer/listener. Here, my mixed methods approach aimed to draw from discoveries made during the course of the project itself. In doing so, I sought to explore the potential of an open-ended mode of collaborative research thinking, making, feeling and being that moves between the vibrant polarities of time and place, subject and object.

Polar Aesthetics drew from research undertaken within the controlled conditions of the BAS ice core laboratory in Cambridge and the unrestricted ‘laboratory’ conditions of the natural environment in sub-Arctic Iceland where I visited the Library of Water by artist Roni Horn. However, my field visit to Iceland and the Library of Water confirmed that developing, sustaining and exhibiting an artistic research project on the Arctic and Antarctic, would require scientific and engineering expertise beyond my personal skillset and financial means. It was also clear that such a skillset and specific set of scientific and engineering resources would be beyond the scope of the RCA.

Having forged a provisional relationship with both institutions over two years, I finally managed to secure and align external supervisory technical support at both BAS and Arup during the second year of my RCA studies when I secured an AHRC doctoral award in 2017. BAS provided the support and expertise of Dr. Robert Mulvaney (Ice Core Lead), Dame Linda Capper (Head of Communication) and Dr. Beatrix Scharb-Ridley (Director of Innovation and Impact). Pete Bucktrout (Creative Service Manager) provided invaluable technical support in the use of large format photographic and film broadcast media.

Probability sampling involves a random (and therefore representative) selection of participants from a population, whereas non-probability sampling entails selecting participants in a non-randomized (and therefore non-representative) manner. As I was primarily trying to develop representative findings that were accessible to a wide range of contemporary audiences, my use of polar ice cores was primarily random and involved core samples of between 300 and 40,000 years old.

I situated a strong alignment between quantitative and qualitative data collection methods to integrate both the human and the non-human. Due to the transient, fleeting and ephemeral nature of ice, I used audio-visual methods to document and interpret the acoustic and visual properties of ice cores at BAS in Cambridge, which was followed by spatial and material analysis of my ice core audio recordings at the Arup SoundLab in London.

My practice-led mixed methods research was partially informed by the scientific method, where one ice core group is pure (in which no variables of the ice are altered by chemical analysis) and another is impure (in which a variable of the ice is altered) by chemical analysis. Within this framework, I primarily used film and photography to document both quantitative and qualitative methods of research enquiry over the course of six years of academic study as this proved to be the most effective means of documenting, interpreting, communicating and disseminating the research.

Data analysis and material methods at Arup: Sound, light, ice, film. Fig.3 Arup Soundlab

What hidden histories written in polar ice can contemporary art reveal?

My research sought to interrogate this key question and posits that advances made within new industrial and engineering technologies offer timely and renewed scope for increased glacial water sustainability, ethical stewardship and cultural awareness. Anchored by audio-visual fieldwork at the BAS ice core laboratory, the research methodology aimed to rethink the specific use of technologies at the pioneering Arup SoundLab in order to artistically reveal and culturally communicate the significant role of polar water within the wider global climate change challenge. While my primary goal was to materially investigate my research question in the human context of the exhibition space, the opportunity to use the Arup SoundLab offered a crucial counterpoint to examine the material agency of the non human. It is with this sense of poles and polarity that led me be more attentive to the seemingly opposing forces of the animate (human) and the inanimate (ice).

The immanent notion of a 'vital materialism' integrates the polarised energies of matter and will. As argued by scholars including Lucretius, Spinoza, Deleuze, Latour and Bennett, vital materialism posits that objects and things as capable of having agency. Examining the three states of polar water at Arup, my aim was to derive a critical ontology of polar water that moved beyond current debates about 'the political climate and atmosphere' towards a more scientifically grounded account of the polar climate and atmosphere. It is a form of vital materialism through which I was also keen to dissolve the disciplinary divide between science and art, as my experience of music - both a science and an art - did not support the theory that the two disciplines are mutually exclusive. While Bennett's more recent work has turned away from the human towards the non human, I wanted to explore the compatibility of that existing between poles, including the positive and negative, the seen and the unseen, the material and the immaterial, the heard and the inaudible.

The Arup SoundLab is an advanced 3D listening environment in which acoustic engineers model the proliferation of sound in the built environment to minimise noise at concert halls, airports and the industrial building service sectors that rely on ventilation technologies for heating and cooling. The Lab was recently used to design an intimate acoustic reverb chamber for musician Bjork's 2019 Cornucopia tour. In this context, the SoundLab situated the transformative research potential to use new engineering tools and technologies to test, modify and develop innovative audio-visual contemporary artworks that reveal and communicate the latent potency of polar ice to a wide range of cultural audiences through a number of exhibitions including Ice Floor (2019) and Polar Zero (2021).

Throughout my research, Arup provided generous access to the cutting edge audio-visual facilities at the Arup SoundLab, including the specialist staff support of Ned Crowe (Senior Acoustic Consultant). After re-calibrating my BAS audio-visual field recordings at the Arup SoundLab through an expanded use of spatialisation[2] techniques, audiences were later invited to participate in a fully immersive, multi sensorial and bodily experience of the BAS ice cores. In counterpoint to tools and methods traditionally used by ice core scientists, the SoundLab techniques of spatialisation involve the digital reconfiguring of imperceptible data streams within a specific listening and viewing environment.

2 Spatialized audio is sound processed to give the listener the impression of a sound source within a three-dimensional environment. This is a more realistic experience when listening to recorded sound than stereo because stereo only varies across one axis, usually the x (horizontal) axis.

Touch and embodied multisensory experience of ice

In the Eyes of the Skin - Architecture and the Senses (2005), Finnish architectural theorist Juhani Pallasmaa articulates his increasing concerns with what he refers to as the ocularcentric present. Up to a certain point, I agree with his reservations about the perceptual and epistemological bias ranking vision over other senses in Western cultures. The former architect and author often explores the writings of Merleau-Ponty and Walter Ong as they might be interpreted and directed toward the spatial affects of light, sound, taste, scent and touch in the context of architectural experience. In his chapter Acoustic Intimacy, Pallasmaa places the ear at the center of spatial perception, arguing that the increased technological use of the singular sense modality of the eye has detached and severely diminished our temporal and spatial connection with the built environment, affecting the way it is conceived and perceived:

> Sight isolates, whereas sound incorporates; vision is directional, where as sound is omni-directional. The sense of sight implies exteriority, but sound creates an experience of interiority. I regard an object, but sound approaches me; the eye reaches, but the ear receives. Buildings do not react to our gaze, but they do return our sounds back to our ears. (Pallasmaa, 2005:49)

Quoting a passage from Ong's Orality & Literacy - The Technologizing of the World (1991) he continues: 'The centring action of sound affects man's sense of cosmos,' writes Walter Ong. 'For oral cultures, the cosmos is an ongoing event with man at its centre. Man is the umbilicus mundi, the navel of the world'. In a concluding remark made in response to Ong, Pallasmaa suggests: "It is thought provoking that the mental loss of the sense of centre in the contemporary world could be attributed, at least in part, to the disappearance of the integrity of the audible world". (Pallasmaa, 2005:49)

Informed by the writings of Walter Ong, Juhani Pallasmaa and Peter Zumthor, I began to think about how the method of experiencing time-based data from the polar regions in the exhibition space might enable the glaciologists at BAS to identify complex correlations in counterpoint to conventional scientific techniques. Robert Mulvaney and Graham Dodd agreed to provide the necessary

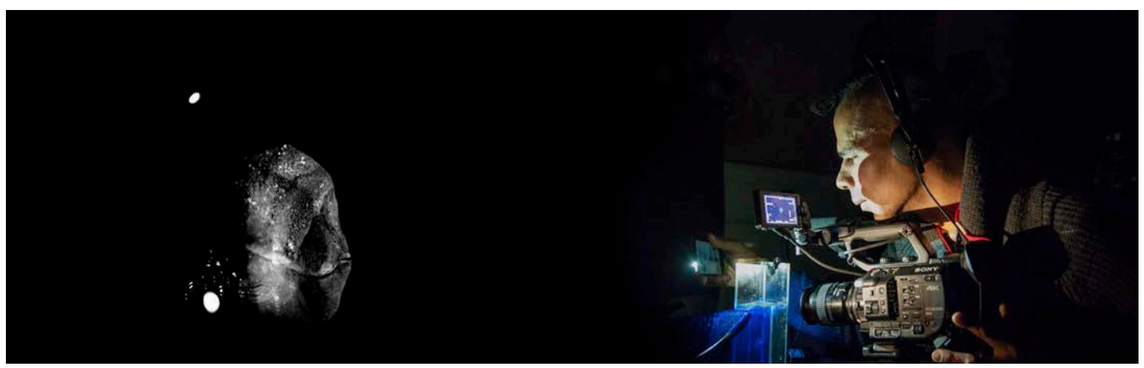


Fig.4 British Antarctic Survey ice core laboratory. Image: Pete Bucktrout/BAS

external supervisory support needed to develop my mixed method approach. Moving between BAS, Arup and the RCA, I began to experiment with making audio-visual recordings of a range of ice cores drilled from different depths to see if they could be turned into useful or engaging spatialised audio files. Robert provided initial access to ice cores that had already exceeded their scientific use.

However, I considered the 'wasted' cores as a material form of significant cultural matter from which to gain close proximity to the polar climate and atmosphere. While it is not possible to just 'play' the release of ice core air (mainly carbon dioxide and methane) directly (since sound is a variation in pressure above and below a 'zero' point), it is possible to map the recorded release of pressurised sound variations in terms of pitch, loudness, speed and spatial location.

In the first year of study, I began using the most direct method of placing the ice cores in glass jars or on plates of glass in the controlled setting of the BAS laboratory, where I could position a condenser microphone in close proximity to the dissolving ice core samples and record the release of ancient air melting over time while documenting the entire process using film. This highly experimental recording method produced unpredictable yet mesmerising audio-visual results, becoming the sole means by which I obtained ice audio recordings at BAS, which were then analysed, edited and reconfigured at the Arup SoundLab through the use of 3D spatial techniques.

In The Poetics of Reverie, French philosopher Gaston Bachelard refers to 'the polyphony of the senses' (Bachelard,1971:6) suggesting an affective capacity of listening and hearing that is both physical and psychological. By my second year of study, I had become sufficiently interested in the idea that the experience of hearing and listening to the sound of multiple ice audio recordings in the exhibited space of the gallery would activate an individual and collective form of remembering and forgetting the past in the present that would collapse spatial distances of time and place.

I was also aware of the ephemerality of sound and silence and wanted to develop a more permanent form of calligraphic notation and mark making using ink and dissolved ice cores. Ice Manuscript (2019) sought to confront and critique commodity driven forms of environmental notation and erasure in the present. The work marks an intensified point of societal and chemical transformation for the polar regions and was made while listening to my ice core audio recordings.

Ice Manuscript was presented in the Arup Fitzroy St Gallery as a contemporary form of calligraphic notation that aimed to examine how the past is written, read and made intelligible in the present. Made with glacial water from the BAS ice-core laboratory, Ice Manuscript involved sustained experimentation with saturated paper forms and surfaces of different weights and thicknesses over two years at the RCA. My early research had demonstrated that ice cores produce intermittent bursts of glacial sound when dissolved in water. Experienced by the visitor to the gallery space in the absence of sound, Ice Manuscript mediated a fluid form of polar history, one that is concurrently chemical and isotopic, absent and present, material and immaterial.

Fig.5 The Incredulity of St. Thomas. Michelangelo Merisi da Caravaggio: 1601-1602. Oil on canvas. 107 cm x 146 cm (42 in x 57 in)
Image: Sanssouci, Potsdam

Fig.6 Ice Floor Exhibition. Image: Janice Cyli

The research use of ice cores aimed to develop mixed methods to activate an im/material form of polar history. The challenge was to use methods that negotiated the polarity between the interiority of the body and the exteriority of the world. My Ice Floor (2019) Arup commission gave me an opportunity to test my research question at the human and non human, material and immaterial levels. I wanted visitors to be able to think and feel about the Arctic and Antarctic history in such a way as to invite both intellectual consideration and sensorial contemplation of the role of temperature.

I devised an installation that involved a specially built heat-controlled room at the Arup Gallery, where visitors would be able to experience glacial sound, light and ice in intimate proximity. I wanted visitors be able to hold polar history in the palms of their hands. In doing so, I hoped they would be able to gain material access to a remote, distant, and conventionally inaccessible polar world. The exhibition took nearly a year to plan and deliver, and I specifically aimed to ask what it means to touch and be in touch with the polar world.

My exhibition thinking and making drew valuable insight from In Touching: The Human Significance of the Skin, in which anthropologist Ashley Montagu's writings (based on medical evidence) suggests that the haptic realm of touch is "the parent of our eyes, ears, nose, and mouth. It is the sense which became differentiated into the others, a fact that seems to be recognised in the age-old evaluation of touch as the mother the senses". (Montagu, 1986:3)

Touch and the division of Art and Science

In his 2014 publication Sculpture and Touch, historian Peter Dent charts the origins, approaches and identities of art since the Renaissance. Overturning the hierarchical dominance of vision, Dent gathers a diverse collection of essays that resonates with Caravaggio's The Incredulity of St. Thomas, where the Apostle Thomas is depicted as a skeptic who refuses to believe until he could see and feel the crucifixion wounds of Christ. Referring to comments made by Dutch author Cees Nootebaum, Dent quotes:

> At the entrance to the cathederal in Santiago de Compostela there is a marble column with deep impressions of fingers, an emotional and expressionistic claw created by millions of hands, including my own. I was not a man of the Middle Ages, I was not a believer, I arrived by car. If you disregard my hand resting the marble, had I never been in that place, the claw would still be there, eroded in the hard stone by the fingers of all the people now dead. Yet, by laying my hand in that hollow one I was participating in a collective work of art. An idea becomes visible in matter: that is always wondrous. (Cees Nootebaum in Dent, 2014:1)

Dent's interest in tactility here exemplifies many threads running through my research, including the im/material ability of art to act as powerful source of mediation that prompts both the senses and intellect. Moving beyond ontological and theological binaries of life/death, positive/negative, Dent suggests an affective power of touch that evokes a shared and collective immediacy of collapsed time and material place that also operates on the outside of disciplinary boundaries. As pointed out by scholars including Pallasmaa and Ong the cultural relationship between art and science has been divided into different spheres of activity since the sixteenth century. Ong suggests the advent of printing and writing has locked us into the singular visual domain at the expense of the oral tradition of speech. (Ong; 1991). This division has been inexplicable to me as my early studies in music (both a science and art) has actively integrated the two disciplines for centuries. Numerous examples of the productive intersection of art and science can be found in early Islamic culture, where the two disciplines were notably integrated to design lettering in manuscripts.

In the Renaissance, Leonardo da Vinci integrated scientific and artistic methods and thought into his working methods as a painter, sculptor, botanist and engineer. The final separation of art and science into different cultures in the West can be understood to have taken place during the 19th century, when their methodologies diverged, and the scientific school of thought became largely driven by hypothesis-based enquiry. Art, in turn, developed its own critical methods and ways of working to observe and reflect upon nature, as can be evidenced in emergent notions of the sublime, the impressionistic paintings of Monet and Turner, and the musical compositions of Ravel and Debussy. To effectively answer the research question posed, Ice Floor explored the combined use of scientific data and engineering expertise to observe and interpret the Arctic and Antarctic at the practical and theoretical levels. In this context, the installation aimed to forge a tactile and distinctive contribution to knowledge of the polar regions using mixed methods drawn from the fields of both art and science.

Ice Floor Exhibition collaborative design methods

Ice Floor was curated by Arup Head Curator Jennifer Greitschus. I based my circular design of the installation on a BAS schematic diagram depicting the proportional composition and storage of ice cores. The circular form was conceptually and functionally positioned to mediate a place of communal encounter for visitors in the enclosed exhibition space. Using my original pencil drawing, Arup industrial designer Pete Webster developed computer aided 3D models, which were shared during several planning team meetings with Arup light, sound and materials experts to guide the installation build.

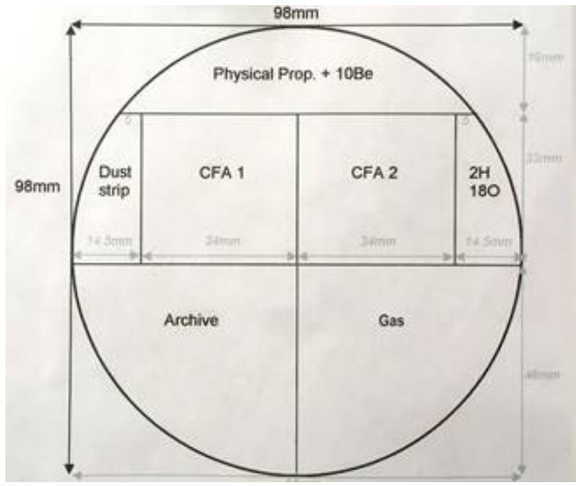


Fig. 7 BAS ice core compositional storage

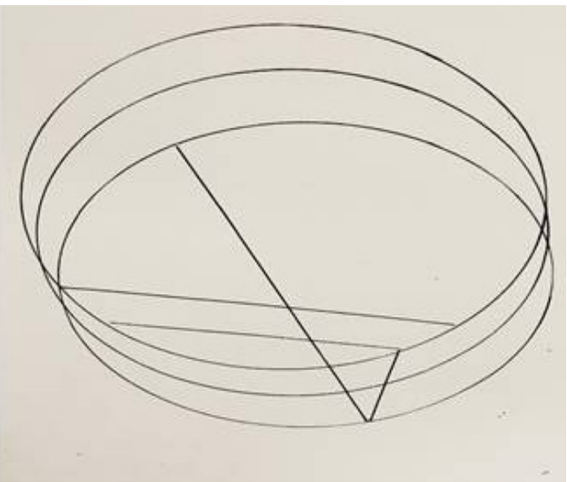


Fig. 8 Ice Floor pencil-drawn design

Stencilled curatorial text and ice core photographic images were installed on the glass façade of the Arup building, where they could be read at street level by the public. The curator and I decided that a contextual film installed in the Arup foyer would be the most effective method of giving audiences direct insight into the making and thinking involved in the production of the installation. In this light, filmmaker Ben Richardson was commissioned by Arup to make a documentary film which drew on footage captured at BAS, RCA and Arup, as well as imagery I had shot in the sub-Arctic and BAS had filmed in Antarctica. I was particularly keen to avoid any attempts of trying to illustrate scientific data as my formative exhibitions had demonstrated that audiences were particularly resistant to being told how to think about the polar regions through the visualization of complex scientific information.

Although ubiquitous within the climate crisis discourse, the significance of the Arctic and Antarctic remains elusive, difficult to comprehend, inaccessible, out of reach. Architects Juhani Pallasmaa, Peter Zumthor and Steven Holl, suggest that such rupture and isolation is due to the singular dominance of the visual sense modality and the way that place and space are conceived, taught and critiqued in the West. In this context, I asked for a specially built cold room to be built by Arup industrial designers to house the installation, so that visitors would be transported to and from a real and imagined polar setting through the calibrated use of ice, light, temperature and glacial sound.

Ice Floor Exhibition. Calculating ice volume

At the point of the Ice Floor commission, I wanted to bring the unbuilt natural environment into the built environment context of exhibition space. I specifically requested a sufficient volume of polar ice to be calculated and reserved for artistic use during the three-month duration of the public exhibition at the Arup Fitzroy Gallery. The ice floor main slab of ice was 2.0 m in diameter, and 0.3 m in depth. The formula used by BAS science lead Robert Mulvaney to calculate the volume needed = pi x square of the radius x depth. This calculation was relatively easy: 3.142 x 1^2 x 0.3 = 0.943 m3. Since a litre of water weighs approximately 1 kg, the weight of water in the main disc is 943 kg, or just a little under one ton.

To calculate the number of ice core slices that would fit onto the 2.0 m diameter large cast ice block, Robert used an engineering calculator readily available on the internet. Opening this link in his browser, there are two boxes, and a 'calculate' button just beneath them. Putting in '2' in the top box (the diameter of the large cast block of ice in meters), and '0.1' in the lower box (the diameter of the ice cores in meters - they were 10 cm cores, hence 0.1 m goes in this box) Robert was able to calculate the number of slices of ice as 280. Robert decided to cut around 330 slices in precautionary reserve. In the end we used them all, and instead of trying for the perfect packing, we placed them a little more randomly, and in places two of three deep. Using his intuitive and factual experience of specific temperature and pressure changes of polar ice, Robert cut the ice slices to a thickness of 20 mm, which he determined was needed to account for their sublimation phase change of state over a period of two or three months.

Sublimation is the transition of a substance directly from a solid state to a gas state. It does not pass through the usual liquid state, and only occurs at specific temperatures and pressures. As the number of visitors to the installation would vary from week to week, and was unknown in advance, it was not possible to exactly determine what the exact temperature and pressure exerted on the cores would be or what the temperature of the cold room should be set at. We also did not fully anticipate that the breath of exhibition visitors would sublime into the ice, becoming an integral part of the piece.

Prior to opening the installation, a temperature of -4 degrees Celcius was provisionally calculated and set by Arup engineers following in-situ sound and lighting tests. This was immediately revised to -6 degrees Celcius when the exhibition opened to account for thermal increase caused by the large number of visitors. In consultation with BAS scientists, myself, the curator and Arup material experts, we decided to create a bed of solid ice installed with frozen 'London' tap water which could then be used as a foundation to place the sliced sections of BAS Antarctic ice on top. This underlying solid ice floor was created by external contractors on site at the gallery in the manner conventionally used in the production of ice-skating rinks.[3]

3 To create the skating surface the ice is built in layers. Water is carefully sprayed directly onto the concrete slab at about 1/32 of an inch. This layer freezes almost immediately when it hits the concrete slab and forms the base of the ice rink skating surface.

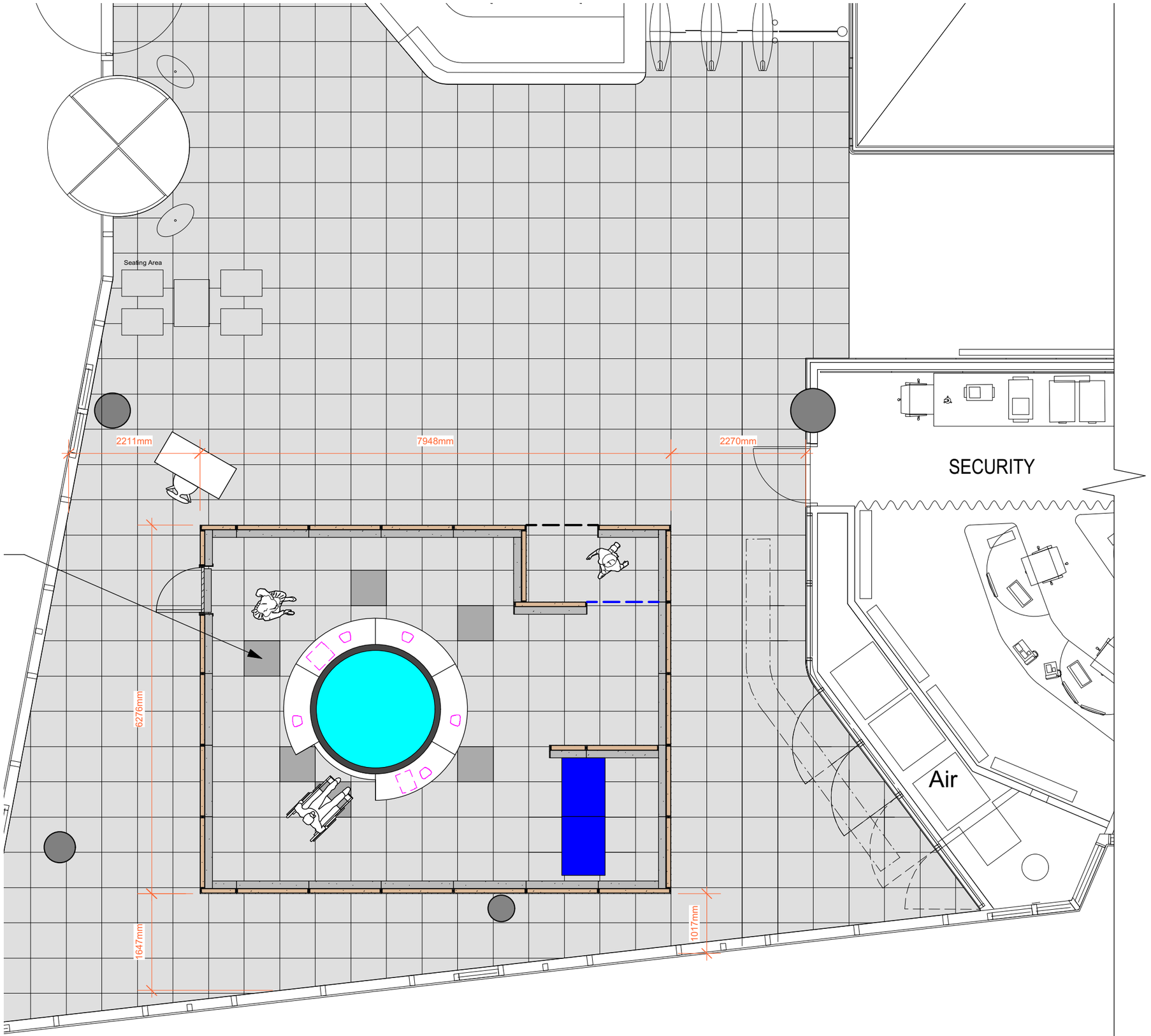


Fig.9 Ice Floor Exhibition Plan. Image Firecracker/Arup

CHECKED BY WORKSHOP

CHECKED BY PRODUCTION MGR

A1

CONSTRUCTION:

FINISH:
Material Finish

MATERIAL - WORKSHOP USE ONLY:

FIRECRACKER work

Address:
The Old Aircraft Hangar,
Wimbledon West Goods Yard,
Dundonald Road,
London, SW19 3QJ.

T: 020 7228 6111 | W: www.firecrackerworks.com

Client:

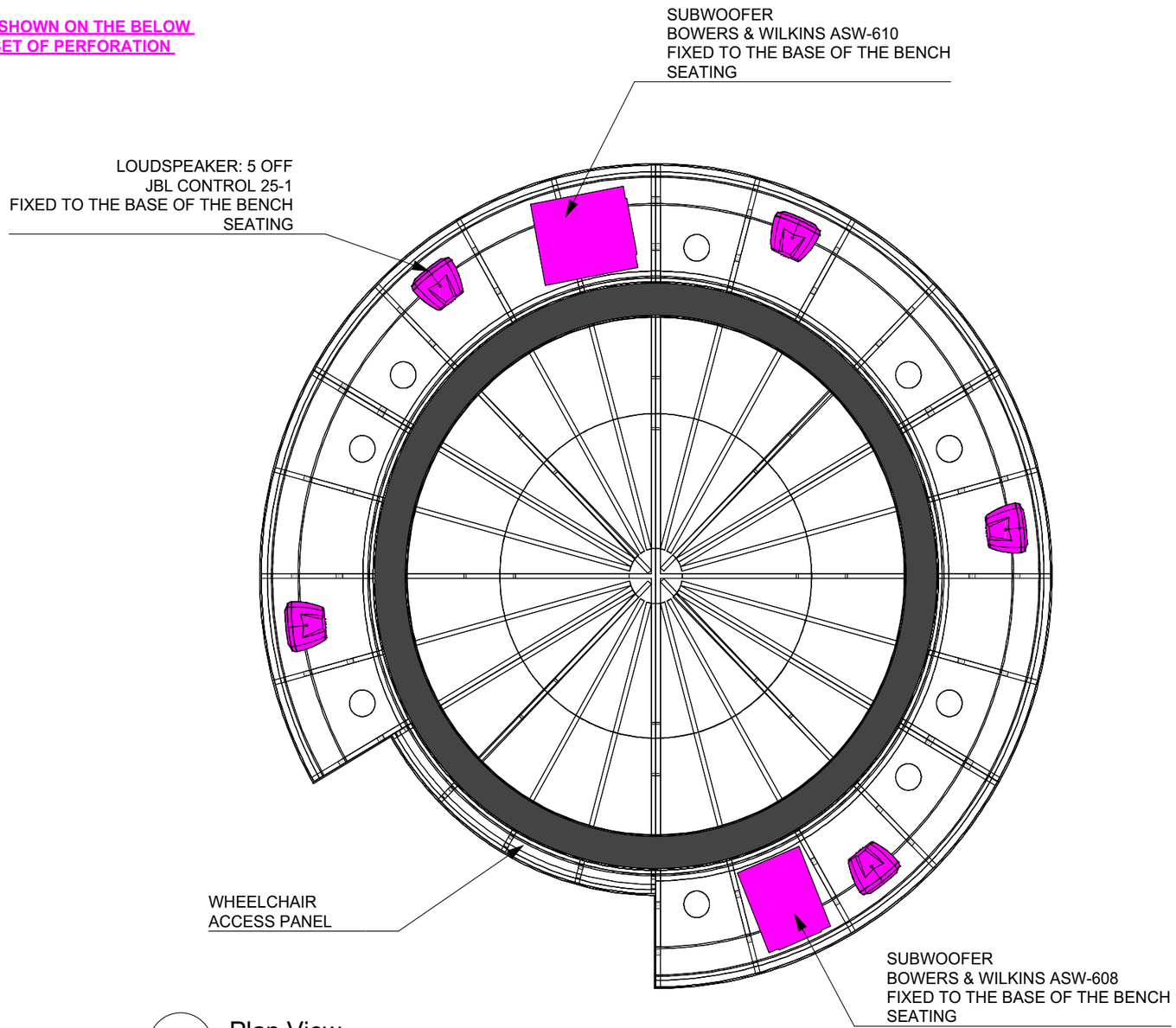
Project name:
ARUP ICE SCULPTURE

Site address:

Drawing Title:
GA PLAN - FOYER

Date: 14/10/2019	Drawn By: AR	
Scale: As Shown		
Job Number: 2137	Drawing Number: PL_01.0	Versio

NOTE:
POSITION LOUDSPEAKERS AS SHOWN ON THE BELOW PLAN TO ALIGN THEM WITH A SET OF PERFORATION HOLES IN THE FRONT PANEL



1 Plan View
Scale: 1:20

PEER REVIEWED BY	
CHECKED BY WORKSHOP	
CHECKED BY PRODUCTION MGR	

A

CONSTRUCTION:
18mm FR MDF - Euroclass C

FINISH:

MATERIAL - WORKSHOP USE ONLY:

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T: 020 7228 6111 | W: www.firecrackerworks.com

Client:

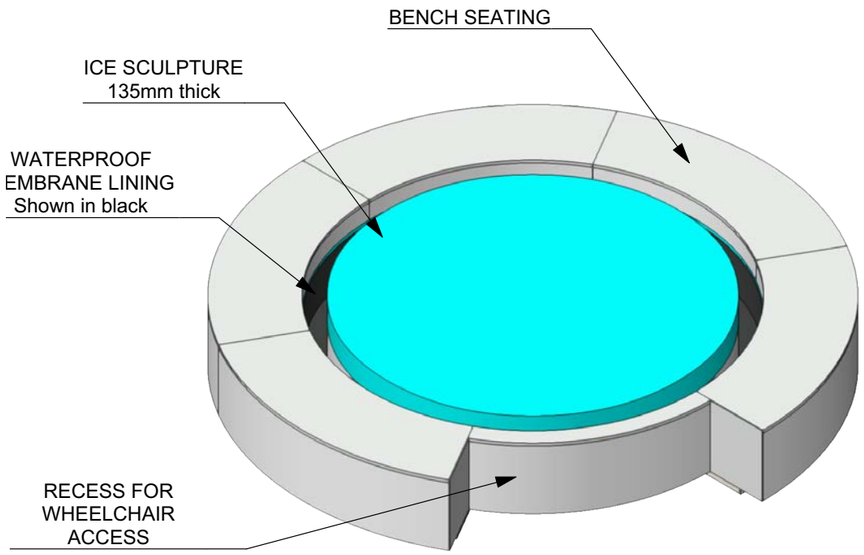
Project name:
ARUP ICE SCULPTURE

Site address:

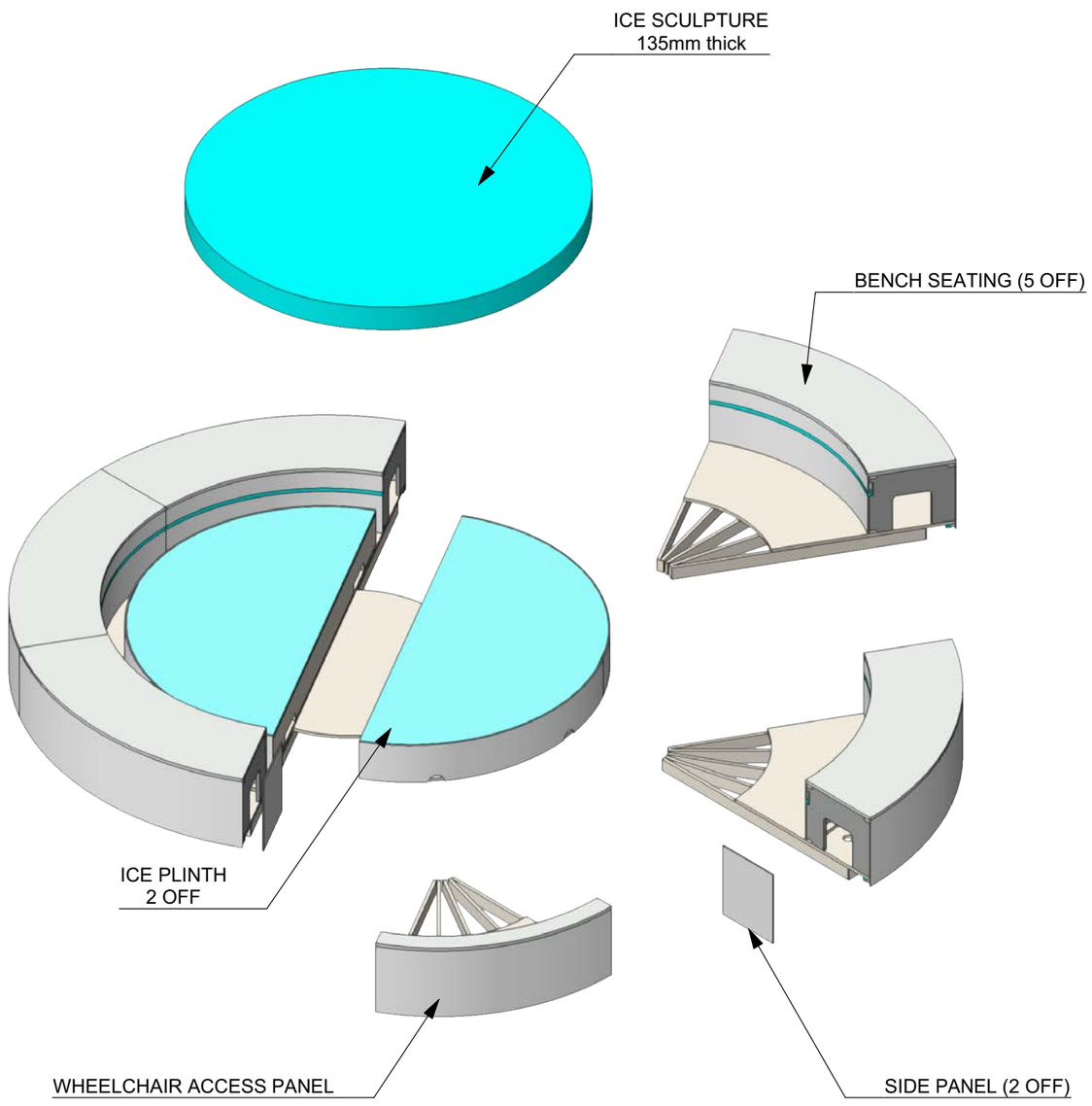
Drawing Title:
SPEAKER ARRANGEMENT

Date: 14/10/2019	Drawn By: AR	
Scale: As Shown		
Job Number: 2137	Drawing Number: CO_01.6	Version:

Fig.10 Ice Floor. Loudspeaker Arrangement. Image: Firecracker/Arup



1 Ice Sculpture - all elements
Scale: 1:30



2 Ice Sculpture - Exploded View
Scale: 1:30

PEER REVIEWED BY
CHECKED BY WORKSHOP
CHECKED BY PRODUCTION MGR

A

CONSTRUCTION:

FINISH:
WHITE EGGSHELL PAINT FINISH

MATERIAL - WORKSHOP USE ONLY

FIRECRACKER

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Dundonald Road,
London, SW19 3QJ.

T: 020 7228 6111 | W: www.firecrackerworks.com

Client:

Project name:
ARUP ICE SCULPTURE

Site address:

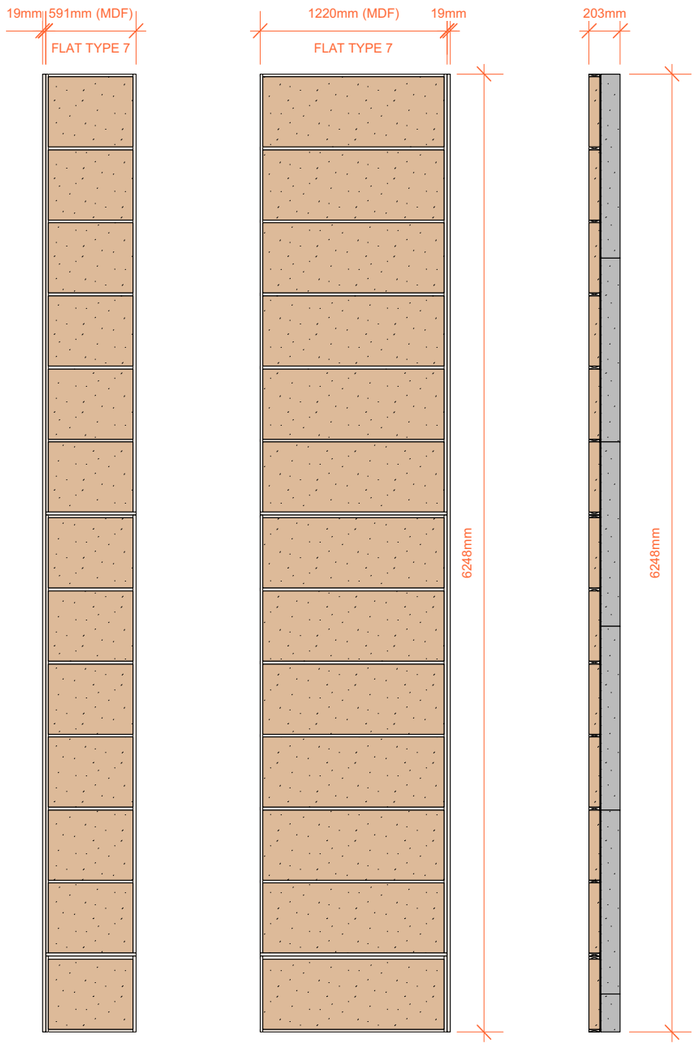
Drawing Title:
ICE SCULPTURE - ASSEMBLY

Date: 14/10/2019
Scale: As Shown
Drawn By: AR

Job Number: 2137
Drawing Number: CO_01.0

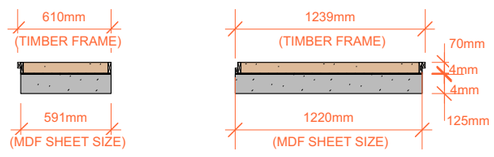
Fig.11 Ice Floor. Assembly. Image: Firecracker/Arup

CEILING FLAT (TYPE 6 & TYPE 7)

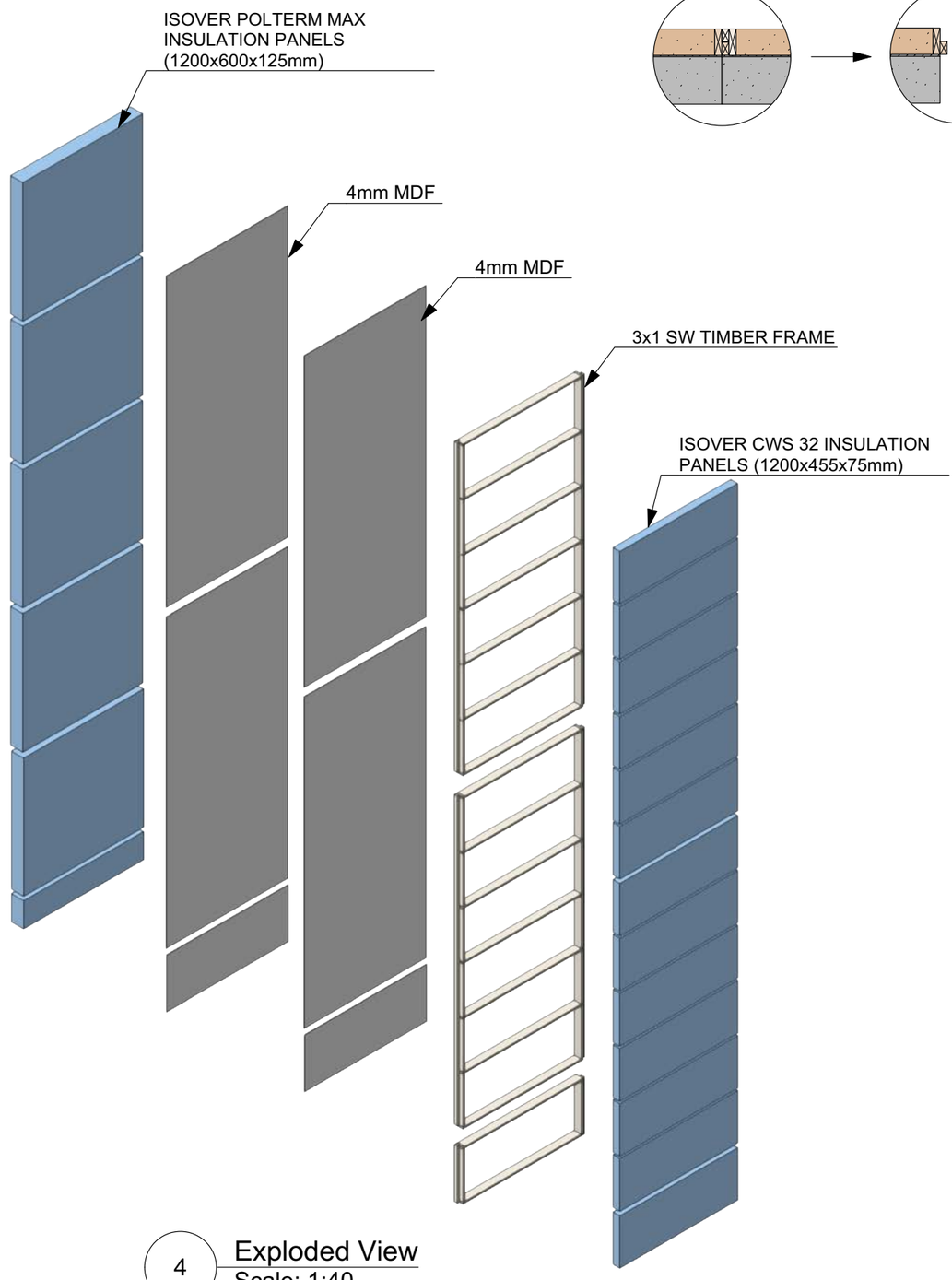


1 Front View
Scale: 1:40

2 Side View
Scale: 1:40



3 Top View
Scale: 1:40



4 Exploded View
Scale: 1:40

PLEASE NOTE:
125mm Isover insulation panels need to be fixed to 4mm inner MDF panel and delivered to site as a seperate piece.

REV:	DESCRIPTION:

PEER REVIEWED BY

CHECKED BY WORKSHOP

CHECKED BY PRODUCTION MGR

A1

CONSTRUCTION:
1 OFF - XXXX

FINISH:
Material Finish

MATERIAL - WORKSHOP USE ONL

FIRECRACK

Address:
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Wimbledon West Goods Yard,
Dundonald Road,
London, SW19 3QJ.

T: 020 7228 6111 | W: www.firecrackerworks.co

Client:

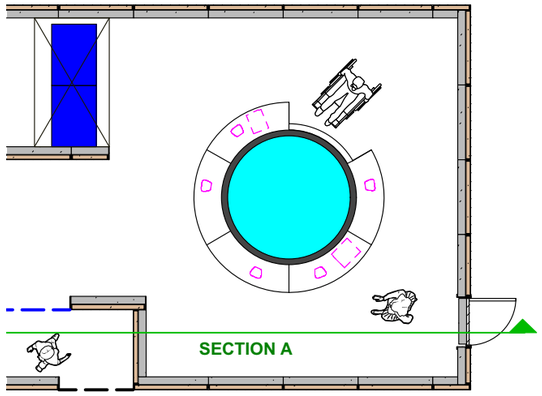
Project name:
ARUP ICE SCULPTURE

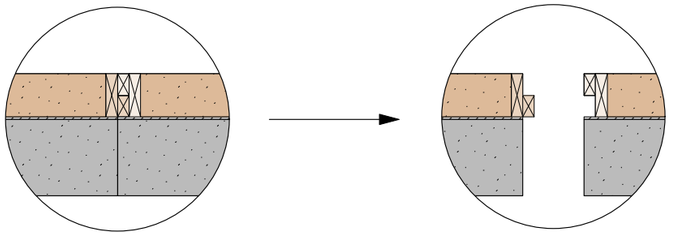
Site address:

Drawing Title:
CEILING FLAT DETAIL

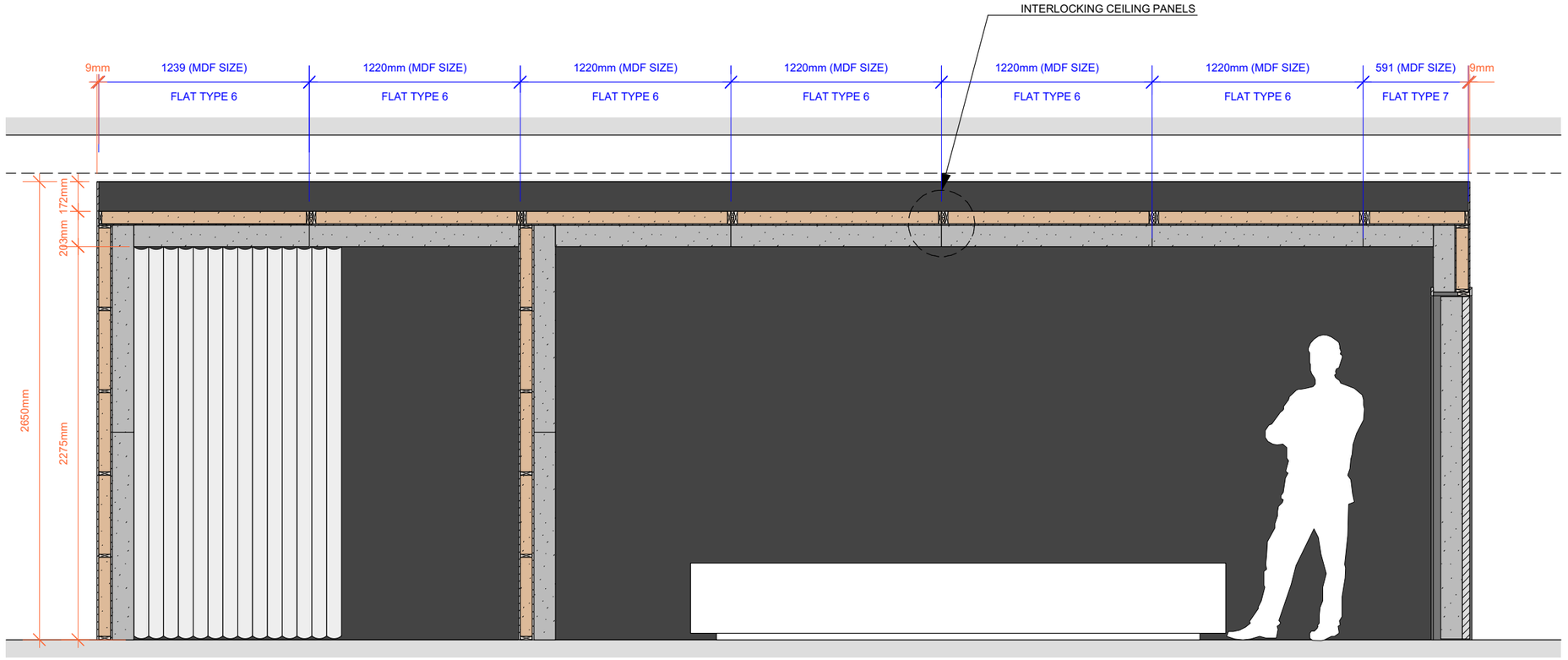
Date: 14/10/2019	Drawn By: AR
Scale: As Shown	
Job Number: 2137	Drawing Number: DT_01.4

Fig.12 Ice Floor. Ceiling flat detail. Image: Firecracker/Arup





CEILING PANELS (FLATS TYPE 6 AND 7)
PLEASE REFER TO CEILING PLAN



Scale: 1:30
Section A 1

REV:	DESCRIPTION:	DATE:

PEER REVIEWED BY

CHECKED BY WORKSHOP

CHECKED BY PRODUCTION MGR

A1

CONSTRUCTION:

FINISH:
Material Finish

MATERIAL - WORKSHOP USE ONLY:

FIRECRACKER works

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Wimbledon West Goods Yard,
Dundonald Road,
London, SW19 3QJ.

T: 020 7228 6111 | W: www.firecrackerworks.com

Client:

Project name:
ARUP ICE SCULPTURE

Site address:

Drawing Title:
SECTION THROUGH

Date: 14/10/2019
Scale: As Shown
Drawn By: AR

Job Number: 2137
Drawing Number: PL_01.4
Version:

Fig.13 Ice Floor. Section through. Image: Firecracker/Arup

Ice Floor Exhibition. Lighting and Acoustics

Arup lighting experts conducted a series of ‘purity’ and ‘impurity’ tests on the ice cores to compare the movement of light between the underlying solid ice floor created by contractors from London tap water and the sliced ice core sections provided by BAS.[4] Water has a melting point of zero degrees Celsius (32 degrees F). The boiling temperature of water changes depending on the pressure in the atmosphere. Purified water is boiled at 212 degrees Fahrenheit (100 degrees Celsius) when it is at its boiling point above sea level. Arup material tests of the ‘London’ tap water needed to build the underlying solid ice floor confirmed that it was severely polluted with contaminants. In contrast, the tests revealed that the BAS ice cores were uncontaminated and pure.

Once the ice core slices were overlaid on top of the solid ‘London’ water foundation, a final series of tests were conducted by the Arup lighting team to calibrate the most suitable colour temperature of LED white lights needed in the installation. Once these optical and thermal qualities of light were tested and corrected, a specific series of LED lights were positioned to illuminate the cores from above, below and within the circular wooden seating-bench container containing the artwork.

In direct collaboration with Arup acoustician Ned Crowe, I spatially remixed my BAS ice core audio recordings at the Arup SoundLab. I also conducted site-specific acoustic tests before and during the installation in person to modify the sound, which was heard and felt via advanced audio speakers in the exhibition space. Integrated with bespoke light and the ice cores themselves, this lighting and acoustic work was designed to situate a proximate sense of the polar regions and to bring the Antarctic alive in the gallery for listeners.

The site-specific spatial mix and use of speakers was designed to move the sound of my BAS ice core recordings around the exhibition space in order to exploit acoustic ‘sweet zones’. Here, four advance audio speakers were positioned at specific points in the floor, walls and ceiling of the space to unable visitors to experience frequencies of glacial sound operating at the upper and lower limits of human perception.

Concealed audio speakers inserted within the circular wooden seating bench structure containing the ice cores further enabled visitors to experience intermittent bursts of glacial sound as it travelled through the wooden bench and up into their physical bodies. The collaborative use of these methods developed and refined throughout the Ice Floor installation were conceptually and theoretically aligned by me to create an intimate space of aesthetic encounter for the visitor within a tactile and fully immersive experience of the solid, liquid and vapour phase changes of polar ice.

4 Material experts know whether a substance is pure or impure by melting or boiling a substance. If there is a difference between the known melting and boiling points of that substance, it means that the substance being tested is impure. Inversely, if the melting and boiling points of known substance are the same, the substance is said to be pure.

Polar Zero Exhibition: Ice as ‘Vibrant Matter’

In her publication, Vibrant Matter, political theorist Jane Bennett shifts her focus from the human experience of things to things themselves, in order to argue for a ‘vital materiality that runs through and across non-human bodies’. (Bennett, 2010). Drawing on both the human and non-human nature of my research question, I made a strategic decision at the outset of my academic studies at the RCA to devise a mixed research method that would be supported by scientific data from BAS and engineering expertise from Arup.

Over the course of six years, this specific decision to situate external supervisory support facilitated a sustained depth of interdisciplinary knowledge making and sharing needed within the research that was beyond the scope of the RCA. Crucially, the scientific and engineering tools and expertise at BAS and Arup facilitated an effectively structured academic framework that enabled me to conceive and secure the large-scale UKRI public commission Polar Zero, which became the fifth methodological component and final research output.

Polar Zero examined the exhibition format as a critical aesthetic method to explore the chemical and societal equivalence of polar ice in the charged political setting of COP26. Moving between the intellectual and emotional polarities of ice and glass, both negative and positive, the method also aimed to determine how the often-contaminated energies of the current climate change debate might be modified, if we acknowledge that political agency emerges as the result of im/material configurations both animate and inanimate, human and non-human.

The exhibition integrated some of the wider theoretical implications put forward by scholars including Bennett to posit that questions of agency are not only formulated by the inert inactions of economists and politicians of the North, but in the chemical actions and material reactions found in the volatile waters of the South. With Polar Zero, I positioned the exhibition format to answer the critical questions:

What are the economic costs of Antarctic and Arctic ice loss? Can polar ice be viewed as a vital political material through which to activate ethical and ecologically moral forms of environmental governance? Can looking back to the glacial past change the way we perceive the political climate of the present and future?

Many things are not said about polar matter. However, it is not enough to speak of the unsaid dimensions. Polar Zero aimed to structure the spoken as finely and as keenly as the unspoken. Challenging the rhetoric used by fossil fuel corporations and ‘big power’, the methods used in the Polar Zero exhibition did not seek to individually blame or shame, but rather sought a collective projection forward to question the very nature of matter and mattering where the current political discourse is reframed and reconfigured to include the critical agency of the indigenous peoples living in the Arctic north and the climate scientists working in the Antarctic south.

Polar Zero. Aims, Objectives and Orders of Work

Between February 2021 and January 2022, I was the Polar Zero Research Associate at the RCA working as a Research Fellow. This position was granted as part of a collaborative UKRI bid and commission awarded to facilitate a summative PhD research output at COP26, an intergovernmental global summit that brought parties together to accelerate action towards the goals of the Paris Agreement and the UN Framework Convention on Climate Change. Polar Zero was a collaborative research bid conceived by myself in close dialogue with BAS Head of Communications Linda Capper. The award stipulated that I would design, procure and stage three artworks, with scientific and engineering collaborative support from BAS and Arup experts to be accompanied by a bespoke sound environment in a show entitled Polar Zero to be held at the Glasgow Science Centre before and during COP26 in 2021. While the commission was collaborative in design, I held the main authorial responsibility of all decisions made on the project.

- **1765 - Antarctic Air** – a sample of air from 1765 encapsulated in a cast glass cylinder
- **Ice Core** – a scientific ice core mounted vertically and melting progressively
- **Ice Stories** – a text installation on the floor of the GSC leading to the exhibition space

The collaborative design of the exhibition involved a scheme stage that was sufficient for suppliers and contractors to develop into final working details according to their most advantageous processes. Procurements involved identifying and securing suitable suppliers and contractors to deliver and install elements of the exhibition that could not be made by myself. The Polar Zero commission and exhibition collided with the outbreak of Covid 19. See impact statement. The specific research methods used for Polar Zero were established within my original collaborative proposal to the UKRI. The principal challenges were:

- Presenting and replenishment of the ice core to engage visitors and allow interaction and contemplation while managing the rate of melting to keep replenishment practical, without the use of refrigeration in the exhibition space.
- Capturing the sample of historic air and encapsulating it within a cast mass of glass that resembles a scientific ice core specimen.
- Lighting Ice Core and 1765 Antarctic Air and the space in which they were exhibited.
- Presenting the sound environment in the exhibition space.
- Adapting and making good the available exhibition space to suit the exhibition.
- Presenting Ice Stories in an impactful and engaging manner.
- Meeting time and budget constraints within RCA policies on supplier approval and payment timelines.
- To make an innovative cultural contribution to climate science communication, diplomacy, and policy.
- To highlight and communicate the strengths arising from collaboration between science, engineering, and art.
- Development of the concept started in February 2020. Installation started on 23rd Sept 2021, and was completed in time for the press launch on 29th Sept 2021.

- Polar Zero opened to the public 2nd to 16th October 2021.
- It was closed during preparations for COP26.
- Polar Zero was opened to delegates during COP26 1st to 12th November.
- Open to public 2nd October.
- Polar Zero was de-rigged at the end November 2021. This was carried out by a local contractor who was sourced by me in consultation with Arup engineers.

As the named Artist/Research Associate I was responsible for:

- Conception, production and delivery of three artworks.
- Ensuring the integrity and delivery of the concept in close dialogue with all partners.
- Working closely with suppliers and the production coordinator to minimise design changes in production (and associated costs)
- Providing suppliers and partners information such that they were able to meet the timeline to installation and de-rig.
- Working closely with the RCA to ensure budgets and timelines were met, including procurement and payment schedules.

ARUP were located within my planned scheme of work to:

- Assist in the design of the pieces, staging, lighting, and sound installation.
- Loan speakers, amplifiers and assist in the design of site-specific spatial audio for the installation.
- Prepare drawings for procurement of work by contractors who will complete design for fabrication.
- Identify and brief suitable contractors for provision of fabricated elements including the columns for Ice Core and 1765 Antarctic Air, drapes and flooring for the exhibition space, light fittings, and sound installation, recognising the RCA's procurement and supplier approval policies.
- Assist in developing the method of production of the cast glass and encapsulation of air for 1765 Antarctic Air in liaison with glass fabricator.
- Advise on the replenishment frequency for Ice Core.
- Coordinate design and engineering activities in liaison with other parties.

BAS were located within my planned scheme of work to be responsible for the following:

- Liaison with Cabinet Office (UK/Italy were COP26 hosts) and AHRC around COP and funding for the project.
- Provision of ice cores and coordination, care and replenishment of their use during the exhibition.
- Capture of air from ice and encapsulation within the cast glass.

RCA were located within my planned scheme of work to provide the following:

- Support of the Artist in design and curation of the exhibition.
- Administration of UKRI funding in line with RCA procurement and supplier approval policies.
- Appointment, approval and payment of all suppliers and contractors.
- Appointment approval and payment of an exhibition production coordinator to supervise final production and installation.

Glasgow Science Centre provided and were responsible for the following:

- Exhibition space (the Egg) within the Science Centre.
- Security of the exhibition during installation, operation, and de-rig.
- Management (switch on, switch off) of the exhibition during operation.
- Staffing the exhibition during operation outside of the COP 26 event.
- Providing cold storage for ice cores.

Media Communications

- Under the direction of Linda Capper, BAS Director of Communication, individual partners worked collaboratively to promote Polar Zero at the national and international levels, and acknowledge the Exhibition Partners.

Media Objectives

- Showcase the contribution that artistic research can make towards addressing questions of the Arctic and Antarctic.
- Promote science-arts collaborations as a method of provoking thought about climate change.
- Inspire climate action by driving the public to engage with the exhibition physically and virtually.
- Encourage collaboration between arts researchers/practitioners, scientists, and engineers.

Media Strategy

- Media engagement focussed on two milestones: the announcement and launch of the exhibition with AHRC leading on comms around the announcement and BAS on the launch.
- The target sectors were high-impact national outlets, regional outlets in Scotland and Glasgow, science and research sector press and arts sector press. Press releases for each milestone were tailored to different sectors including radio, and included a range of carefully curated visual assets as well as messaging around the importance of the collaboration between art and science.
- A press event was positioned at the exhibition space ahead of the opening of the exhibition to the public. A particular emphasis was put on securing the attendance of photojournalists for this launch due to the high potential for images to be picked up nationally and internationally by radio, tv, print and broadcast media outlets.

Covid Impact Statement

To mitigate the impact of COVID-19 on my research project within the funded period and make a timely submission, I applied for and successfully received a three-month AHRC study extension during which I carried out a series of adjustments and mitigations.

Impact

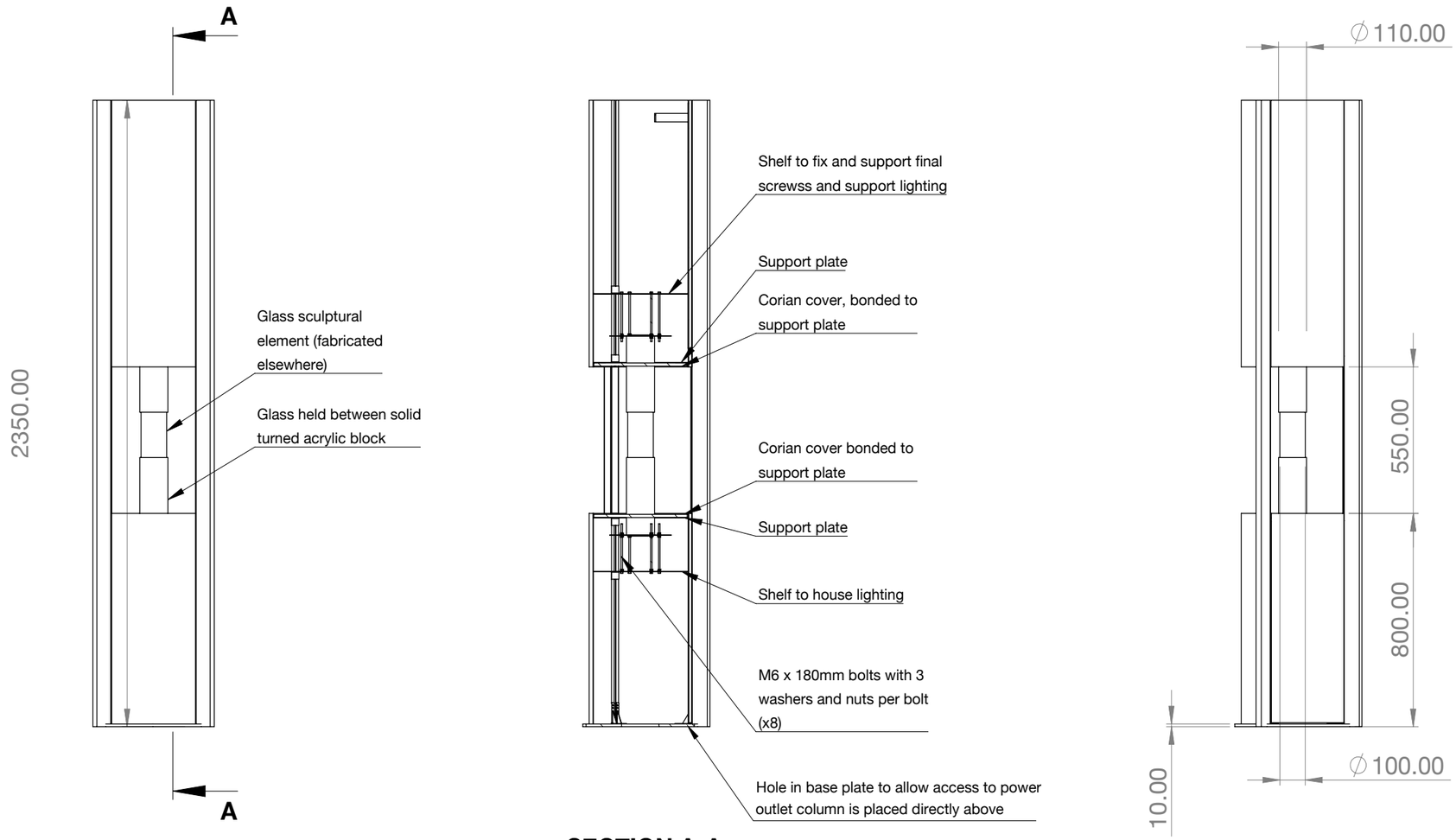
The primary impact of COVID-19 on my research project was the cancellation of a pre-planned field visit to the British Antarctic Survey headquarters in Rothero, northern Antarctica. The cancellation of a crucial field visit in my final year of study resulted in a significant loss of primary source material into my practical and written research of the polar regions. This loss greatly impacted on the aims, scope and achievability of the research, and forced me to adopt new research methods of production, evaluation and dissemination. The Covid-19 pandemic also prevented me from exploiting the transformative use of tools, expertise and technical support at the RCA and Arup in London, and the British Antarctic Survey ice core laboratory in Cambridge previously in place. As such, these combined losses severely diminished the breadth and depth of my practical and written research at both the qualitative and quantitative level.

Adaptations and Mitigations undertaken

To decrease the delaying effects of my cancelled field visits and the use of tools, expertise and facilities at the RCA, BAS and Arup, I adopted a new working process by which the research became fitted to the ongoing pandemic and ecological crisis. Acting on the current climatic and environmental crisis required me to restructure the written and practical approach used in the final stage of my project including the use of secondary sources of historical and contemporary literature on the polar regions. In an attempt to mitigate the loss of primary sources, I reviewed and consolidated a newly argumentative and analytic approach to the contemporary writing of polar history, including a focus on the central role of temperature within the research. In turn, this new research thinking and making contributed to me devising, gaining and delivering the large-scale commission Polar Zero from the AHRC to present a series of artworks for the Glasgow international conference on climate change COP 26 in collaboration with Arup/BAS/RCA.

1765 Glass Column Concept

Polar Zero Exhibition | Glasgow Science Centre



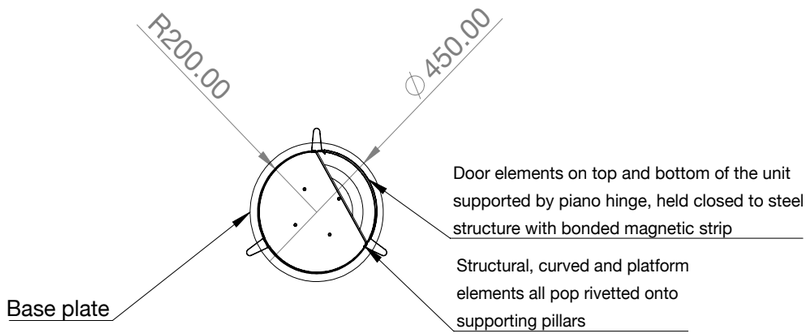


Fig.14 Polar Zero Exhibition Design. Image: Peter Webster/Arup

CLIENT: Wayne Binitie & British Antarctic Survey		PROJECT: Polar Zero Exhibit			ARUP			
DATE: 12/08/21	UNIT: MM	SCALE: 1:20	DRAWN: PW	CHECKED:	APPRVD:	VERSION: 1	SHEET: 2	A3
MATERIAL: Steel unless otherwise stated		FINISH: 7043 RAL powder coated						

The Egg | Polar Zero Proposed Layout

Polar Zero Exhibition | Glasgow Science Centre

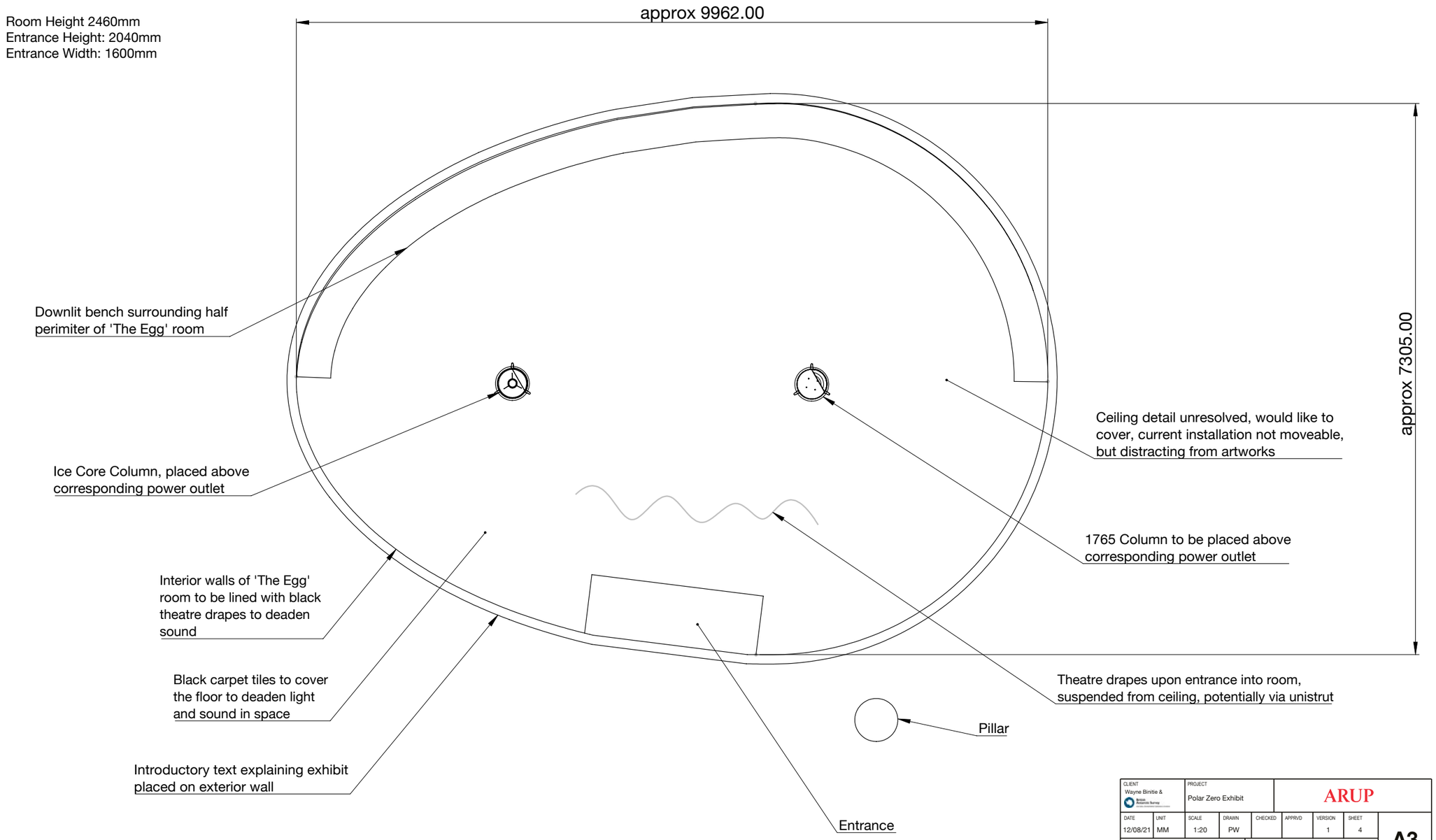


Fig.15 The Egg. Polar Zero proposed layout

Fig.16 Polar Zero Exhibition install. Image: Pete Bucktrout/BAS

Fig.17 Polar Zero Exhibition install. Image: Pete Bucktrout/BAS

Fig.18 Polar Zero Exhibition install. Image: Pete Bucktrout/BAS

Polar Zero collaborative research methods: 'Ice Stories'

My previous exhibitions had shown that visitors have a limited interest in curatorial texts, even when professionally articulated in the usual way either on gallery walls with large-scale vinyl lettering or in printed exhibition catalogues. Exhibition films proved more effective, giving visitors direct insight into the making and thinking involved in the production of the artworks. In this light, filmmaker Ben Richardson was commissioned by BAS to make a Polar Zero documentary film which drew on footage captured at BAS, RCA and Arup, as well as imagery I had shot in the Arctic and BAS had filmed in the Antarctic. We wanted to make use of the large screen outside of the GSC to promote a series of exhibition films. Three weeks before COP26 opened, Arup visual specialists offered the opportunity to use their newly-acquired 3D cameras to film the artworks in the Egg exhibition space. This exciting if experimental process required several days of filming in Glasgow, followed by several days of editing in the Arup E Lab space in London. The Polar Zero Exhibition Film aimed to document the three COP26 commission pieces, and was storyboarded by Arup Materials Lead Graham Dodd and myself. The process involved integrating three sets of film footage:

1. **Polar Zero Documentary Film** made by Ben Richardson.
2. Insitu footage of '**1765'** and '**Ice Core'** shot at the GSC in Glasgow.
3. **Ice Stories Film created** at the Arup E Lab in London. Edited by John Lucy/Arup

The insitu footage of '**1765'** and '**Ice Core'** was filmed by Arup using stereoscopic 4K cameras at the GSC in Glasgow with a variety of matching cinematic fixed focal lengths lenses to explore the details within the two pieces inside the space. To create movement the cameras were mounted on a Manfrotto Syrp Genie 3-Axis motion control which ran along 5 metres of slider track. This produced fluid and smooth footage to explore the details of the ice sculpture in an immersive stereoscopic film. The **Ice Stories** film involved a form of animated writing that used original audio, words from glaciologists and a photograph of an iceberg from my photographic series. Arup Experience Designer John Lucy explains the production methods explored in the Arup E Lab using After Effects software:

> The text was created by using the cut-up poetry method on accounts of Antarctic scientists. It was duplicated several times and had multiple instances of blur and displacement effects applied to give the text the appearance of being set behind the surface of the ice. This was combined with using varying blend modes to further integrate the text into the material surface. The aim was to create the appearance of the ink bleeding into the ice. The parameters of these effects were animated and offset in time across the image to create an organic realistic transition between slides of text. Instead of bringing the text in and out of focus all at once, a Time Displacement effect was to delay parts of the effect. The Time Displacement effect uses a black and white map image to selectively composite later frames in the sequence into the current frame, similar to the slit scan effect. By using a gradient, starting in the top left and ending in the bottom right, as the Time Displacement map, it was possible to gradually bring areas of the text into focus over time to create visual interest for the viewer. (John Lucy, Arup Experience Designer, 2023)

Jamie Oliver, BAS Communications, provided a pdf of graphics for the Ice Stories words to be installed by a local contractor on the concrete floor of the Glasgow Science Centre in vinyl lettering at the entrance of the exhibition space. Working in close dialogue with Toria Richardson, Jamie also produced a large scale photographic image (on following page) outlining signficant events in Antarctic history, which was installed on the exterior wall of the Egg exhibition space, where they could be read by COP26 visitors.

In chemistry, deposition is the phase change transition by which, in sub-freezing air, water vapour changes directly to ice without first becoming a liquid. In Ice Stories, deposition refers to the process by which the words and written testimony of leading international glaciologists are inscribed on a solid concrete floor of the Glasgow Science Centre. Within the heat-driven context of COP26, the inclusion of these international voices was conceptually positioned to remove the excess of collective thermal energy forged across this highly politicised global event. After a period of two months, I selected individually written words and phrases that were submitted via email from the international glaciologists to make a single continuous text. In my final selection of multilingual words, it was clear that each phase transition has its own atmospheric language and material identity.

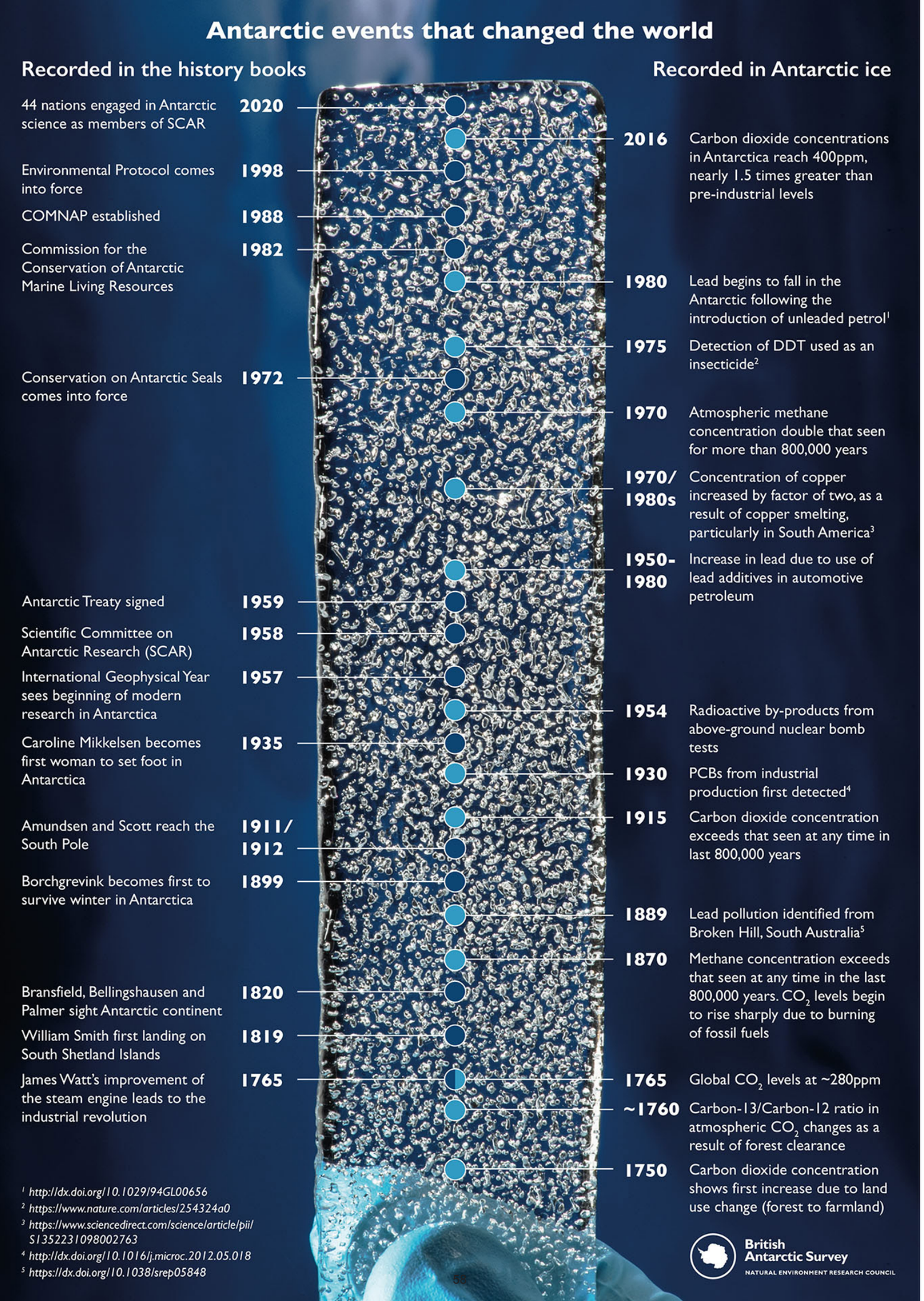
Transparency

That the glass would melt in the heat,
That the water would freeze in the cold,
Shows that this object is merely a state, one of many between poles.

- Wallace Stevens in Selected Poems, Alfred A. Knopf, 2011.

As suggested by Stevens, words, like objects, can be transparent or opaque. They can also evoke an evaporation and condensation of meaning that moves between poles. Ice Stories was a text installation seen on the floor leading to the Glasgow Science Centre exhibition space and a film. The work draws on personal anecdotes, memories and oral testimonies from the national and international scientists and experts whose lived experiences of the Arctic and Antarctic facilitate and enable their narrative futures to be written.

Ice Stories articulated my interest in how polar history is written, read, and eased at the human and non-human, chemical and societal levels. The piece was conceived as a multi-part work that could be accessible to visitors both online in the digital realm and offline as a physical work. In close dialogue with Robert Mulvaney, we created a list of participants to include in the piece before sending out invitation emails and letters of consent. In my artistic brief, I requested something intimate, poetic and unpublished that could not be found on the internet. Informed by Roni Horn's use of inscribed Icelandic and English words at the Library of Water, I wanted exhibition readers/listeners to imagine what it means to experience the phase changes in between solid, liquid and vapourous matter. I therefore specifically asked the glaciologists to use the phase changes of polar water:



Freezing and melting, condensation and evaporation, sublimation and deposition

The film created for Ice Stories used a fragment from La Cathédrale Engloutie (The Sunken Cathedral, a piano prelude by Debussy). This piece is shaped by an ancient Breton myth in which a cathedral submerged underwater off the coast of the Island of Ys rises from the sea on clear mornings when the water is still and glassy. The continuous panoramic shot of this specific Polar Zero film echoed the idea of Antarctica as an immense 'ice cathedral' as it slowly emerges from the polar waters at sunrise.

Fig.19 Polar Zero Exhibition Wall Text. Image: Jamie Oliver/BAS

Fig.20 Polar Zero Exhibition Film production with Graham Dodd. Image: John Lucy/Arup

Fig.21 Ice Stories Film production. Image: John Lucy/Arup

Fig.22 Ice Stories Film production. Image: John Lucy/Arup

Fig.23 Ice Stories Film production. Image: John Lucy/Arup

Polar Zero collaborative research methods: ‘1765 - Antarctic Air’

In 1765, James Watt designed a new steam engine that kicked-started the Industrial Revolution. The atmospheric archive captured in Antarctic ice shows, that at the same point in time, the carbon-di-oxide emitted by coal-burning began the inexorable increase in atmospheric greenhouse gases that has changed our planet forever.

Extracted from its resting place deep in Antarctic ice, and encased forever in a cylindrical glass sculpture reminiscent of an ice core, is a single bubble of 1765 air. The glass sculpture aimed to embody our dependence on our planet and the unseen impact human activities have had on it, while speaking of our collaborative commitment to polar memory and collective action. Indivisible and unequivocal, the work captures a pivotal moment in the Earth’s history - the pre-industrial rev-olution era. Inspiration came from audience reaction to exhibitions from the collaboration (the most recent being Ice Floor at Arup) and the timing of the UK’s hosting of a major international climate conference in Watt’s home city of Glasgow. It deliberately made a connection to the Paris agreement [5] by referencing Marcel Duchamp’s seminal work 50cc of Paris Air. In 1919 Duchamp purchased an ‘empty’ glass ampoule from a pharmacist in Paris as a souvenir for his close friend and patron, Walter C. Arensberg. Now held in the Philadelphia Museum, the ampoule was accidentally broken in 1949 and later repaired, raising questions about the veracity of air contained within it.

I wanted to capture a verifiable volume of air from 1765 in glass to provide an artistic marker of how much the earth’s atmosphere and climate has altered since the last possible date before Watt’s advancements unwittingly unleashed damage to the climate and atmosphere. We cannot see air. A method was collaboratively devised (between myself, Robert and Graham) to cast the glass first, and only later inject the air. The method involved me casting an internal cylindrical void within a solid glass cylindrical form, which was then filled with a light oil by Robert Mulvaney, who displaced the oil with the old air before sealing the glass channel.

Using this method, the required volume of ancient air was physically discerned by the exhibition-viewer at eye level, within a sculpture lit internally and held by floor-to-ceiling cylindrical steel plinths within a darkened exhibition space. The material needed to fill the void in the cast glass of ‘1765’ had to have crystal clear transparency, without any colour that might contrast with the clear glass. Arup lighting specialists conducted several lighting tests to maximise the optical visibility of the air while minimising the optical visibility of the liquid. The liquid needed to have a refractive index as close as possible to that of glass so that the filled cylinder of glass would not appear as a separate object below the bubble of air. Arup Materials Lead Graham Dodd describes the complexity of this specific engineering problem and the technical solutions he found to resolve it:

> This posed a challenge because the lead crystal glass used to make the sculpture (Schott LF5) has a high refractive index, meaning that it bends light strongly, which we wanted to avoid. Silicone oils have been used in some similar applications, but their refractive index is substantially lower than the glass being used. We identified a two-part clear silicone encapsulant with the highest available refractive index, but it was still substantially lower than that of the glass, and it was difficult to source in the timescale of the work. It would also require heating to achieve correct curing, which posed a risk of breaking the glass, and that would have been a disaster for the programme. We also identified a single-part clear silicone encapsulant with a much lower refractive index that was readily available and would cure at room temperature. Searching for clear fluids with high refractive index, benzyl benzoate was found to have only a slightly lower refractive index than the glass, so it provided the best optical match to minimise the visibility of the cylindrical inclusion below the bubble. Benzyl benzoate is denser than the clear silicone sealant we had identified, so the sealant would float on the fluid, suggesting a method of filling the void, sealing with clear silicone and then injecting the air specimen. (Graham Dodd, 2022)

We needed to be scientifically certain that the air enclosed within the glass sculpture remained ver-ifiably ‘uncontaminated’ air, sourced from the year 1765. As this had not been attempted before, we needed to devise an experimental yet precise approach. The practical method for extracting, filling, sealing and then injecting air into the glass was developed by BAS glaciologist Robert Mulvaney:

> [The] first stage was of course the selection of the ice with the air. The ice came from an ice core recovered in the 2007/08 season in Antarctica, from James Ross Island. The core was drilled from close to the highest point on the island, Mount Haddington. The James Ross Island core is 364m long, reaching the bedrock, and has an unbroken record of ice from the last 14,000 years that can readily be dated, plus 6m of ice at the bottom that is approximately 60,000 years old. Once the bubbles are closed off, then as you got deeper in the ice, the air gets older at the same rate as the ice surrounding the air bubbles. So, some metres deeper, the ice may be 10 years older, but so is the air. We also need to know the age of the ice at the point of close-off. All this comes together in what we call the ‘delta-age’, the difference between the age of the ice at a particular depth, and the age of the locked-in bubbles. So, we can construct age scales for both the ice and the air locked into the ice. For the Polar Zero piece, we needed air from 1765, which in the case of James Ross Island, we can work out was at a depth of 170.4m from the surface. (Mulvaney, 2022)

The method of encapsulating Antarctic air in glass involved me casting an internal cylindrical void within a solid glass cylindrical form, which was then filled with a light oil (Benzyl Benzoate) by Rob-ert Mulvaney. After sealing the oil with a clear liquid encapsulant (Dow 2888) Mulvaney inverted the glass sculpture and injected it’s internal void with old air before another final sealing off of the glass channel. Using this method, the required volume of ancient air was physically discerned by the exhi-bition-viewer at eye level, within a sculpture lit internally and held by floor-to-ceiling cylindrical steel plinths within a darkened exhibition space.

5 The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at the UN Climate Change Conference (COP21) in Paris, France, on 12 December 2015. It entered into force on 4 November 2016. Its overarching goal is to hold “the increase in the global average temperature to well below 2°C above pre-industrial levels” and pursue efforts “to limit the temperature increase to 1.5°C above pre-industrial levels.”

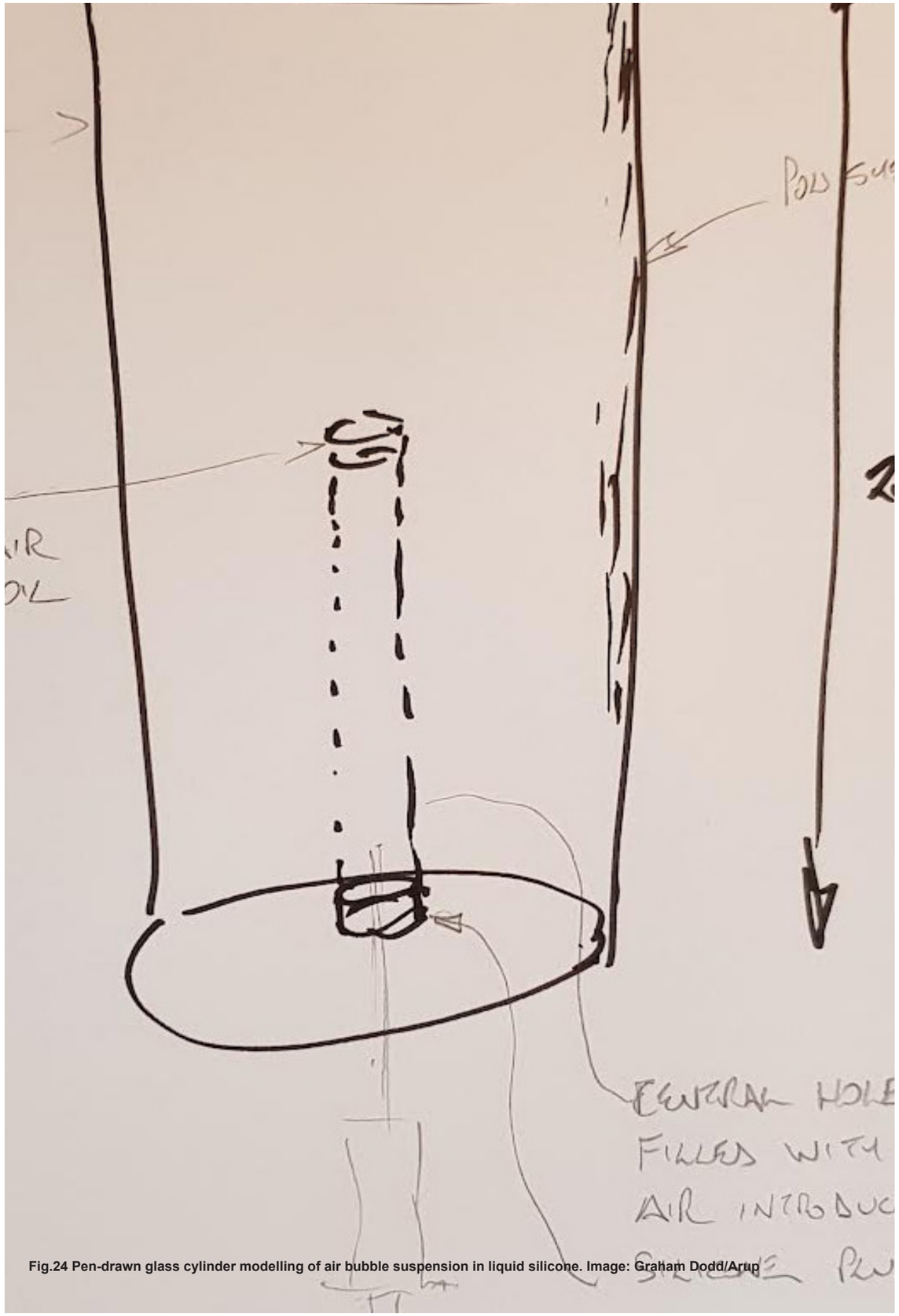


Fig.24 Pen-drawn glass cylinder modelling of air bubble suspension in liquid silicone. Image: Graham Dodd/Arup

Fig. 25 Computer model visualisation of 'I765-Antarctic Air' installation design with spray painted floor-to-ceiling steel plinths. Image: Peter Webster/Arup

Fig.26 Computer model visualisation of ‘Ice Core’ installation design with spray painted floor-to-ceiling steel plinths. Image: Pete Webster/Arup

Polar Zero collaborative research methods; ‘Ice Core’, ‘1765’ and ‘Ice Stories’

To display samples of ice core, we had concluded as a team that there should be no refrigeration and no powered moving parts. This led to the conclusion that the ice should be inclined steeply enough to slide from an insulated zone into an exposed zone under its own weight as it melted. The shape of the Egg room available for the exhibition lent itself to a vertical column of ice, standing in a clear acrylic tube, the bottom of which would have openings to allow melt water to flow out and for visitors to touch the ice and see it directly. Clear acrylic plastic is easy to fabricate and is available in tubular form, so size was selected to allow the ice cores to slide easily inside. A solid acrylic lens was designed to stop the core falling out of the bottom end, and to guide light up into the ice from below.

The top of the tube was housed in a wider diameter enclosure, allowing it to be insulated to keep it as cold as possible before emerging into the lower zone where it was visible. Although we had imagined completely filling the insulated zone with high performance insulation, we discovered during installation and commissioning that a relatively thin insulating sleeve was sufficient to regulate the melting rate so that drips would fall regularly. We also noted that the top of the tube had to be sealed and insulated to prevent convection currents of air between the ice and the inside of the acrylic tube, which tended to increase the melting rate and distort the cylindrical form of the core before it emerged into view.

The lighting strategy was to emphasise the ice and the air in the glass as the objects of interest. Therefore, both pieces were lit from below within their respective columns. For Ice Core, this involved lighting through the container into which the melt water would drip, so a clear bowl was required. This could have been fabricated from clear acrylic like the tube for the ice core but it was faster and more economical to purchase a glass bowl, in fact a glass lens for a common washing machine. The washing machine door glass was easily sourced for early lighting experiments before the final design was confirmed and the bowl incorporated in the display piece was actually salvaged from a redundant machine.

Ice Core was insulated around its upper section, which was concealed from view, in order to control the rate of melting without the use of refrigeration. The clear acrylic tube was designed to be a removable cassette in the pedestal, so that it could be lifted out and loaded with sections of ice core provided by BAS. The cores of ice were brought from storage at BAS in insulated boxes and stored in a freezer at the venue until required. Each day of the exhibition the cassette was loaded with sections of ice core, which were intended to melt progressively during the day.

The method of designing the insulation for ‘Ice Core’ was experimental, starting with a trial for few hours with no insulation around the upper part of the cassette (1 day before opening). We observed that the melting rate was rapid, producing a constant flow of melt water rather than the intended regular dripping that was the intended effect.

This rapid rate of melt was estimated by Graham Dodd and Robert Mulvaney by measuring the volume of melt water collecting over the few hours of the trial, and found that it would consume more ice core samples than were available within the duration of the exhibition. Therefore, the rate of melting needed to be controlled to deliver the intended rate of dripping, slow enough to generate some feeling of tension but fast enough to maintain engagement on the part of the viewer, and to enable the piece to last for the intended duration of the show. It was agreed that the ice would be removed at night on closing the exhibition and stored in the freezer until being re-loaded in the morning. The amount and position of insulation was developed experimentally, using a wrap of flooring underlay to add layers of thermal insulation around the cylindrical upper part of the cassette. This was found by a further trial to slow the rate of melting but not as much as desired. It was also observed that melting occurred to the sides as well as the bottom end of the core, and this melting opened spaces between the core and inner diameter of the cassette tube, which allowed warm air to circulate upwards beside the ice, melting away ‘flutes’ in the sides, which soon changed the form of the ice from the intended original cylinder.

This convection current of air was countered by adding a cap of insulation to the top of the cassette in the concealed zone, to close the top of the tube and prevent air movement. When the insulated cap was fabricated from the same plastic foam floor underlay, any air gaps between the ice and the inside of the tube became stagnant insulating cavities and this dramatically reduced the rate of melting. The form of the visible part of the ice, tapering in the lowest part where the cut out arches allowed air and human contact, and cylindrical in the middle visible part within the clear tube were then as intended. The rate of melting and dripping was then as intended, as evidenced in exhibition video. This experimental method of designing and optimising the insulation was the right one for the task because it was fast and responsive to the numerous variables in the situation, including the room temperature, fit between ice and acrylic tube, conductivity of the tube and heat transfer effectiveness between ice and tube, temperature within the concealed zone in the upper part of the pedestal, and heating from the lights.

During a COP26 conversation with BAS scientists, I learnt that the coldest temperature ever recorded in Antarctica (and on Earth) was the -93.2°C recorded at the Vostok research station in 2010, while the warmest temperature ever recorded in Antarctica was 15°C in 1974 at Vanda research station. In the darkened exhibition space, Arup Materials expert/engineer Graham Dodd conducted numerical and analytical engineering modelling of the melting rate, which gave some broad bounds for the melting rate but that method would have been too slow for the production schedule and would have required several iterations to achieve the intent. Here, the dynamic between the Artist, the Engineer and the Scientist working collaboratively in the exhibition space with the ice enabled rapid transfer of knowledge and judgement. Hand fabrication of the insulation by the Arup engineer, using materials that were adaptable to adding insulation progressively until the desired dynamic was achieved (polyethylene foam floor underlay and gaffer tape), was the best method of design to tune the melting rate and the melted form of the ice to achieve the artistic intent.

Fig.27 ‘Ice Core’ installation. Image: Pete Bucktrout/BAS

The bottom end of the acrylic cassette was formed by a disc of clear acrylic machined and polished into a lens form with a flat top and a concave bottom face to spread the narrow beam of light coming up through the glass bowl into the core of ice to give it a glow as if lit from inside, to enable the internal bubbles of trapped air to be prominent. This arrangement was arrived at experimentally, by Arup lighting designer Dan Lister using a tumbler dryer door glass bowl to experiment with luminaires, water and lenses to establish correct placement to ensure the ice was the most brightly lit element in the composition without having the heat of a light fitting close to the ice.

Some computer modelling was used for initial scheme selection but experimental insitu adjustment in the exhibition space was essential to appreciate the effect of the water and the ripples caused by falling droplets. An unexpected phenomenon was observed occasionally when bubbles within the ice burst, a tiny jet of water could momentarily be seen arcing out from the core and vanishing. It was illuminated by the upward flow of light and only visible to the naked eye against the black background in the room.

Fig.28 ‘1765 - Antarctic Air’ production still from Polar Zero documentary. Plaster model making. RCA

Fig.29 ‘1765 - Antarctic Air’ production still from Polar Zero documentary film. Lathe working the plaster model for glass casting. RCA

Fig.30 ‘1765 - Antarctic Air’ production still from Polar Zero documentary film. Demolding cast glass. RCA

Fig.31 ‘1765 - Antarctic Air’ production still from Polar Zero documentary film. Grinding cast glass. RCA

Fig.32 ‘1765 - Antarctic Air’ production still from Polar Zero documentary film. Polishing cast glass

Fig.33 ‘1765 - Antarctic Air’ production still from Polar Zero documentary film. Washing cast glass

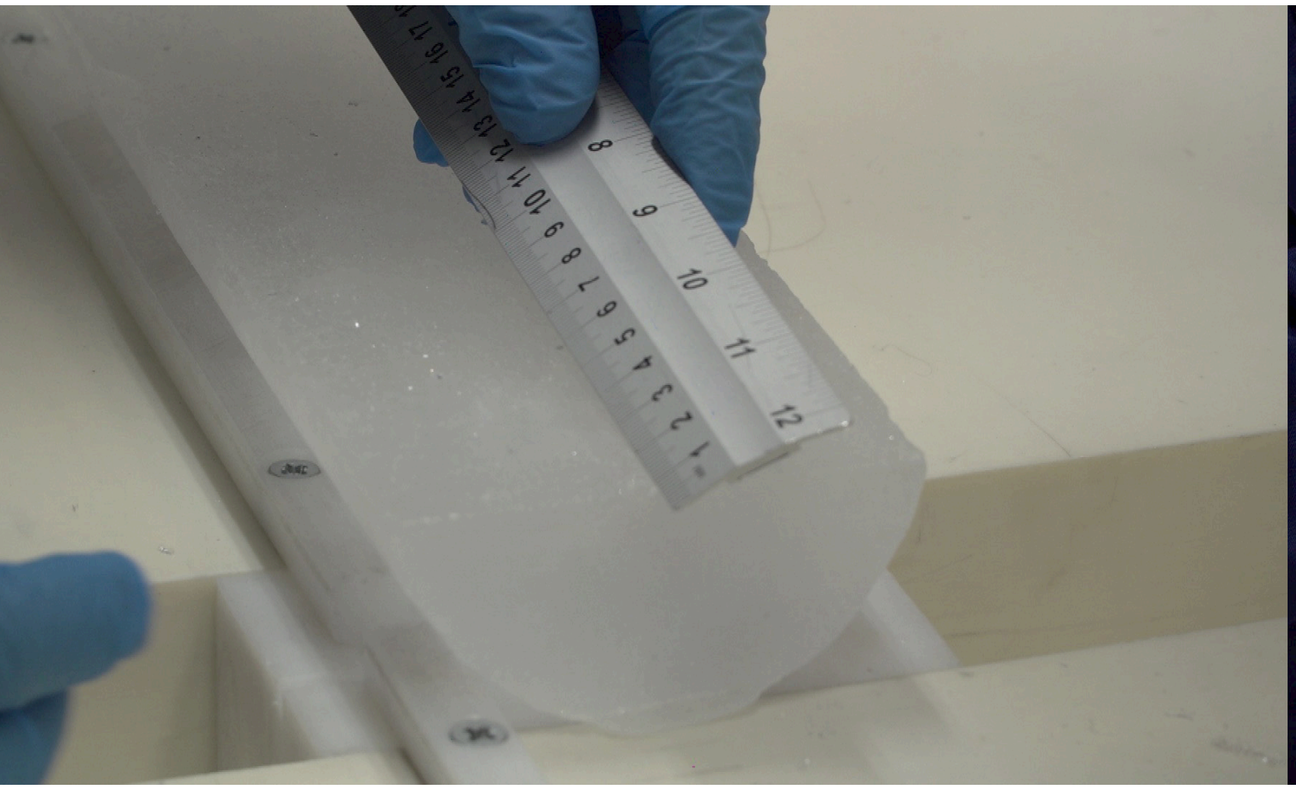


Fig.34 Gas extraction. British Antarctic Survey ice core laboratory. Image.Pete Bucktrout/BAS

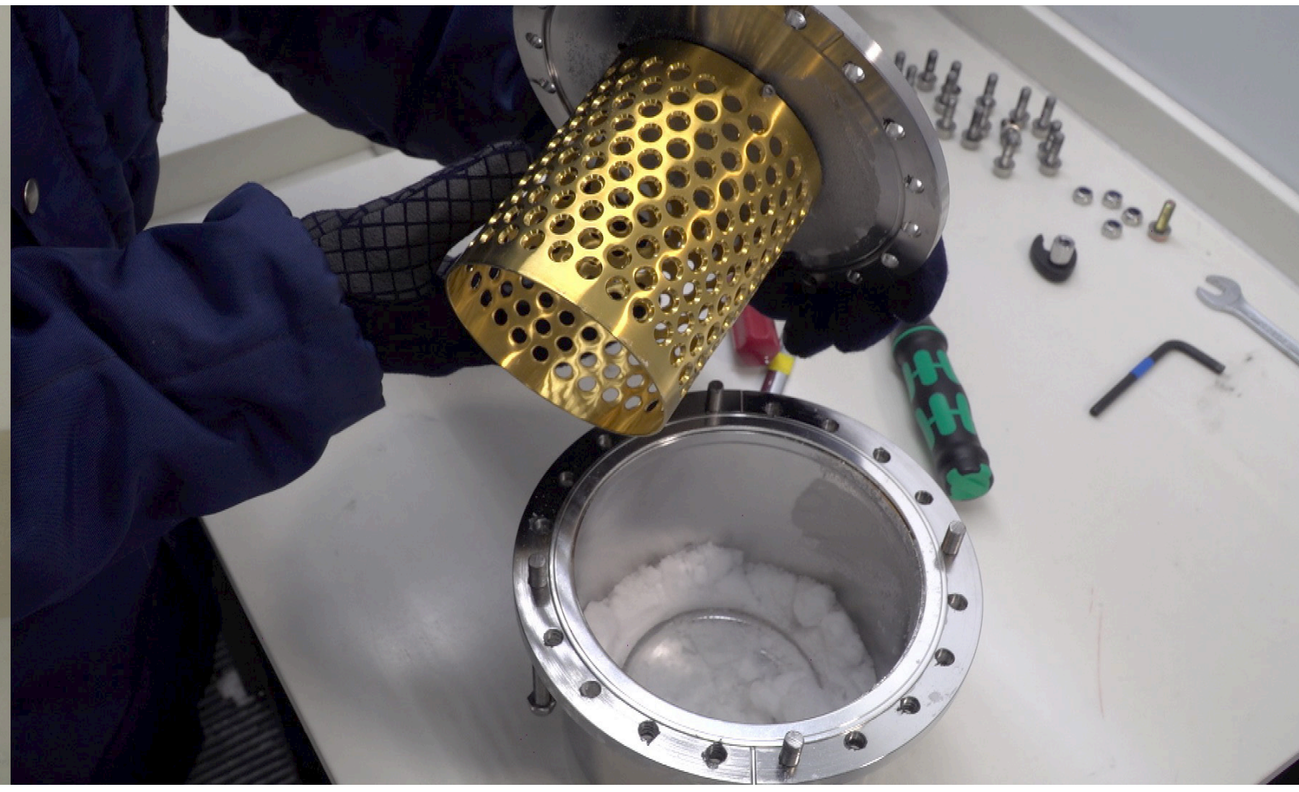


Fig.35 Gas extraction. British Antarctic Survey ice core laboratory. Image.Pete Bucktrout/BAS

Fig.36 Gas extraction. British Antarctic Survey ice core laboratory. Image: Pete Bucktrout/BAS

Fig.37 Gas extraction. British Antarctic Survey ice core laboratory. Image: Pete Bucktrout/BAS

Fig.38 Gas extraction. British Antarctic Survey ice core laboratory. Image: Pete Bucktrout/BAS

Fig.39 Gas extraction. British Antarctic Survey ice core laboratory. Image: Pete Bucktrout/BAS

Fig.40 British Antarctic Survey ice core laboratory

Fig.41 Robert Mulvaney filling internal void of glass sculpture with oil benzyl benzoate. Image: Robert Mulvaney/BAS

Fig.42 Robert Mulvaney sealing with liquid encapsulant Dow 2888. Image: Robert Mulvaney/BAS

Fig.43 Robert Mulvaney injecting glass sculpture ‘1765’ with ancient air. Image: Pete Bucktrout/BAS

Fig.44 COP26. Glasgow Science Centre. Image: Arup

Fig.45 Polar Zero exhibition film on the large screen outside the Glasgow Science Centre: Image: Pete Bucktrout/BAS

Fig.46 ‘1765 - Antarctic Air’ COP26. Glasgow Science Centre. Image: Pete Bucktrout/BAS

Fig.47 ‘Ice Core’. COP26. Glasgow Science Centre. Image: Pete Bucktrout/BAS

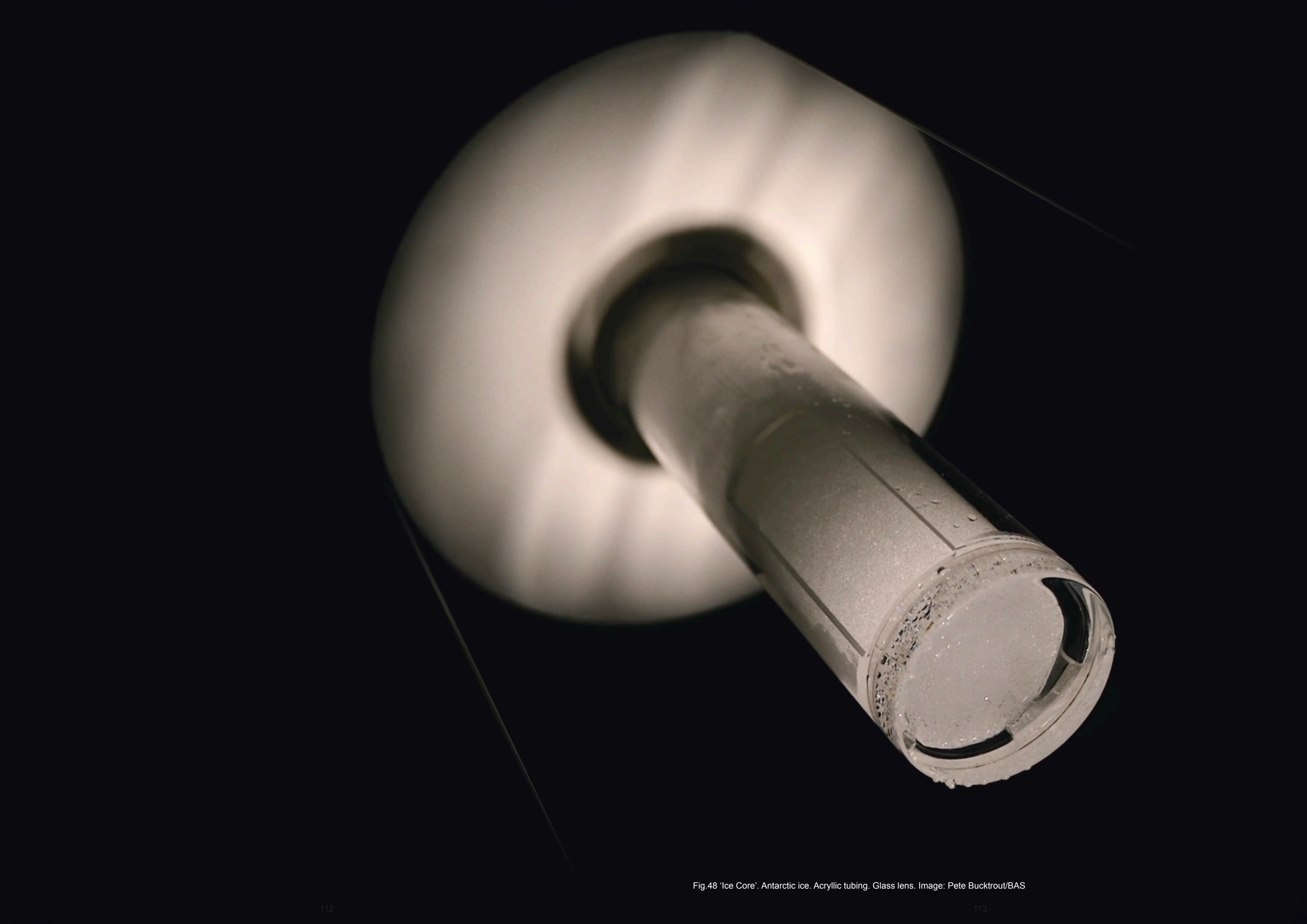


Fig.48 ‘Ice Core’. Antarctic ice. Acryllic tubing. Glass lens. Image: Pete Bucktrout/BAS

Fig. 49 ‘Ice Core’. UKRI Chief Executive. Dame Ottoline Leyser. Image: Pete Bucktrout/BAS

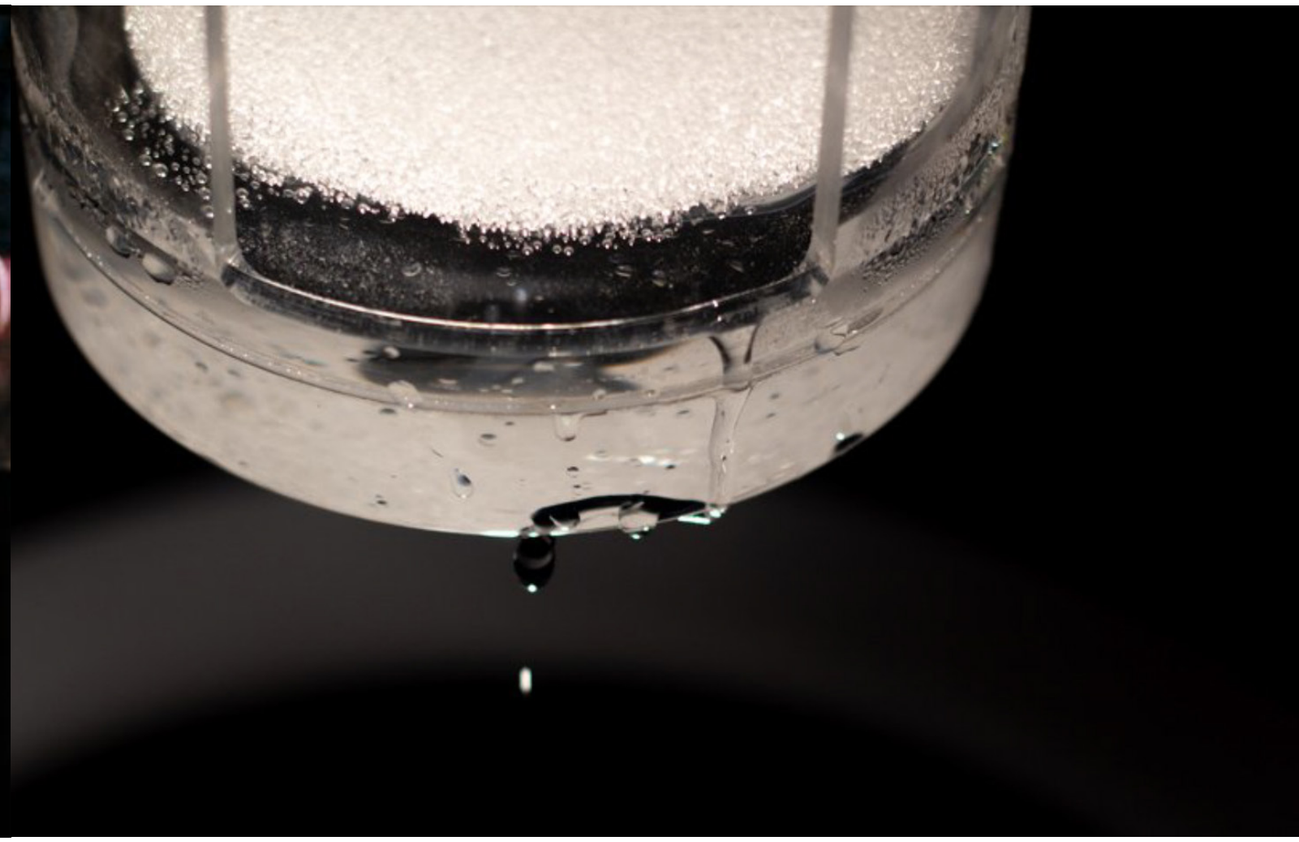


Fig. 50 ‘Ice Core’ Detail Image: Pete Bucktrout/BAS

Fig.51 ‘1765 - Antarctic Air’. Image: Jane Barlow. Guardian/PA

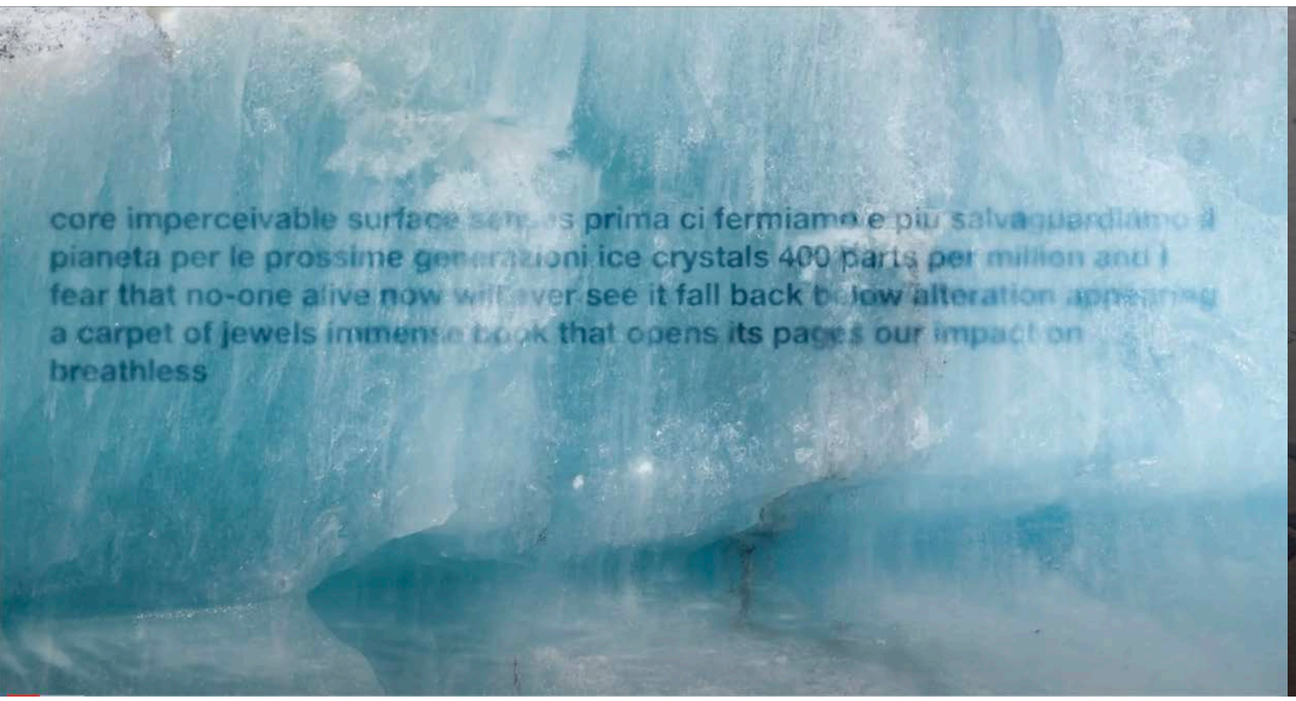


Fig.52 Ice Stories Film. Production still. Inscribed words of national and international glaciologists on photographic image. Sound

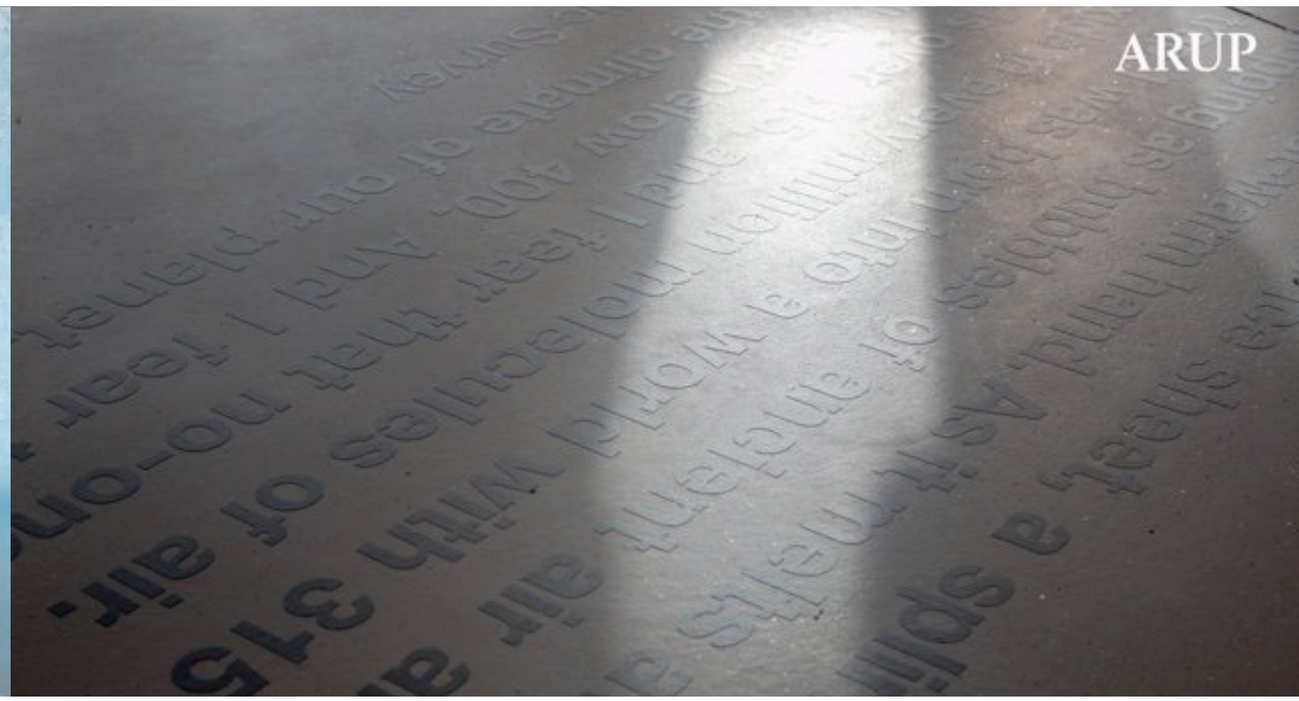


Fig.53 Ice Stories. Inscribed words of national and international glaciologists. Vinyl lettering on concrete. Image: Arup

Methodological Limitations

Data Access

The research required me to consider what type of data I would need access to, how much data would be necessary for effective results and how I would collect it within the prescribed period of PhD registration. The first practical constraint was my access to data at BAS. While both Arup and BAS were extremely generous in their support of my research, I needed sustained access to the BAS ice core laboratory in Cambridge. As I live in London, this had to be carefully planned to within strategically scheduled visits to the laboratory, where I would have a brief window of opportunity to document and interpret the many complex quantitative scientific methods used.

Another limitation was the type of data and the number of scientific respondents that I would realistically have access to. For Ice Stories, I wanted my creative approach to ice cores to be grounded in my own real and imagined experience of the Arctic and Antarctic. I also wanted to integrate the lived experience of those scientists who have devoted the bulk of their careers to polar science. The research therefore required access to a wide number of national and international glaciologists to gather their written responses. I also needed statistically significant results to develop convincing artistic conclusions. I therefore had to consider several methodological limitations, including if the glaciologists would be agreeable to my artist brief, where they were located, and if they would be able to respond within a specific time frame.

Time

The Solid, Liquid and Vapour Series of artworks were developed concurrently at the RCA, BAS and Arup, and often involved stages of research that took longer to develop, refine and cohere than originally anticipated. As the data collection components of different mixed methodologies required periods of development experimentation, I adopted both longitudinal and latitudinal time horizons.

Funds and Logistics

Arup and BAS provided generous support-in-kind at zero costs. However, finance was a significant constraint throughout the research even when successful funding applications were secured. While some aspects of the project required very little money, others required a substantial part of my budgets. Large scale public exhibitions are expensive to produce effectively, with some production costs during a time of Covid proving to be higher than initial estimates.

As my Ice Floor exhibition was professionally curated and supported by a studio manager from the outset, production and delivery of the exhibition were in direct symmetry. Polar Zero was not supported by a professional curator. From the outset, it quickly became clear that this was a planning mistake with the many logistical and technical demands of organising a large scale public exhibition in Scotland during Covid greatly exceeding funding remits of the PhD researcher as artist-curator. As a result, a studio manager was recruited at my request to situate an ordered series of logistical events that enabled the project to meet COP26 deadlines.

RCA procurement and supplier approval policies were often not in synch with the payment of external suppliers and contractors, resulting in significant production delays that threatened to overhaul the entire Polar Zero project. Highlighting the difference between the private and the public sectors, this singular issue of contractor payment required delicate negotiations and personal interventions on my part in order to maintain the flow of strict production schedules.

Intellectual Property

As discussed earlier in the thesis, there had been no IP agreement signed between the collaborative partners prior to COP26, as the environmental focus of my original Polar Zero bid and commission held no commercial remit. The Polar Zero team worked closely together in good faith to further the work of all parties. As a result of this good faith, the ensuing research developed successfully. At the end of COP26, we decided that we wanted to tour the work. However, IP, ownership and provenance remained unresolved. As a result, we began discussions about satisfactory terms to secure equal rights for contributing partners in order to freely exhibit the work in public settings.

This important issue of unresolved IP was an administrative oversight which left my individual and collaborative research outputs vulnerable to commercial and intellectual exploitation. My own perspective is that the important intersection of art, science and engineering innovation requires its own space of imaginative contemplation beyond the commodification of the commercial gallery or private marketplace, where its critical significance is severely diminished. Post Viva PhD examination, collaborative parties were able to resolve this IP administrative oversight. The new TECHNE/AHRC doctoral partnership agreement and the Polar Zero commission agreement sets out the ownership of resulting IP rights from my PhD research. The agreement states:

In detail, resulting IP from my PhD research shall vest in the RCA (according to section 10 of the TECHNE partnership agreement relating to my PhD research) and will revert to me upon graduation (according to section 3.1 of the RCA IP policy). In addition, resulting IP from my research conducted as part of Polar Zero commissioned project in collaboration of BAS and Arup shall vest with me and I shall cover any protection, maintenance, transportation or insurance costs, as well as make any such IP publicly accessible and use it for the purpose of informing and engaging people with the issues of climate science and climate change and in any case for the benefit of society and the economy. (according to section 9 of the Polar Zero Commission agreement)

Methods Summary

This section outlined what mixed methods were used, why these were the best methods for my practice-led research and states how collaborative knowledge sharing took place within it. Supported by visual documentation and critical thinking, the section highlights the philosophical/conceptual underpinnings of my research and discussed the specific research design choices made, including a short concluding discussion of the methodological limitations.

Contextual Review

The next section provides a wider contextual understanding of the historical and contemporary field within which the research operates. Outlining a range of polar historians, artists and theorists drawn from my expanded literature review, the section includes a more comprehensive survey and critical analysis of the landscape within which I am locating the research writing and making.

Contextual deconstruction of the collective cultural investment in the polar regions

The Arctic and Antarctic polar regions have fired the human imagination since antiquity. First theorized by Greek philosophers between 600-300 BC, the notion of traversing polar water to reach the North and South Pole can be found in the hypothetical writings of Ptolemy first published Geographica in 1st century AD.[6]Ideas of the poles and polar exploration continued to be perceived, dreamed of, and obsessed about throughout maritime, colonial and more recent cultural history. In the early days of 18th century polar exploration predominantly male persons[7] of 'exceptional character' were selected to travel - often woefully unprepared - to the most remote and inhospitable regions of the earth.

As evidenced in the work of leading polar historians and cultural authors including Michael Bravo, Klauss Dodds, Francis Spufford and Zemon Davis, many journeyed with desires of being the first person to unravel new geographic and scientific discoveries including James Clark Ross and Ernest Shackleton. Others ventured to the polar north and south in search of mineral resources, wildlife and new shipping trade routes. When Captain Scott died in 1912 on his way back from the South Pole, his story became embedded in the English imagination, fixing the national cultural obsession with the idea of the 'heroic' yet ill fated polar explorer.

In this context my literature review examined the libraries and archives held at both BAS and the Scott Polar Museum in order to contextualise and deconstruct the collective cultural investment in the polar regions. Here, I explored issues concerning what is historically and culturally articulated as "the Arctic" and "the Antarctic" in public, political and scientific discourse, including models of polar governance and geopolitics. The review specifically explored notions of temporality and spatiality pertaining to constructions of "region" and "territory" in the polar regions. This phase of the review navigated and deconstructed questions of Inuit historiography, orality and traditional knowledge systems against the production, circulation and consumption of the cryosphere found in western scientific accounts.

The cryosphere can be understood to be the frozen water part of the Earth system, including parts of the ocean, such as waters surrounding Antarctica and the Arctic. As discussed by Olsen (2019) the social and ecological dynamics of the global cryosphere saw a significant shift from the Cold War period of the late 1950s onwards following the establishment of the International Geophysical Year as ideas of the polar regions became problematised by divergent ethnographies of science, histories of geographical thought, indigenous ontologies, geopolitics and newly emergent ideas of regional governance in the polar regions.[8]

6 John Noble Wilford: The Mapmakers, the Story of the Great Pioneers in Cartography from Antiquity to Space Age, p.139, Vintage Books, Random House 1982.

7 Explorer Caroline Mikkelsen was the first woman to set foot on Antarctica on the 20th Feb 1935, when she accompanied her Norwegian husband Klarius on a resupply vessel M/S Thorshavn during a polar expedition. While hoisting the Norwegian flag, the party came to shore on an Antarctic island, with Caroline rowing a boat that carried her husband and seven other sailors to shore. Women in Antarctica: Sharing this Life-Changing Experience. Archived 10 March 2012 at the Wayback Machine, transcript of speech by Robin Burns, given at the 4th Annual Phillip Law Lecture; Hobart, Tasmania, Australia; 18 June 2005. [Last accessed June 22nd 2023)

8 Dian Olsen. 2019. Deep Freeze. The United States, The International Geophysical Year, and the origins of Antarctica's Age of Science. University Press of Colorado.

In key publications such as North Pole: Nature and Culture (2019), Arctic Geopolitics and Autonomy (2017) and Narrating the Arctic (2002), Michael Bravo examines the critical relationship between science, international politics, law and history. Reflecting on how issues of climate crisis and political governance have a direct consequence on the sovereignty of the peoples and ecosystems of the polar north, Bravo suggests that historical processes of colonisation and integration are 'blind' to the lived realities of contemporary life in the Arctic.

The Cambridge Professor and Head of the Circumpolar History and Public Policy Research Group at the Scott Polar Research Institute, University of Cambridge, suggests that the current political narrative surrounding the Arctic is trivialized in both geopolitics and the arts. Bravo - who often collaborates with Nicola Triscott of Arts Catalyst (London) and the Slovenian artist Marko Peljhan - argues convincingly that increased forms of spatial and temporal mobility for Inuit peoples is not supported by the new technological advances put forward within current political and economic policies.

Contemporary historian Natalie Zemon Davis posits that historical and contemporary literary works on the Arctic and Antarctic produced within the dominant European gaze retain a biased western view of non-European Indigenous peoples and their custodial lands. While acknowledging the depth of critical insight gained by comparing methods of Europeans with those of non Europeans, Davis' post-colonialist analysis of the poles and polarity cautions against 'the limitations of treating multiple knowledge systems as though they simply emanate from singular epistemic communities without shaping each other across different spatial and temporal scales'. (Davis in Bravo's The Postcolonial Arctic, 2015:1)

Within this framework, my expanded literature review aimed to travel, locate and return with a dialectical sense of the poles and polarity articulated by Davis where she foregrounds 'indigenous peoples and Europeans as both "actors" and "reactants" [that might be reformulated] to construct accounts of their relations in terms of the polarities of hegemony and resistance'. Zemon Davis draws on her doctoral thesis on the Arctic to 'focus on the middle ground, a hybrid or third space of exchange and mixing, where she aims 'to follow the paths of material objects (e.g. indigenous maps, memory sticks [sic] through the material culture of the middle ground to reveal complex processes of autoethnography'.[9]

Following paths both material and immaterial opened by a range of polar scholars, my historical and contemporary literature review examined the way in which the Arctic and Antarctic have come to occupy a highly charged space in the collective cultural imagination. Moderated by continuous flux and flow, my review is punctuated by a contested and invested space of shifting geopolitical forces and im/material cultural polarities both positive and negative, near and far. My expanded literature review of the collective cultural investment in the polar regions is also specifically informed by an autoethnographic approach formulated in my adolescent years as a boarder at Woolverstone Hall School.

9 Davis, Z. in Bravo. 'The Postcolonial Arctic, 2015, p1. Moving Worlds (2015) Vol. 15 No. 2

Historical and Autobiographical Context

I was born in London but attended Woolverstone Hall School, an off shoot of the London Nautical School, set in 80 acres of parkland on the banks of the River Orwell in Suffolk. The river is known as the River Gipping, but its name changes to the Orwell at Stoke Bridge where the river becomes tidal. The Orwell widens into an estuary at Ipswich, leading to the shipping dock at Felixstowe, and then flows into the North Sea. During the Second World War, the school became a naval training base, HMS Woolverstone, a shore-based naval station located next to the Royal Harwich Yachting Club. (RHYC)

Fig.54 Woolverstone Hall. Image: Stone Saunders

Established through an official warrant from Queen Adelaide in 1845, the Royal Harwich Yachting Club's first permanent premises were built on part of the land later occupied by the school at Woolverstone. The RHYC has a direct involvement in the history of polar exploration including Captain Nares expedition to the North in the 1880s, Prince Luigi di Savoia expedition to the North in 1898, Captain Robert Falcon Scott's first expedition to the South in 1900.[10] Woolverstone Hall School was bought by London County Council in the 1950s to create a secondary grammar school for boys from London, who studied alongside students from military families.

By the time I arrived in 1977, the school had just begun to accept comprehensive boys who were admitted through means tested grants. Photographs from the time, show an England from a vanished era. Masters wore ties, woollen v neck jumpers and smoked pipes. The Sex Pistols, Thatcher's revolution and multiculturalism was just around the corner - but you would never have suspected it in the regimented tone of our Oxbridge educated teachers: "steer by your own compass"! Although some boys kept sailing dinghys and attended Orienteering and Sea Corps down on the marina near the RHYC, the school bore little resemblance to its former nautical past. There were no set examinations in navigation and seamanship, or the need to mast, row and scull big heavy whalers down on the River Orwell.[11] Nissen huts designed during the First World War as military accommodation were now used for maths classes. However, early cross-country runs and the unfortunate freezing showers continued in mid-winter, as did the fiercely contested rugby and cricket matches.

Another important feature of the school was the passion for poetry and literature. In a 2016 newspaper review, author Ian McEwan states that his introduction to poetry and literature as a pupil of Woolverstone Hall in the late 1950's as being integral to his development as a writer: "We knew the English canon, we had read our Chaucer".[12] Looking back now, I can see that my formative adolescent period spent at the school as laying the foundations (both consciously and unconsciously) for my own current research writing and making. I strongly believe my memories of being on or near the waters of the River Orwell and the RHYC has significantly informed my current interest in Arctic and Antarctic water as a vital yet critically underdeveloped source of polar history. It is a personal and autobiographical form of individual memory that lay dormant for many years. This memory was often recalled during visits to the BAS ice core laboratory and chance anecdotal conversations with both current and former staff members including BAS Emeritus Fellow and Member of the RHYC General Committee Paul Rodhouse:[13]

> Scott's first Antarctic expedition ship was the 'Discovery' which wore the defaced blue ensign of the Royal Harwich Yacht Club. Scott was a serving naval officer at the time of the expedition, but he was not permitted to fly the Royal Navy's White ensign because it was strictly speaking a 'private expedition'. I am told by our club's former archivist that the RHYC made Scott an honorary member. When Scott sailed south on his tragic second expedition in the 'Terra Nova', the Royal Yacht Squadron made him an honorary member, so the ship wore the white ensign. The RYS is the only yacht club whose members are permitted to fly the white ensign. It was usual at the time for Antarctic expedition ships to be registered as yachts. Shackleton's 'Endurance', for instance, wore the ensign of what is now the Royal Northern and Clyde Yacht Club. These ships were, of necessity, heavily overloaded when they set off and would have broken regulations that governed merchant shipping since 1894 when the Plimsoll Line became law. Private yachts were not subject to the regulations. (Paul Rodhouse. 2023)

10 Captain Robert Falcon Scott (1868-1912) was the British Royal Navy officer and explorer who led two important expeditions to the Antarctic regions: the Discovery Expedition (1901–1904) and the ill-fated Terra Nova Expedition (1910–1913). Scott qualified to lead a polar expedition after having obtained the required registration documents from the RHYC.

11 The writer Eric Blair chose the pen name under which he would later become famous, "George Orwell", because of his love for the River Orwell.

12 Ian McEwan (2016) East Anglian Daily Times. Published 16th Sept. 2016. [Accessed 26th June, 2023]

13 Private email correspondence. 26th March. 2023

Fig.55 Ice grotto with Terra Nova in the distance. Image: Herbert Ponting/Scott Polar Museum

Fig 56 In the ice pack from the maintop of the Terra Nova. Image: Herbert Ponting/Scott Polar Museum

Fig 57 Ice pack from the maintop of the Terra Nova. Image: Herbert Ponting/Scott Polar Museum

Fig.58 Image: Herbert Ponting/Scott Polar Museum

Fig.59 Captain Robert Falcon Scott. Image: Herbert Ponting/Scott Polar Museum

Fig.60 Image BAS

Principal British voyages and expeditions to the Antarctic

Date	Captain or Leader	Vessel	Purpose or Title
1772-75	James Cook	*Resolution* *Adventure*	Exploration
1819	William Smith	*Williams*	Mercantile
1819-20	William Smith Edward Bransfield	*Williams*	Exploration
1820-21	Robert Fildes	*Cora*	Sealing
1821-22	George Powell	*Dove* *Eliza*	Sealing
1822-24	James Weddell	*Jane* *Beaufoy*	Sealing
1828-31	Henry Foster	*Chanticleer*	Magnetic observations
1830-32	John Biscoe	*Tula* *Lively*	Sealing and exploration
1833-34	Peter Kemp	*Magnet*	Sealing
1838-39	John Balleny	*Eliza Scott* *Sabrina*	Sealing
1839-43	James Clark Ross	*Erebus* *Terror*	British Antarctic Expedition
1844-45	Thomas Moore	*Pagoda*	Magnetic observations
1872-76	C.Wyville Thomson	*Challenger*	Marine biology and oceanography
1892-93	Thomas Robertson Alexander Fairweather Robert Davidson James Davidson	*Active* *Balaena* *Diana* *Polar Star*	Dundee Whaling Expedition
1898-1900	Carsten Borchgrevink	*Southern Cross*	Exploration
1901-04	Robert Falcon Scott	*Discovery*	British National Antarctic Expedition
1902-04	William Bruce	*Scotia*	Scottish National Antarctic Expedition
1907-09	Ernest Shackleton	*Nimrod*	British Antarctic Expedition
1910-13	Robert Falcon Scott	*Terra Nova*	British Antarctic Expedition
1914-16	Ernest Shackleton	*Endurance* *Aurora*	British Imperial Trans-Antarctic Expedition

Principal British voyages and expeditions to the Antarctic
continued

Date	Captain or Leader	Vessel	Purpose or Title
1920-22	Thomas Bagshawe	unknown	Scientific investigations
1921-22	Ernest Shackleton Frank Wild	*Quest*	Shackleton-Rowett Antarctic Expedition
1925-49	Neil Mackintosh	*Discovery* *William Scoresby* *Discovery II*	Discovery Investigations
1929-31	Douglas Mawson	*Discovery*	British-Australian-New Zealand Antarctic Research Expedition
1934-37	John Rymill	*Penola*	British Graham Land Expedition
1943-45	James Marr Andrew Taylor	*Fitzroy* *William Scoresby* *Eagle*	Operation Tabarin
1946-61	Edward Bingham Vivian Fuchs	*Fitzroy* *William Scoresby* *Trepassey* *John Biscoe* *Shackleton*	Falkland Islands Dependencies Survey
1949-52	John Giaever	*Norsel*	Norweigan-British Swedish Antarctic Expedition
1951-57	Duncan Carse	unknown	South Georgia Survey
1955-57	Peter Mott	*Oluf Sven*	Falkland Island Dependencies Aerial Survey Expedition
1955-58	Vivian Fuchs	*Theron* *Magga Dan*	Commonwealth Trans-Antarctic Expedition
1955-present	Royal Navy	*Protector* *Endurance* *Protector*	Hydrography and logistics support
1962-present	Vivian Fuchs Dick Laws David Drewry Barry Haywood Chris Rapley Nick Owens Jane Francis	*Shackleton* *John Biscoe II* *Bransfield* *James Clark Ross* *Ernest Shackleton*	British Antarctic Survey

Historical Context: Relevant artists and theorists working on aligned themes

Land Art, Earth Art

> My investigation into the absences and erasures in archives led me to view them as a springboard for reinvention. (Isaac Julien, Frieze. No.234. 2023)

The British Antarctic Survey (BAS) is the UK's national Antarctic operator, and has for the past 60 years been responsible for most of the UK's scientific research in the Arctic and Antarctic. BAS has its roots in Operation Tabarin, a secret World War II mission. Designed to deny Antarctic waters to enemy ships, Tabarin also had a scientific role, collecting data on Antarctic biology, geology and weather during the last two years of the war. After the end of the war in 1945, Tabarin's three bases and its scientific work were transferred to a new organisation – the Falklands Islands Dependencies. Following the The Antarctic Treaty covering the area 60 degrees South, the British Government decided to divide up the Falkland Islands Dependencies, renaming the Antarctic Peninsula area 'British Antarctic Territory'. To reflect this change, on 1st January 1962, FIDS was renamed the British Antarctic Survey and its headquarters were formally transferred to London, which in turn, was renamed in 1962 as the British Antarctic Survey. (bas.ac.uk, 2023) BAS's operational headquarters moved to new buildings in Cambridge, consolidating the organisation on a single site in 1976, when the original BAS ice core labs were built. In 1989, a cold-room for cutting and storing ice cores and laboratories for ice core gas analysis were then added to the site in 1992. State-of-the-art chemistry labs were installed and refurbished in the mid-2000s to the present layout, with an updated gas lab added in the last few years.[14]

Anchored by my interest in canonical works of Land Art pioneered in the 1960s and 70s, the research explored the BAS ice core archives as a locus of aesthetic invention that reacts to the critical limits of sculpture, painting and installation by embracing site, construction, architecture and landscape as resources for new ways of thinking about art's object and place of material experience. Artists working in the field of Land Art initially rejected the commodification of the gallery; instead, they travelled out into the space of the landscape. Five decades later, the BAS ice core laboratory has shifted my focus towards bringing the polar landscape back inside, to the gallery, museum and auditorium. As evidenced in the rock paintings and petroglyphs[15] found in the Altimara caves of northern Spain, and the Lascaux paleolithic complex in southwest France, it is clear that the natural environment has been central to the lived existence of ancestral peoples for over 30,000 years. Using rock, charcoal, ochre, chalk and pigments drawn from the earth, these diverse proto-artworks demonstrate the extent to which indigenous populations throughout time and culture have invested in a primal space and place articulated by eco-theorist Lucy Lippard as being 'at the radical edge of life itself'.[16]

14 Private email from Dr. Robert Mulvaney. BAS Leader of Ice Dynamics and Palaeoclimate team at BAS. June 2023.

15 A petroglyph is an image created by removing part of a rock surface by incising, picking, carving.

16 Feminist eco-art critic Lucy Lippard's 1968 essay "The Dematerialization of Art" and her 1973 book Six Years: The Dematerialization of the Art Object from 1966 to 1972 foregrounds the conceptual roots of the Land Art movement.

The research is directly informed by spatial and temporal readings of the landscape found in the work of specific land artists including Robert Smithson's Proposal for an Monument in Antarctica (1966); Paul Kos's The Sound of Melting Ice (1970); Micheal Snow's La Région Centrale (1971); Nancy Holt's Sun Tunnels (1976); Walter De Maria's Lightning Fields (1977) and Miss Mary's Perimeters/Pavilions/Decoys (1978). Here, the research draws inspiration from the nature and scale of artworks whose scope and ambition significantly exceed the limits conventionally produced within the museum or gallery contexts of the period.

The research is therefore historically located within a mode of environmental sculpture that reflects upon and intervenes in the negative human effect on the natural environment such as Dennis Oppenheim's Accumulation Cut which was made on a frozen Bebe Lake, Ithaca, New York in 1969. Annual Rings (1968) and Polarities (1971) are a number of seminal site-specific works by Oppenheim that juxtapose different geo-political boundaries and spatial-time zones. (Taylor, 2001)

For Annual Rings Oppenheim enlarged the circular patterns of the tree's growth and, by carving pathways in the snow, transposed the annual rings to the frozen waterway that divides the United States and Canada. In this context, my research interest in the Arctic and Antarctic draws from the engaged and situated practice of artists including Oppenheim and Snow that questions the relative values of the ordering systems through which we conceive the natural world including critical notions of accumulated growth and entropic decay.

Fig.61 Annual Rings. Dennis Oppenheim. Image: John Gibson Gallery

Polar Aesthetics explored the BAS ice-core archive in the spirit of artists and thinkers from the early Land Art avant-garde who posited that the new artworks could be both placed in and made from the environment itself, including Michael Snow's 1971 experimental film La Région Centrale. Snow stated that he wanted to make a film using a camera that moved "in every direction and on every plane of a sphere" in a location without any evidence of human activity.[17] In collaboration with his wife Joyce Wieland,[18] sound editor Bernard Goussard and film engineer Pierre Abbeloos[19], Snow shot his 180 minutes long film in the Quebec mountains from a chartered helicopter using a custom

17 Cornwell, Regina (1975). "Michael Snow's La Région Centrale". MoMA. No. 6. Museum of Modern Art. p. 4.

18 Joyce Wieland (1930-1998) was a painter, activist and experimental filmaker whose iconic ecological works including Cooling Room II (1964) championed issues of Canadian national identity and feminism. https://www.gallery.ca/collection/artist/joyce-wieland#:~:text=Joyce%20Wieland%20is%20legendary%20for,art%20culture%20of%20the%20time.

19 Pierre Abbeloos was an engineer at the National Film Board of Canada. At the request of Snow, Abbeloss spent a year constructing a CAM (camera activating machine) on which a 16mm camera was mounted to determine the required 360 degrees filmic motion.

made mechanical camera that was able to move without human intervention. Snow was originally a professional musician before he became an artist.[20]He used a modified Revox to record the acoustic tones from the CAM's control box on quarter-inch cartridges which he dubbed during post-production. Film scholar Wyndham Wise described the technological breakthrough of La Région Centrale [as a] "convergence of form and content, [where] camera movement becomes the raison d'etre. Rarely, if ever, has a film so clearly delineated the role of this machine in our reception and perception of the objected filmed".[21]

The form and content of our Polar Zero exhibition film aimed to bring the remote and distant polar regions into intimate proximity to COP26 visitors - online and in-situ - through the technological use of spatial image and glacial sound. Shot from a bi-plane on a high definition large format camera above the vast pristine desert of the Antarctic Peninsula by BAS cameraman Pete Bucktrout, the film was cut, colour coded, and edited by myself using ice core audio recorded in Cambridge. Through the use of audio and slowed down single continuous image, the Polar Zero exhibition film specifically explored notions of absence and presence, motion and stasis, as found in both La Région Centrale and Snow's earlier filmic masterpiece Wavelength (1967).

Fig.62 La Région Centrale. Northern Quebec. Image: Micheal Snow

20 Michael Snow, Richard Serra, James Tenney and Bruce Nauman, performed Steve Reich's audio sculpture Pendulum Music on May 27, 1969 at the Whitney Museum of American Art.

21 Wise, Wyndham, ed. (2001). Take One's Essential Guide to Canadian Film. University of Toronto Press. p.179.

Historical Context: Conceptualism, Minimalism, Post Minimalism, Fluxus

The research has drawn key inspiration from the work of artists who used process as an integral part of their work including Herbert Beyer, Carl Andre, Eva Hesse and Walter de Maria, some of whom featured in the pivotal 'Earthworks' exhibition that was organised by pioneering gallerist and curator Virginia Dwan at her New York gallery in 1968.[22] Dwan simultaneously operated galleries on each side of the American coast, with locations in Los Angeles (1959–67) and New York (1965–71) and was one of first curators to identify and fund site-specific work of Lynda Bengelis, James Turrell, Robert Morris, Robert Heizer and Richard Serra.

While many of these artists exhibited work that examined the hot deserts of New Mexico and Nevada,[23]the central focus of my own research explores the icy deserts of Antarctica and the Arctic. The research draws specific insight from Richard Long's A Circle In Antarctica, a 2012 work made during ten days walking in the heritage range of the Ellsworth Mountains. Long often presents a series of text works and photographs of his work in the exhibition space of the gallery setting. These chart the conceptual and minimalist path he has followed since the 1970s to the present day that are concerned with walking as an aesthetic and philosophical practice.

Fig.63 A Circle In Antarctica. Image Richard Long

22 Virginia Dwan (1931-2022) was also an American art collector, philanthropist and founder of the Dwan Light Sanctuary in Montezuma, New Mexico.

23 Early Land Art exhibitions include**: Earth Works**, Dwan Gallery, New York, 1968. **Earth Art**, Museum of Art at Cornell University, New York, 1969; **Ecologic Art,** 1969; **Live In Your Head: When Attitudes Become Form**, 1969; **Earth Air Fire Water**: Elements of Art, Museum of Fine Arts, 1971.

Since A Line Made by Walking (1967) Long's innovative use of words, photography and sculpture have evidenced a sustained preoccupation with the engagement of his own body. He has made work in a variety of physical terrains that evoke the workings of temperature and the geological, including interventions placing rocks from the existing environment into both circular and linear arrangements in works such as Circle in the Andes (1972) and River Yangtze Stone Line (2010). Long's photographic approach to documenting his journeys through mountains, deserts, rivers and snowscapes shaped the thinking and making of my Icelandic photographic series 64° 04' 13" N 16° 12' 42". Informed by Long's consistent use of maps and indexical naming of sites, the series aims to portray my own experience of a vanishing sculptural landscape and pays direct homage to the temporal specificity of Long's photographic and text work, with each image given a precise geographical co-ordinate to locate the viewer.

Notations is a book that was compiled by American visual artist/avant-garde composer John Cage (1912–1992) in collaboration with Fluxus artist Alison Knowles.[24] First published in 1969, the book frames the emergence of a newly interdisciplinary form of conceptually driven art making of the period that was characterised by indeterminacy. Outlining his understanding of notation as a site of interaction between artist and audience, Notations is comprised of graphical scores and facsimiles of holographs that determined which composer would be asked to write about their work, and how many words would be used. (Cage, 1988) Following Zen and Buddhist procedural methods of mark making and performance that Cage studied since the 1940s, Notations can also be understood as a visual attempt to negotiate the implied presence or absence of sound and silence developed earlier in his 1952 work 4′33″. As articulated in his late watercolour paintings, prints and ink drawings made on prepared paper with feathers, river stones, fire and smoke at the Mountain Lake Workshop in the rural Appalachian Mountains of Virginia (1983-1990), Cage's sustained interest in modes of visual notation extended to the study of natural river systems and their relationship to chance occurrence.

Fig.64 River Rock on Feather Brush. Image Ray Kass

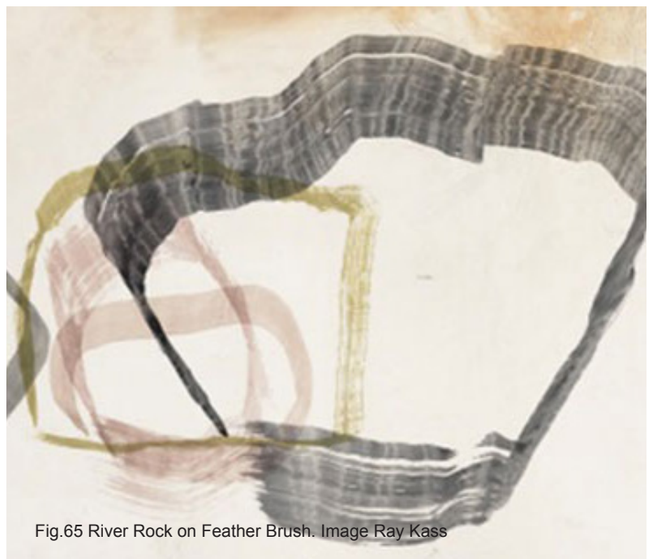


Fig.65 River Rock on Feather Brush. Image Ray Kass

24 American visual artist Alison Knowles (b.1933-) was a founding member of the Fluxus movement - an intermedia collective of artists, writers that formed in the 1960s who emphasized process and chance over a completed 'product'. Knowles' ongoing body of work is distinguished by the indeterminacy of her event scores and performance.

Fig.66 Liquid Series No.30. Ink on Somerset Velvet paper. 255gsm

Fig.67 Ice Manuscript. Ink drawing on Somerset Velvet paper

Cross Cultural paths

Following ideas advanced by Cage, Manuel De Landa and Iberall discussed earlier in the thesis, Ice Manuscript (2019) is a calligraphic ink drawing on Somerset Velvet paper made whilst listening to the sound of my own audio recordings of a 1,500 year-old ice-core sample at the British Antarctic Survey. The work was exhibited across the entire length of the Arup Fitzroy Street gallery floor alongside my hand carved glass sculpture, and operated within the non linear and discursive logics of the research as a contemporary form of calligraphic watermark that explores how the past is written, read and made intelligible in the present. I particularly wanted to rethink co-existing and concurrent ideas of polar matter and equivalent notions of chemical and societal phase change transition. Ice Manuscript sought to examine the extent to which history can be said to transform in equivalent and co-existent ways in which the polar world itself has liquefied, condensed and evaporated, over critical points of ancestral time and place.

Informed by the speed and velocity of the present, Ice Manuscript was forged through two years experimental ink drawings made on a range of different weighted paper surfaces. Exploring notions of scale, size, surface and depth, these works were initially small before being subsequently printed large scale. Here, ideas of condensation and evaporation were further mediated through a number of performative exhibitions, including S: Future (2016) at the Royal College of Art, The Resonance of Water (2017) at the Trinity Laban Conservatoire, and Aqua Per Sulis (2018) at the Chelsea School of Art. While my research examines the ancient waters of the north and south, Ice Manuscript also explored cross-cultural modes of visual and sonic notation found within water based works of western and eastern artists. Water has held a prominent position in the cultures of China and Japan for many centuries. Examples can be found in the traditions of landscape painting, ink drawing, and calligraphic drawing, and elements of clouds, sea, mist, rivers, waterfalls are found in the art produced by Asian cultures since the Song Dynasty (960-1279). For years, the cultural stewardship of water in China was controlled by Maoist regimes, when all actions by individuals were subject to political scrutiny, with any perceived transgressions by outward-looking artists considered unlawful.

Against these limitations the artist Song Dong's Stamping the Water, 1996, is a performance work that emerges as an important political discourse concerning water. In the absence of control of Mao, Song's work calls attention to questions of pollution in the Yangtze River Three Gorges dam project, and the social inequities conducted by the ruling Communist Party concerning homes along the river destroyed to make way for the control of water by the government. Notions of state power are strongly resonant in the work of Dong, which includes another ongoing series of performances begun in 1995, referred to as Writing Diary with Water. The placing of seals on documents and images is a common feature of Chinese visual culture that carries connotations of power, authority and ownership. In his performance art piece, and the photographic images that document it, Song Dong repeatedly attempts to place a large seal onto the Lhasa River, whose ever-moving surface yields to the pressure of the seal which has been inscribed with the Chinese character for water (shui) while nevertheless refusing to retain any permanent inscription or record of its impress. Given the location of the river, in Tibet, ideas of state power encountering watery resistance enable the piece to succeed in reminding us that power can be 'dissolved'.

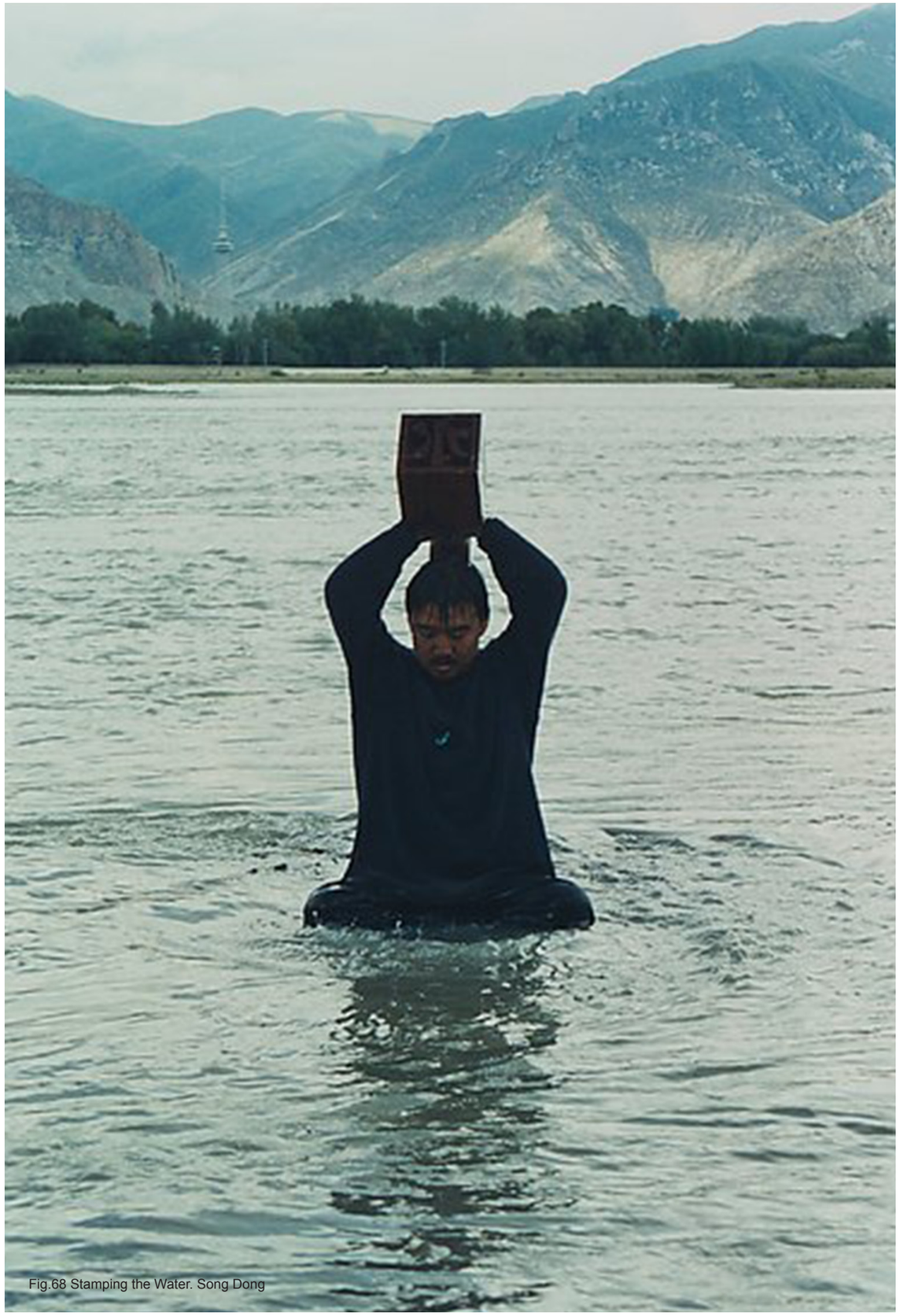


Fig.68 Stamping the Water. Song Dong

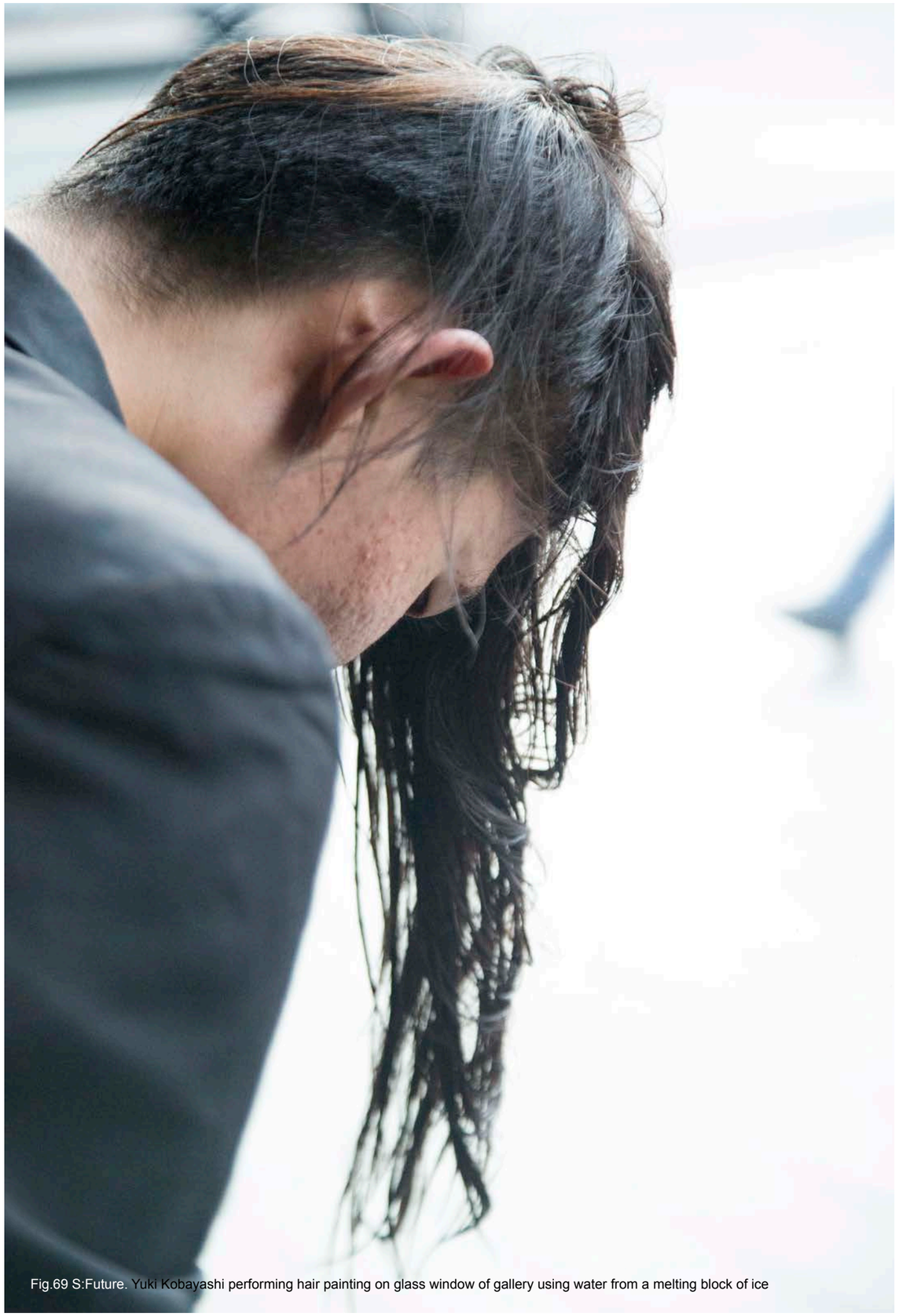


Fig.69 S:Future. Yuki Kobayashi performing hair painting on glass window of gallery using water from a melting block of ice

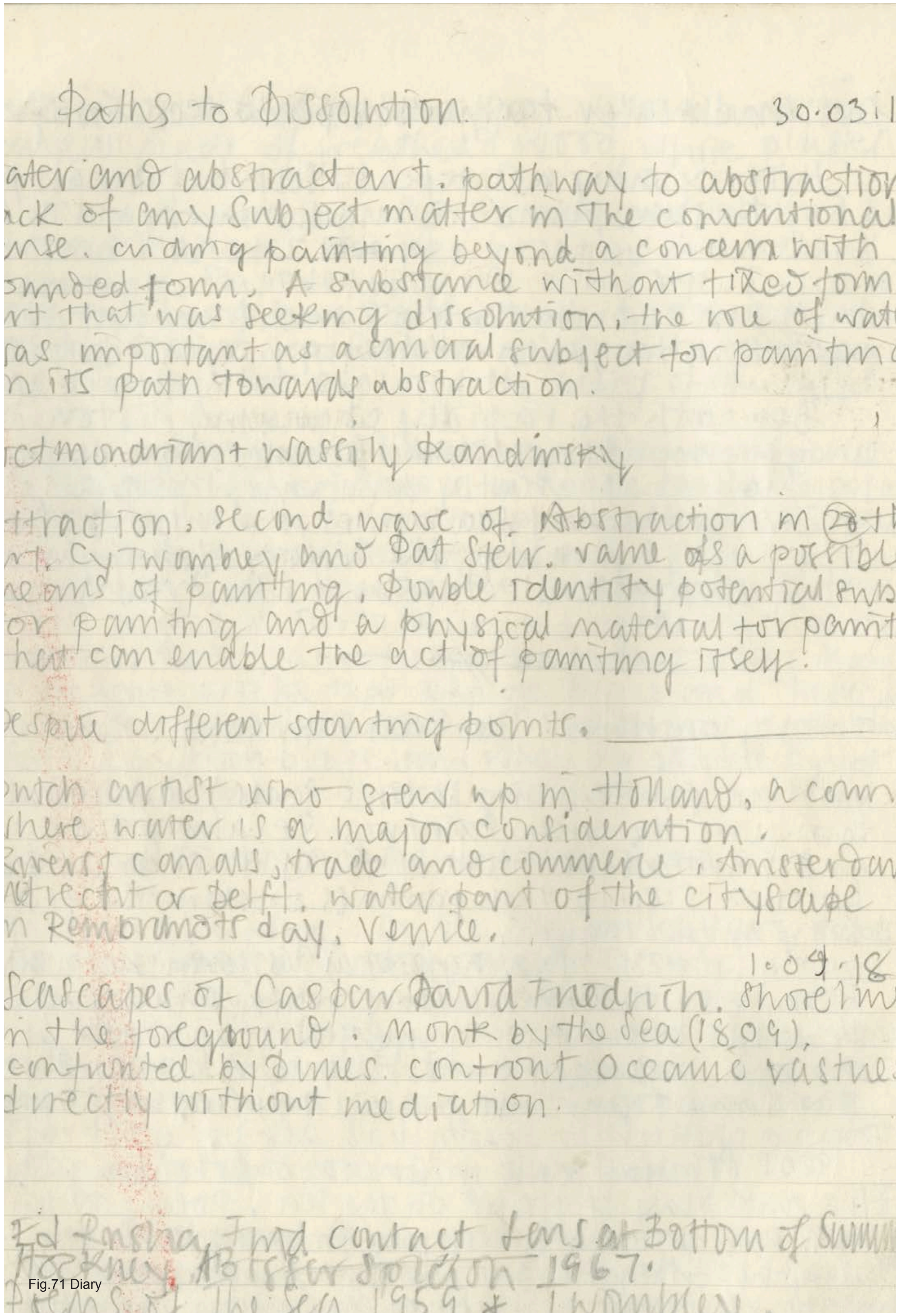
S: Future was a group exhibition held in the RCA Dyson Gallery that opened at my request with a ritual sacrifice of a block of melting ice (250cm x 50cm x 25cm) by performance artist Yuki Kobayashi. After kneeling on the floor to dip his head into the box containing the ice, Yuki performed an improvised ‘hair ‘painting’ across a single length of internal glass façade in the intimate setting of the groundfloor space while listening to my ice core audio recordings which were played via loudspeakers. The hair painting would both appear and disappear, inviting continuous interaction and engagement from each person that visited the exhibition.

In many ways the performance was an intimate meditation on the permanence and impermanence of the Arctic and Antarctic, and the impossibility of attempting to write a rapidly vanishing polar history. Inspired by Song Dong’s Printing On Water and Writing Diary With Water[25] the performance and subsequent body of works on glass and paper also connects to my own autobiographical history of notating music.

In 2018 I began my own pencil written ‘water diary’ in a small leather volume. Having observed multiple log-books, journals and manuscripts at the British Antarctic Survey, National Maritime Museum and the Scott Polar Museum, the diary reflects a personal sense of journey and navigation taken over the course of the research. Written to condense my evaporating ideas before they disappeared, the diary specifically notates the speed and direction of the newly emergent Liquid Series of paintings and calligraphic ink drawings. The diary is strictly non linear and non-sequential, documenting multiple cross-cultural paths.

Fig.70 Solid Series No.34. Laser engraved audio data on glass. 15cmx10cmx1cm

25 https://www.pacegallery.com/journal/song-dong-s-writing-diary-with-water-at-the-2018-kochi-muziris-biennale/



Paths to Dissolution. 30.03.1

ater and abstract art. pathway to abstraction
ack of any subject matter in the conventional
nse. drawing painting beyond a concern with
unded form. A substance without fixed form
rt that was seeking dissolution. the role of wat
as important as a moral subject for paintin
n its path towards abstraction.

ct mondriant wassily kandinsky

traction. second wave of Abstraction in 20 t
rt. Cy Twombley and Pat Steir. vame as a possibl
eans of painting. Double identity potential sub
or painting and a physical material for paint
hat can enable the act of painting itself!

espite different starting points. ______

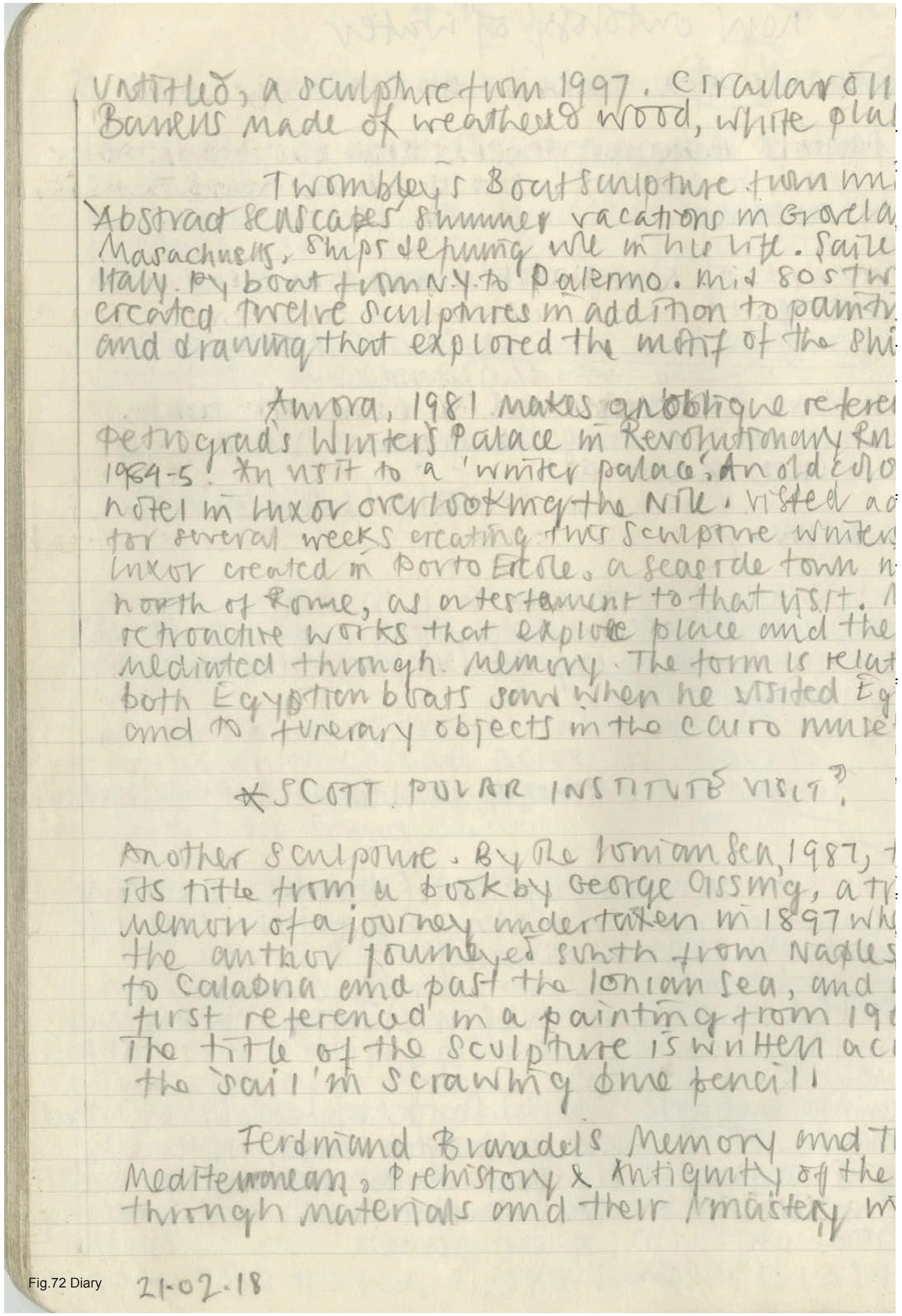
utch artist who grew up in Holland, a coun
here water is a major consideration.
rivers canals, trade and commerce. Amsterdam
Utrecht or Delft. water part of the cityscape
n Rembrandts day. Venice.

1.09.18

Seascapes of Caspar David Friedrich. shoreline
n the foreground. Monk by the sea (1809).
confronted by dunes. confront oceanic vastne.
directly without mediation.

Ed Ruscha, find contact lens at Bottom of Swimm
Hockney, A Bigger Splash 1967.
[illegible] the Sea 1959 * Twombley.

Fig.71 Diary



Untitled, a sculpture from 1997. circular o[illegible]
Barrels made of weathered wood, white pla[illegible]

Twombley's Boat sculpture from mi[illegible]
Abstract seascapes summer vacations in Grovela[illegible]
Massachusetts, ships defining role in his life. Saile[illegible]
Italy. By boat from N.Y. to Palermo. mid 80s Tw[illegible]
created twelve sculptures in addition to paintin[illegible]
and drawing that explored the motif of the shi[illegible]

Aurora, 1981 makes an oblique referen[illegible]
Petrograd's Winter's Palace in Revolutionary Ru[illegible]
1964-5. An visit to a 'winter palace'. An old Euro[illegible]
hotel in Luxor overlooking the Nile. visited a[illegible]
for several weeks creating this sculpture winter[illegible]
Luxor created in Porto Ercole, a seaside town n[illegible]
north of Rome, as a testament to that visit. [illegible]
retroactive works that explore place and the
mediated through memory. The form is relat[illegible]
both Egyptian boats seen when he visited Eg[illegible]
and to funerary objects in the Cairo muse[illegible]

*SCOTT POLAR INSTITUTE VISIT?

Another sculpture. By the Ionian Sea, 1987, t[illegible]
its title from a book by George Gissing, a tr[illegible]
memoir of a journey undertaken in 1897 wh[illegible]
the author journeyed south from Naples
to Calabria and past the Ionian Sea, and [illegible]
first referenced in a painting from 19[illegible]
The title of the sculpture is written ac[illegible]
the sail in scrawling fine pencil!

Ferdinand Braudel's Memory and T[illegible]
Mediterranean, Prehistory & Antiquity of the
through materials and their mastery [illegible]

21.02.18

Fig.72 Diary

Fig.73 Pat Steir. Wind and Water

> I began looking at Chinese Literati paintings and at Southern Song Dynasty pottery and painting, and I realized that I didn't have to use the brush, that I could simply pour the paint, that I could use nature to paint a picture of itself by pouring the paint. That gravity would paint my painting with me. I was influenced and inspired by John Cage, his idea of non-intention. Essentially, my whole voyage, from that first painting of a young woman, fighting her way through the paint to now, is a search and an experiment. All of my work is a search and an experiment. I don't consider anything finished, I think of it as all only a step along the way. (Pat Steir, interviewed in The Brooklyn Rail, March 2011)

Although influenced by the natural world, Pat Steir describes her work as coming from within. Known for her large-scale Waterfall series of works on canvas, Steir has a strong physical dimension in her practice. The splashes, drips and marks made on her un-primed canvasses are often created whilst almost dancing. Steir is interested in the movement of line. In the Water and Wind work of 1995, Steir's line is connected intentionally to her movement across her studio floor or from the top of the canvas where she has made a pour while on a ladder.

Developed over a fifty-year career, this method has involved the use of water or solvent from over-saturated brushes. Steir firmly rejects the use of the term Abstract Expressionism to describe her work on the grounds that her work is a concrete examination of the line. Despite the freedom of execution and the large areas of canvas to be addressed, Steir has measured control over her methods, which she developed in part through in-depth study of Japanese and Chinese painting.

Steir sprays water from a water bottle onto layered strata of acrylic and oil, then allows the fluidity of paint to cascade down the length of the support. Integrating the sensibilities of Conceptual art and Eastern philosophy, Steir's use of water in her paintings can therefore be considered as contemplative investigations of space and chance.

Steir's use of chance operations influenced the production of a number of works from the Liquid Series, including No.4 (Antarctic Seascape, Night). This 210cmx120cm work involved the use of beeswax which was initially heated in a pan and mixed with titanium white pigment before being poured vertically from the top of the canvas. The canvas was then rotated 180 degrees and hung landscape on the studio wall where the effect of gravity created the main compositional form in the lower half of the painting.

Horizontal lines of varying density and translucency were then added to the to top right of the work through the use of intermittent brushwork and chance related mark making. While my exploration of beeswax here was influenced by Steir, Liquid Series Nos. 7,14 and 58 were directly shaped by the philosophical consideration of beeswax and pollen found in the work of German sculptor Wolfgang Laib.

Fig.74 Liquid Series No.4 (Antarctic Seascape, Night) Beeswax and Oil on Canvas. 120cmx210cm

Wolfgang Laib originally studied medicine and completed a doctoral thesis on the hygiene of drinking water. Having visited India and Southeast Asia, where he discovered the Chinese philosophy of Laozi,[26]Laib found the focus on the body in medicine to be at the expense of the soul. For over forty years he has created sculptures and installations using a variety of organic materials such as milk, beeswax and rice in meditative works that attempt to connect past and present, the ephemeral and the eternal.

Ideas of ritual, sustenance and nourishment then play a central role in Laib's minimalist aesthetic which seeks to explore the polarity between complexity and simplicity. He often presents pastel drawings and marble sculptures high on the wall or low on the gallery floor. Each year, during the spring and summer months, he collects pollen from the fields surrounding his home in a remote region of the Black Forest, which he stores in jars before exhibiting them as luminous colour fields in museums and galleries around the world. Laib states:

> The pollen recalls the beginning and creation; the rice mountains and the beeswax Ziggurat (pyramid and steps) nourishment and the bond of the sky with the earth; in the end, fire recalls destruction and the possible renewal of the world, the transformation of what is physical to a new cycle, to a state of change. (Wolfgang Laib, 2022)[27]

During visits to the BAS ice core laboratory, I learnt that pollen grains are commonly found in polar ice, particularly in mountain glaciers, where they are blown across the Antarctic continent at low to middle latitudes and trapped in layers of snow.[28] The visits also revealed to me the phenomena referred to as Watermelon Snow.[29] Watermelon snow, also called pink snow, red snow, or blood snow, is a phenomenon caused by a species of cold thriving algae containing red pigment and chlorophyll. The algae use the pigment to protect itself from ultraviolet light. Snow blooms contribute to climate change. Because of the red-crimson colour, the snow reflects less sunlight and melts faster. High temperatures in the Arctic and Antarctica are linked to increased blooms causing pink and red snow because it produces more and more bright algae.

Laib's practice of collecting and storing grains of pollen shaped my collecting and storing of ice core air bubbles at the BAS ice core laboratory. In particular, his use of scent within the gallery space guided my exploration of sound as a vital source of indivisible knowledge. Following indeterminate processes in the work of both Steir and Laib, I began to use pollen as primal form of critical material in my Liquid Series of oil paintings, which I presented concurrently in the exhibition space alongside my Solid Series of glass sculpture.

26 Laozi was a 5th century thinker considered the founder of philosophical and religious Taoism.

27 https://ropac.net/news/947-wolfgang-laib-interview/

28 https://www.tandfonline.com/doi/full/10.1080/15230430.2019.1638202

29 The earliest accounts of watermelon snow are in the writings of Aristotle. Aristotle (2018) "History of Animals V". University of Chicago Press.

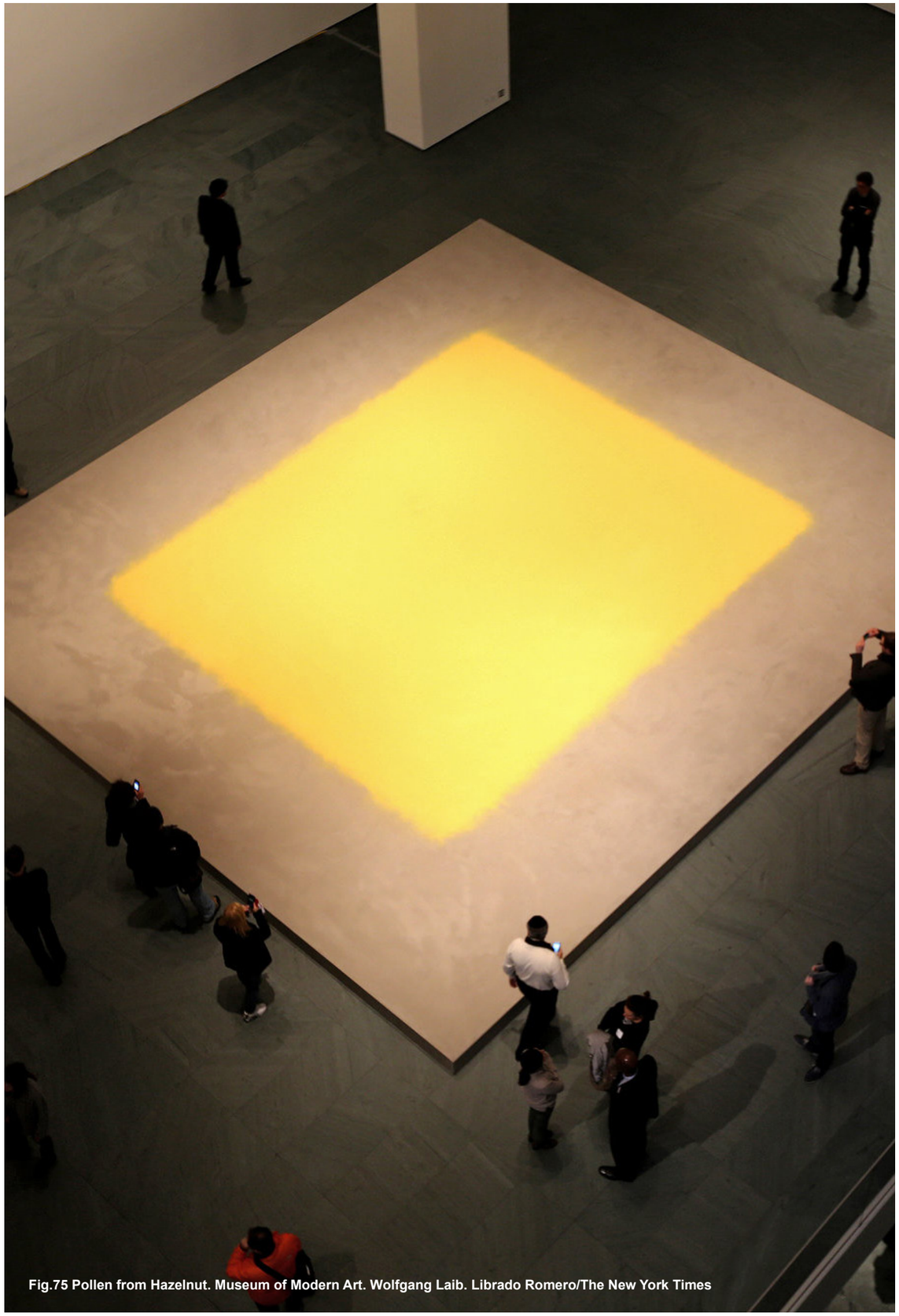


Fig.75 Pollen from Hazelnut. Museum of Modern Art. Wolfgang Laib. Librado Romero/The New York Times

The research draws from both analogue and digital aspects of work by Ryojo Ikeda, Song Dong, Hiroshi Sugimoto and Fujuko Nakaya, all of whom use the sound and image of water and the sea to ’travel’ across the space of gallery, museum and landscape. The material use of the ocean by these artists has specifically informed my own use of ice audio and video recordings as the basis of original sonic and visual composition. The political status of the Arctic and Antarctic is often reduced within contemporary art discourse to that of either passively perceived subject or actively illustrated object. Moving away from binary questions of representation or documentation, participation or observation, the research aimed to explore a mode of polar history at the British Antarctic Survey ice core laboratory that is concurrently, visual and sonic, absent and present, stable and volatile. Here the research was influenced by the work of Ryojo Ikeda.

Ryojo Ikeda is a Japanese sound artist whose work is primarily focused on sound in a variety of raw states, such as imperceptible sine tones and noise. Ikeda’s work is often comprised of frequencies operating at the upper and lower extremes of human audibility. Radar (2012) was a sound and light installation that explored the physical boundary between sea and a Rio De Janeiro beach, creating a large-scale immersive experience for night-time visitors. This ambitious work attracted thousands of revellers to a site with an extremely violent political history; it consisted of multiple layers of visual data taken from the internet that was then edited, re-programmed and retransmitted as audible sound and light via state-of-the-art loudspeakers and laser projection. The installation incorporated the movement of the sea as a way of framing a reminder that nature should be respected above the speed of technological advances, and that the natural environment should be lived, felt and experienced bodily and cannot be controlled or guided in the manner of a conventional radar or object detection system.

Fig.76 Radar. Rio de Janeiro Beach. Production still

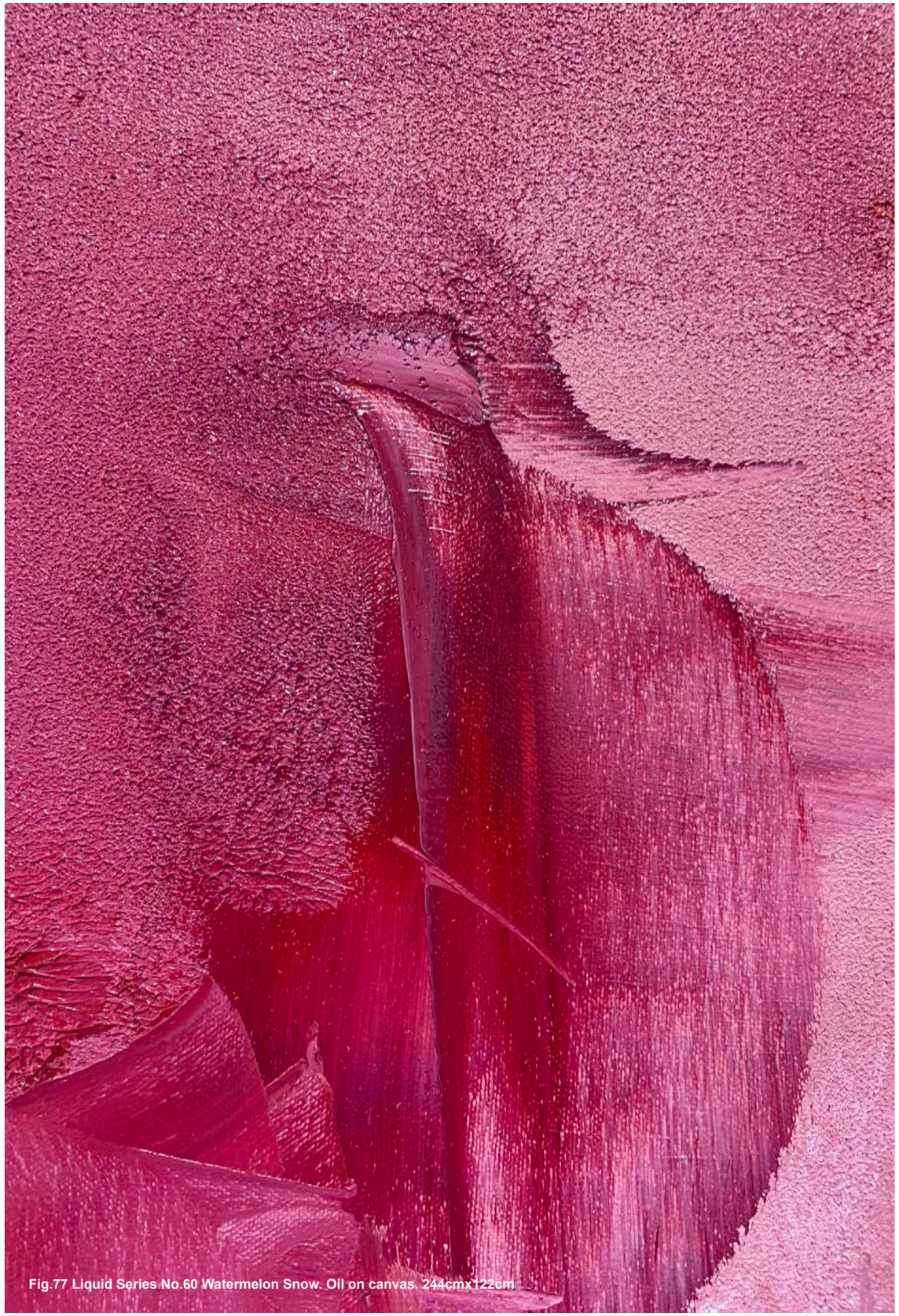


Fig.77 Liquid Series No.60 Watermelon Snow. Oil on canvas. 244cmx122cm

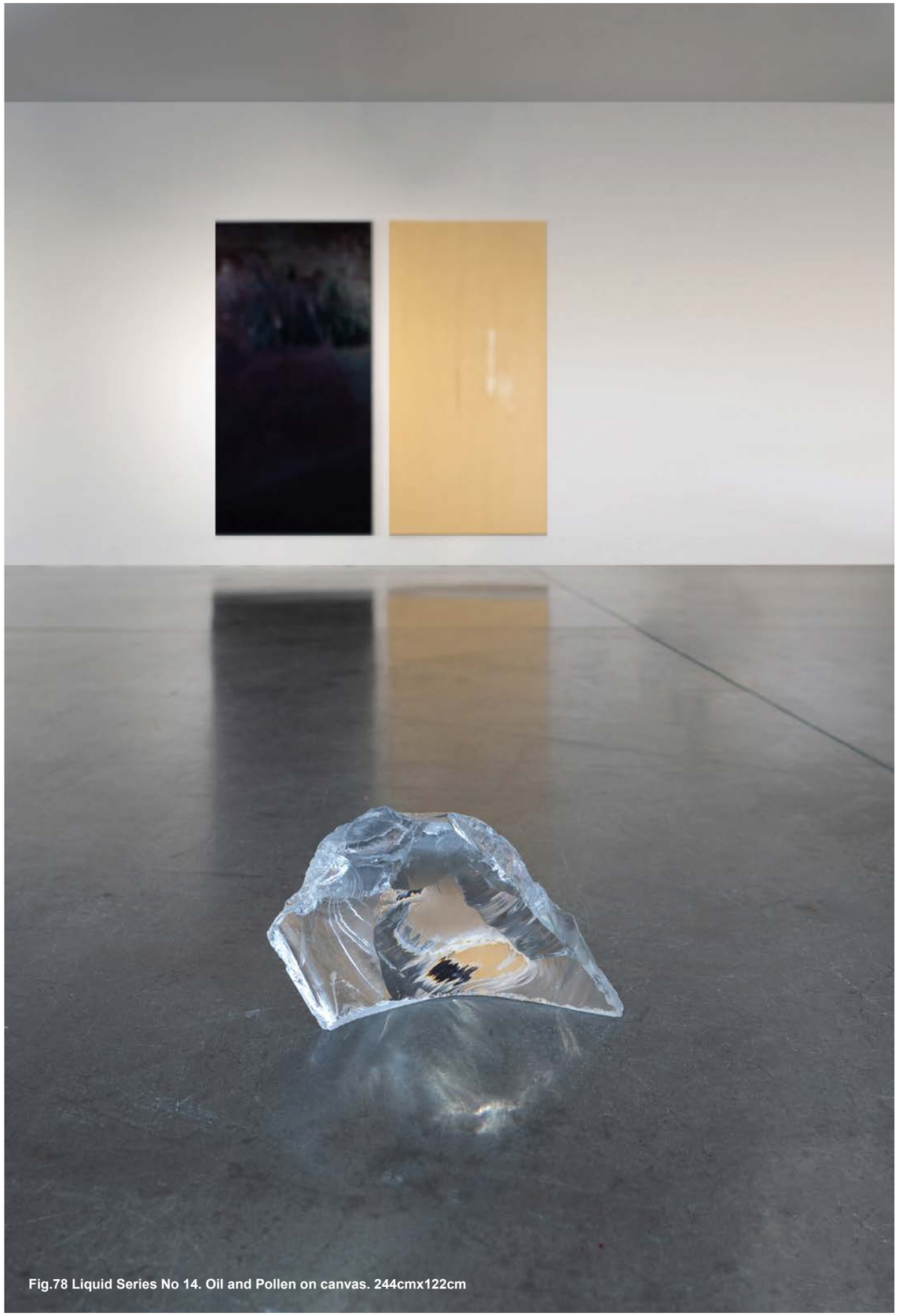


Fig.78 Liquid Series No 14. Oil and Pollen on canvas. 244cmx122cm

Exemplary Group Surveys

New Directions May Emerge. Helsinki Biennial. Finland. 2023

https://www.myhelsinki.fi/en/see-and-do/events/helsinki-biennial-2023-new-directions-may-emerge#

Dear Earth: Art and Hope in a Time of Crisis. Hayward Gallery. 2023

https://www.southbankcentre.co.uk/whats-on/art-exhibitions/dear-earth-art-and-hope-time-crisis

Tideline. Messums Gallery. 2022

https://messumswiltshire.com/exhibitions/private-viewing-room-tideline/

Among the Trees. Hayward Gallery. 2020

https://www.southbankcentre.co.uk/whats-on/art-exhibitions/among-the-trees

Eco-Visionaries: Confronting a planet in a state of emergency. Royal Academy. 2020

https://www.royalacademy.org.uk/exhibition/architecture-environment-eco-visionaries

Arctic. Louisiana Museum. Denmark. 2013

https://www.youtube.com/watch?v=pzs6jphDw3U

Ice Age Art. British Museum. 2013

https://www.royalacademy.org.uk/article/preview-ice-age-british-museum

earth: Art of a changing world. Royal Academy. 2009-10

https://www.capefarewell.com/earth-art-of-a-changing-world/

RETHINK// Contemporary Art and Climate Change. COP15. 2009

https://www.rethinkclimate.org/en/

Relevant contemporary artists and theorists working on aligned themes: Works, Websites

Francis Alys. Sometimes making something leads to nothing. 1997

https://francisalys.com/sometimes-making-something-leads-to-nothing/

Benoit Aquin. The Chinese Dust Bowl.

http://www.benoitaquin.com/the-chinese-dust-bowl

Amy Balkin. Smog Index 2018+

https://tomorrowmorning.net/smogindex

Maria Bartuszova. Melting Snow. 1985

https://www.tate.org.uk/whats-on/tate-modern/maria-bartuszova

Subhankar Banerjee. Resource Wars in the American Arctic

https://hoodmuseum.dartmouth.edu/news/2007/03/subhankar-banerjee-resource-wars-arctic

Mathew Barney. Drawing Restraint. 1987

https://www.sadiecoles.com/artists/5-matthew-barney/

Daniel Beltra

https://danielbeltra.photoshelter.com/index

Wayne Binitie. Dark Bubbles. 2017

https://www.rmg.co.uk/stories/topics/wayne-binitie-art-climate-change

Erika Blumenfeld. Antarctica. 2009

https://erikablumenfeld.com/works/the-polar-project/

Christian Boltanski. Animitas. 2021

https://www.mariangoodman.com/artists/33-christian-boltanski/

Canary Project

https://experimentalstudio.ca/outdoorschool/2015/10/27/canary-project-increase-your-albedo/

Edward Burtynsky. Water Project. 2010

https://www.edwardburtynsky.com/projects/photographs/water

Jason de Caires. Underwater Sculpture

https://www.underwatersculpture.com

Mary Ellen Carroll. indestructible language. 2021

http://mecarroll.com/indestructible-language/

Matt Costello. Hidden

https://www.rca.ac.uk/students/matthew-costello/

Song Dong. Writing Diary With Water. 2018

https://www.pacegallery.com/journal/song-dong-s-writing-diary-with-water-at-the-2018-kochi-muziris-biennale/

Nicole Dextras. View. 2007

https://nicoledextras.com/2010/11/view-project/

Marjolin Dijman. Surviving New Land. 2010

https://www.marjolijndijkman.com/?rd_text=22-2&lang=en

Susan Durges. The River Taw. 1998

https://www.purdyhicks.com/artists/38-susan-derges/works/9527-susan-derges-river-taw-willow-1998-2019/

Chris Drury. Iceprint. 2007

https://chrisdrury.co.uk/portfolio/mapping/antarctica/

Bright Ugochukwu Eke. Acid Rain. 2005

https://axis.gallery/artists/bright-ugochukwu-eke/#foogallery-491/i:1/p:1

Olafur Eliasson. Ice Watch. Tate Modern 2018

https://icewatch.london

Simon Faithful. Going Nowhere 1.5. 2016

https://www.simonfaithfull.org

Bill Fontana. River Sounding. Somerset House. 2014

https://www.resoundings.info/new-page-1

Anya Gallacio. Intensities and Surfaces. 1996

https://www.thomasdanegallery.com/artists/36-anya-gallaccio/works/3206/

Andy Goldsworthy. Ice Arch. 1982

https://celluloidwickerman.com/2016/06/13/responses-andy-goldsworthys-ice-arch-1982/

Tue Greenfort. Untitled Switch. 2002-7

https://nicolausschafhausen.com/tue-greenfort/

Alex Hartley. Nowhere Island. 2012

https://www.victoria-miro.com/artists/21-alex-hartley/

Mona Hartoum. Hot spot III. 2009

https://www.whitecube.com/artworks/hot-spot-iii?edition

Naoya Hatakeyama

https://prix.pictet.com/cycles/earth/naoya-hatakeyama

HEHE. Champs D'Ozone. 2003

http://www.hehe.org/projets/champs-dozone

Pierre Huyghe. A Journey That Wasn’t. 2005

https://www.publicartfund.org/exhibitions/view/a-journey-that-wasnt/

Christina Inglesias. This Fountain Which Is Not One. 2008

https://cristinaiglesias.com/concepts/the-underground-and-phreatic-zones/

Ryoji Ikeda. Radar. 2012

https://www.ryojiikeda.com/project/theradar/

Isuma Collective

https://aabaakwad.com/artists/isuma-collective/

Eva Josprin. Panorama. 2022

http://www.noirmontartproduction.com/en/projets/eva-jospin-2/

Isaac Julien. True North. 2010

https://www.isaacjulien.com/projects/true-north/

Nadav Kander. Yangtze, The Long River. 2009

https://www.nadavkander.com/works-in-series/yangtze-the-long-river/single

Tania Kovats. Cotidal. 2023

https://www.rmg.co.uk/whats-on/lecture-theatre/cotidal-world-oceans-day-film-premiere

Wolfgang Laib. Pollen from Hazelnut. 2013

https://www.youtube.com/watch?v=e-_92MYcANk

Richard Long. A Circle in Antarctica. 2012

http://www.richardlong.org/Sculptures/2013/circleinantarctica.html

David Maisel. The Lake Project. 2001

https://davidmaisel.com/essays/david-maisel-the-lake-project/

Gustav Metzger. RAF/Reduce Art Flights. 2013

https://reduceartflights.lttds.org

N55. Clean Air Machine

https://www.collective-edinburgh.art/programme/2007-n55-

Fujiko Nakaya

https://www.hausderkunst.de/en/exhibitions/fujiko-nakaya-nebel-leben

Svetlana Ostapovici. Water

http://www.svetlanaostapovici.it/water1.html

Nyaba Leon Ouedrago. The Hell of Copper. 2008

https://prix.pictet.com/cycles/growth/nyaba-leon-ouedraogo

Giuseppe Penone. Albero d’acqua. 1979

https://www.mariangoodman.com/artists/58-giuseppe-penone/

Paterson. K. Vatnajokull (the sound of) 2007-8

https://katiepaterson.org/artwork/vatnajokull-the-sound-of/

Superflex. Hunga Tonga. 2019

https://superflex.net/works/hunga_tonga

Cecilia Vicuna. Brain Forest Quipu. 2022-3

https://www.tate.org.uk/whats-on/tate-modern/cecilia-vicuña

Notable Residences and Academic Researchers

Arts Catalyst

https://artscatalyst.org

Atmospheric Data Collective

https://www.manifest-data.org

Ars Bioarctica

https://bioartsociety.fi/projects/ars-bioarctica/pages/residency

Cape Farewell

https://www.capefarewell.com

Polly Gould

https://pollygould.co.uk/work/alpine-architecture

Library of Water

https://www.artangel.org.uk/library-of-water/writers-residency-programme/

Ruth Maclennan

https://ruthmaclennan.com

Nordic Alliance of Artists's Residencies on Climate Action

https://naarca.art

Susan Schuppi

https://susanschuppli.com/ICE-CORES-1

Clea T Waite

https://clea-t.de/work

Climate crisis and contemporary collaborative practices embedded in scientific communities[30]

Fujuko Nakaya is a Japanese artist, painter, sculptor and video maker who first participated in American art collective Experiments in Art and Technology (E.A.T.), in 1967. This not-for-profit service organization forged interdisciplinary collaboration between artists, engineers and scientists, and was an important development for Nakaya who is the daughter of Ukichiro Nakaya, a noted essayist and physicist known for his work in glaciology and low-temperature sciences.[31] Fujuko Nakaya produced the world's first 'fog sculpture' for Expo '70, in Osaka, enveloping the roof of the Pepsi pavilion with a vapourous mass of artificially produced fog.

The use of technology developed for Expo '70 was made in close collaboration with atmospheric physicist Thomas Meehas, and has formed the basis of Fujuko's subsequent work.[32] The sustained interrogation of Fog by Nakaya and E.A.T can be understood as an important precursor to the more recent explosion of both large and small scale interdisciplinary contemporary collaborative practices devoted to issues of the atmosphere and climate including: Cape Farewell (England); The Nordic Alliance of Artists' Residencies on Climate Action (NAAR); CoSaari Residence (Finland); Artica Svalbard (Norway); Art Hub Copenhagen (Denmark); Baltic Art Center (Sweden); Narsaq International Research Station (Greenland), and Skaftfell Art Center (Iceland). The increased proliferation of new interdisciplinary modes of contemporary collaborative practices engaged with the polar environment raises important questions regarding the ontological status of knowledge construction and innovation operating within these projects in general and across society in particular. This rapid transformation poses further critical questions around shifting concepts, methods and forms of accountibility in the technological present that has prompted a number of research authors to interrogate the validity and principles of the 'logics of interdisciplinarity'.

'Logics of interdisciplinarity' Economy and Society, (2008) was a funded research project led by investigators Barry, Born and Weszkalnys that examined the bounded question of the interdisciplinary. Part of a wider ESRC programme 'Science in Society', the eighteen month empirical study moved between the three fields of environmental and climate change research, ethnography in the IT industry, and art-science, in order to determine the extent to which notions of discipline and interdisciplinarity function as epistemic markers. Addressing the question of whether a given subject of enquiry is too disciplinary or interdisciplinary, the authors state their aim to 'interrogate the current preoccupation with interdisciplinarity, in particular the ascendance in recent years of a particular discourse on interdisciplinary where it is associated with a more generalised transformation in the relations between science, technology and society:

30 On 22 November 2019, a public discussion was organised at Arup's London office, to celebrate the opening of 'Ice Floor'. The interdisciplinary context of this Arup Phase 2 commission is outlined in a short Arup film involving Robert Mulvaney (Science Leader, British Antarctic Survey), Graham Dodd (Arup Fellow and Global Materials Leader) and Jennifer Greitschus, (Head of Arup Exhibitions). https://www.youtube.com/watch?v=W4dAz_x4M1o

31 Ukichiro Nakaya is primarily known for his work in glaciology and is credited with making the first artificial snowflakes.

32 These include permanent fog installations at the Guggenheim Museum Bilbao, the San Francisco Exploratorium and Domaine de Chaumont-sur-Loire, France. Nakaya acted as a consultant to architects Diller+Scofidio on Blur Building created for the Swiss Expo 2002 on Lake Neuchâtel in Yverdonles-Bains.

> We are therefore less concerned with interdisciplinarity in general than with the contemporary formulation of interdisciplinarity, how it has come to be seen as a solution to a series of contemporary problems, in particular the relations between science and society, the development of accountability and the need to foster innovation in the knowledge economy'. (Barry, Born and Weszkalnys, 2008:21)

Referencing Nowotny,[33]the authors identify the [problematic] emergence of 'novel forms of quality control which undermine disciplinary forms of evaluation; the displacement of 'a culture of autonomy of science' by a 'culture of accountability'; (Nowotny, 2003:211-15) ; the growing importance of 'context of application' as a site for research; and a growing diversity of sites at which knowledge is produced'. Barry, Born and Weszkalnys' study questioned the notion that interdisciplinarity research should be understood within binary models of *integration-synthesis, subordination-service* and *agonistic-antagonistic*, before positing three logics of *accountability*, *innovation* and *ontology*. The research involved ten case studies that moved between environmental and climate research; ethnography in the IT industry; and art-science, with its authors suggesting that, 'it is these kinds of interdisciplinary research that are thought to have the greatest significance in the transition to a new mode of knowledge production, auguring closer relations between science and society'. Weszkalnys (2008:22) While Barry, Born and Weszkalnys' study asks how can they conceptualise relations between disciplinary and interdisciplinary forms of knowledge production, Zemon Davis' cautionary post-colonialist analysis of the poles and polarity reminds us against 'the limitations of treating multiple knowledge systems as though they simply emanate from singular epistemic communities'.[34] Paraphrasing Davis, I caution against the limits of treating disciplinary and interdisciplinary forms of knowledge production in the fields of science, arts and engineering as though they emanate from singular ontological modalities.

Fig.79 BAS ice core laboratory. Image BAS

Polar Aesthetics explored scientific and engineering tools to examine how history is written in polar ice drilled from depths of up to three kilometres below the surface. The research attempted to crystallise some of the philosophical themes, arguments and ideas advanced earlier by Michel Foucault in The Archaeology of Knowledge (1969). Foucault's treatise posits an analytical method and historiography of the systems of thought (epistemes) and of knowledge (discursive formations) within a given time and place, which he suggests operate beneath the consciousness of the subject individuals, and which define a conceptual system of possibility that flow across the boundaries of language and thought. In counterpoint to Benjamin's literary method of 'plumbing the depths of thought and language',[35]my method of collecting ice core samples or fragments as a means of gathering information is therefore not an integrative-synthesis model of investigation outlined by authors in Barry, Born and Weszkalnys text[36]but rather an analytical and argumentative attempt to crystallise fragments of thought (ideas) and discursive formations (ice cores) which can be said to exist beneath the metaphorical and literal surface of the Arctic and Antarctic. Barry, Born and Weszkalnys cite authors including Nowotny (2001) and Strathern's (2004) account suggesting that interdisciplinary research is frequently employed across society as 'it helps to foster a culture of accountibility, breaking down barriers between science and society, leading to greater interaction, for instance between scientists and various publics and stakeholders'. Here, the inference is one of subordination-service, where interdisciplinary practice is used as a way of 'defending or legitimising the sciences by providing them with a protective layer of scientific expertise or public engagement'. (Barry, Born and Weszkalnys. 2008:31)

Polar Aesthetics examined the Arctic and Arctic at a time of ubiquitous societal visibility and chemical invisibility. The research explored a narrative form of discourse analysis in the exhibition format that aimed to assess how ice cores might be used to express differing viewpoints of polar history, including the positive and the negative, the emotional and the intellectual. Moderated by the phase changes of matter, my material use of polar ice therefore aimed to avoid what many interdisciplinary sci-art collaborations do in the present, which is to employ complex statistical charts and visual graphs to attempt to tell audience 'what the message is'. While I do not recognise the agonistic-antagonistic statement made by Barry and co-authors -'[i)n some cases it appeared as though the minimal performance of interdisciplinarity through the social sciences in a natural science laboratory could be held out as accountability' - I do accept the weight of observation made by Stathern in response to atypical sci-art funding remits where:

'[a] frequent rhetorical elision in governmental and other public statements is that between dealing with materials in an interdisciplinary way and being able to communicate to anyone (stakeholders). Similar currents are at work in the British art-science field, which emerged in the 1990s in response to a series of funding schemes including the Wellcome Trust's Sciart programme and the Arts Council England/Arts and Humanities Research Council's Art-Science Fellowships.

While the ACE/AHRC scheme entailed a different rationale, the Wellcome Trust's programme was predicated on the 'public understanding of science' paradigm: that art can be used to popularize or communicate science and its social, cultural and ethical dimensions, whether through aesthetic elaboration or by rendering scientific discovery comprehensible by expressive means an aestheticizing legitimation that might obviate other forms of accountability. Here, artists' collaboration with scientists is expected to effect a wider social engagement'. (Strathern as quoted in Barry, Born and Weszkalnys. 2008:31)

33 Nowotny, H. 2003. Science in search of its audience. Nova Acta Leopoldina. NF. (325), 211-15) Professor Nowotny is Chair of Social Studies of Science at the Swiss Federal Institute of Technology (ETH) in Zurich

34 Davis, Z. in Bravo. 'The Postcolonial Arctic, 2015, p1. Moving Worlds (2015) Vol. 15 No. 2

35 See thesis p.32 for Arendt's discussion of Benjamin's method of drilling into literary fragments of the past. Arendt, H. (1968) Illuminations. Trans. Harry Zohn. US: New York: Harcourt, Brace & World Inc.

36 Tait & Lyall, 2001;Ramadier, 2004; National Academies, 2005, p.26; Mansilla, 2006.

Contemporary Context: Speed, immediacy, art and climate crisis

Invention typically refers to a form of composition, illegitimate claim, discovery, or any expression of the imagination, while innovation is commonly a device, strategy or process that originated after a period of experiment not previously in existence. Innovation can refer to something new or a transformation made to an existing subject, object, idea, or field. In this context, the first thermometer was therefore an invention, the first cellular thermoscope either an invention or an innovation, and the first mercury thermometer an innovation. Within the contemporary collaborative practices embedded in scientific communities, the work of **David Buckland** is both inventive and innovative. Since 2001, the designer, photographer, artist, filmmaker, writer and curator has been recognised as the most significant pioneer of sustained artistic response to the climatic crisis in the world. Buckland's *Cape Farewell Project* has measured the nature, scope and temperature of the climate crisis discourse through interdisciplinary collaboration with a range of leading scientists, artists and activists. In 2005[37] Buckland produced an expedition to Tempelfjorden, north Norway, aboard the schooner Noorderlicht with a crew including Anthony Gormley, Rachel Whiteread, Ian McEwan and choreographer Siobhan Davies, where they experienced temperatures as low as -30 degrees Celsius.

At a time of increased environmental and climatic transformation, many authors such as Doreen Massey, Paul Virilio and Marc Augé have asked questions about the critical erosion of spatial boundaries across modernity. French author Virilio argues that technological excesses have now moved us from a culture of the historical record to a culture of speed and immediacy. Describing our transit through non-spaces such as airport terminals, ATM machines, computer screens and the internet, French anthropologist Marc Augé (2009) suggests that the increased speed and immediacy of the present has rewired our emotional and intellectual understanding of the 'near', the 'far', resulting in a precise yet impartial experience of the world. Against this discourse of speed, immediacy and technological precision, Scottish artist **Katie Paterson**'s poetic use of technology maps data on environments that are distant in both time and space including the moon, stars, planets, forests and glaciers. As can be evidenced in works such as *All the Dying Stars*, 2009, and *Inside this desert lies the tiniest grain of sand*, 2010, Paterson's interdisciplinary practice - made in close consultation with scientists - examines the interconnectedness of geological time and place. I first became aware of Paterson's work when I arrived as a student of the Slade School of Fine Art in 2008. At the time, I was developing my emergent ecological interest in using blocks of ice as sculptural objects with the UCL Atmospherics Lab for a sound and video projection work. The previous year Paterson had exhibited Vatnajókull (the sound of) 2007-8, where a phone line was connected to an Icelandic glacier, via an underwater microphone submerged in the Jökulsárlón lagoon, the outlet of the Vatnajókull. A number could then be called from anywhere in the world, and the listener would hear the sound of the glacier. In another technologically mediated artwork by Paterson *Langjókull, Snaesfellsjókul, Solheimajókul,* involved sound recordings made from three Arctic glaciers that were pressed into three records, before being cast and frozen using the meltwater from each constituent glacier. The discs were then played via three turntables until they completely disappeared.

37 Cape Farewell has led eight expeditions to the High Arctic. In 2009 the first Cape Farewell expedition outside of the Arctic was launched to the Andes in Peru, in collaboration with the Environmental Change Institute, Oxford University.

Fig.80 Katie Patterson. 2007-2008. Neon sign, telephone logbook; sound recording on iPod; 4 photographs

In On Slowness:Toward an Aesthetic of the Contemporary author Ludz Koepnick (2014) holds that as the speed and velocity of the present becomes augmented and stretched, our attention spans become inversely shortened and diminished. Koepnick suggests that we ‘no longer take time to contemplate an image, follow the intensity of an emotion or traverse a gorgeous landscape’. The author’s stark assessment is perhaps associated with the rise of an unquestioning visualisation of technological information in the present which is often made in response to atypical sci-art public funding remits, and which predominantly produces a varient mode of immaterial work increasingly found in contemporary environmental art theory and practice commonly referred to as ‘data-art’.

Here, complex visual graphs, statistics and charts are nominally used to promote arguments for a qualitative experience of quantative data as contemporary art practice. Koenick suggests that in such a free-floating world of mass communication and saturated technological speed, historical notions of time and place are frequently omitted or erased. Koepnick’s text concludes that such an emphasis on mass comunication of accelerated technological exchange has greatly affected the intellectual and emotional materiality of our daily lives, resulting in ‘less substance, less depth, less meaning, less freedom, less spontaneity’. (Koepnick, 2014)

My own observations of the way in which climate scientists work with technology and data does not totally accord with positions put forward by Koepnick. On the ground, polar scientists tend to combine material experience in the Arctic and Antarctic with empirical studies of data taken above, below and from the surface of the earth to model and predict that which cannot be observed physically. The recent discovery of a previously undetected series of sub-glacial lakes in Vostok, in eastern Antarctica, was only possible through a sustained and imaginative interpretation of inconsistencies between what was experienced in the field and anomalies revealed by the data.

This creative approach to both technology and data that is taken from extreme depths and heights has, in turn, shown that the protective zone of the earth’s upper stratosphere – known as the ‘ozone layer’ – is not suffering from worryingly high levels of depletion caused by ultraviolet radiation from the sun, as was previously thought, but is actually showing signs of slowly repairing itself. The ozone layer is predicted to be restored to health by 2060. In the early 2000s, an international team drilled an ice-core from Antarctica to reveal a climate record going back 800,000 years. British Antarctic Survey scientists have recently drilled down 3 km into the surface of the East Antarctic Ice Sheet to reach ice that froze about 1.5 million years ago.

The 1.5-million-year-old ice contains tiny bubbles of air that became trapped in the ice as it froze. BAS ice-core lead scientist Robert Mulvaney states: ‘Now we want to double the length of that record to investigate an important shift in the earth’s climate around one million years ago, when the planet’s climate cycle between cold glacial conditions and warmer interludes changed from being dominated by a 41,000-year pattern to a 100,000 year cycle’.[38] Following the comments made by Mulvaney, Polar Aesthetics seeks to move beyond the simple visualization of ice core data towards a complex set of philosophical questions that prompt us to ask how the wider climate crisis narrative is composed, notated and erased across geological time and cultural place.

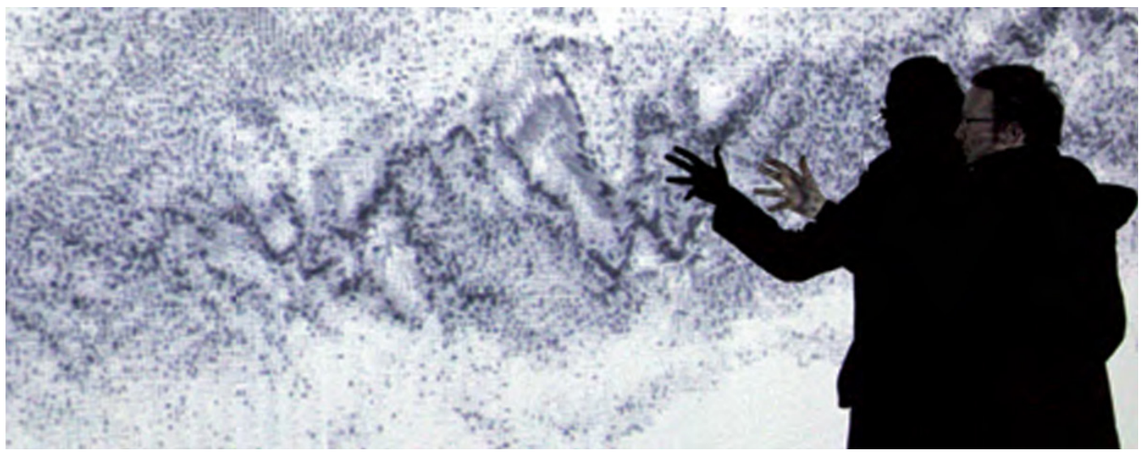
38 https://www.ipcc.ch/report/ar6/wg1/

Tom Corby, Gavin Bailey, Jonathan Mackenzie are London based artists who work collaboratively using data systems, models, physical theories and sensing technologies to examine global infrastructures. In 2009 they embarked on a project *The Southern Ocean* with the British Antarctic Survey. I was able to experience the non-illustrative and interconnected nature of this piece during a visit to Cambridge in 2014. Using real-time software algorithms as creative forms of expression, the piece involved a collective mapping of oceanic and ecological data sets in a work that interprets a range of phenomena including the geophysical movement of tidal flows, wind direction and weather patterns. The project has become an important interdisciplinary nexus through which to interpret the complexity of climate models to both non specialists and specialists.

Funded by Arts Council England and the Arts and Humanities Research Council, the project has benefited in close dialogue with **Giles Lane, Erin Dickson, Louise Sime, George Roussos,** who work collectively using public-domain data, satellite imagery and the internet to research new ways in which digital information can be used as material forms of creative information. There are a number of ontological and epistemic problems involved with the issue of visualising the complexity of environmental data. Corby and his collaborators have forged a distinctive path to embrace data streams in such a way as to explicate how the use of climate data can function beyond the purely graphic and the photographic, the abstracted and the representational. In a recent interview Corby states:[39]

> Climate data captures complex phenomena in the world which describe vast geological timescales, atmospheres, biotics and other planetary phenomena. These link to human, political, and social behaviours in ways that are hard to grasp even if their effects are catastrophically present. The complex abstractions of climate change make communication of it difficult and this is doubled through technical, visual and statistical approaches which also operate as bulwarks of specialist expertise that constrict more public participatory modes of engagement. Addressing this communication gap was one of the core motivating factors for our project and doing so using approaches that explore the potential of climate data to operate in sensory ways is the method we employ.

Fig.81 The Southern Ocean.Corby



39 https://www.panarchiccodex.com/tom-corby

Fig. 82 HEHE. Champs D'Ozone. 2003. Image: HEHE

The 2021 IPCC report[40] stated that carbon neutrality will not be achieved without a shift in the way we measure the transfer of climatic heat and temperature at the global and local levels. Temperature is a measure of how hot or cold an object is relative to another object, whereas heat is the flow of thermal energy between objects with different temperatures.

In this context, **HEHE** is a Paris-based duo whose artistic use of light, sound and image can be understood as an art, design and environmental research exploration into the flow of chemical and thermal energy of the urban climate and atmosphere.

Champs d'Zone (2003) involved the use of projected live images of the Paris skyline with colours portraying invisible pollutants contained within the atmosphere. For this work, sensors were positioned around the city by an independent association *Airparif,* who provided analytical real-time data of the chemical composition and quality of the air. Using this technological method, HEHE developed a basis to float suspended clouds of computer saturated colour across and within architectural spaces that reflect dangerous concentrations of nitrogen, sulphur dioxide, ozone and particle dust.

> One can choose the quality of our water or food, but not the quality of 15,000 litres of air that each of us breathes in one day and which is transported into our body, the oxygen as well as the dust and gas pollutants. (HEHE in Brown, 2014:34)

Champs d'Zone is a vapourous monument to the four hundred people who died in nine French cities due to ozone emissions caused by the heatwave of 2003. My chemical and societal investigation into the absence and presence of unpolluted air held in ice at the British Antarctic Survey laboratory in Cambridge is directly shaped by the critical influence of HEHE.

HEHE's inventive use of scientific data to measure environmental change specifically shaped my research exploration of hot and cold shifts of thermal energy and heat within the current climatic and atmospheric discourse that directly informed my making and thinking around how polar history is written, read and made legible in the contemporary present including works shown at the exhibitions Solid, Liquid, Gas at the V&A Museum, Ice Floor at the Arup Gallery and Polar Zero at the Glasgow Science Centre.

40 https://www.ipcc.ch/report/ar6/wg1/

Fig.83 Mary Allen Caroll. indestructible language

COP26

The Italian, Santorio Santorious (1561-1636) is thought to be the inventor of the thermometer as a temperature measuring device, and is credited with having applied a scale to an air thermoscope at least as early as 1612 using an instrument called an air thermometer. A subsequent sealed liquid-in-glass thermometer that is more closely related to that in use today, was first produced in 1654 by the Grand Duke of Tuscany, Ferdinand II (1610-1670).[41]

Although this instrument was a significant development, his thermometer was inaccurate and there was no standardised scale in use. As evidenced by the interdisciplinary work of collectives such as The Canary Project, Superflex, Arts Catalyst, N55 and the Atmospheric Data Collective, there are a wide range of artists and activists measuring the temperature driven political discourse of the current climate crisis debate whose contemporary collaborative practices are embedded in scientific communities.

At COP26, the 26th UN Climate Change Conference of the Parties (COP26) in Glasgow on 31 October – 13 November 2021, the work of American conceptual artist and activist **Mary Allen Caroll** was the most accurate measurement of the standardised temperature scale of political debate. The COP26 summit brought international parties together to accelerate action towards the goals of the Paris Agreement and the UN Framework Convention on Climate Change, whose net-zero primary target was to keep the Earth's global warming limits of 1.5 degrees Celcius alive. *indestructible language* is a nine word illuminated red neon text piece exhibited by Caroll during COP26 and involved the use of words derived from phrases selected from random spreadsheets.

Part of an ongoing corpus of work shown in different locations, the monumental piece was created in collaboration with artist Joel Stenfeld and publisher Donna Wingate, and aimed to both educate and illicit climate change action through high profile public art. The piece consists of the phrase *IT IS GREEN THINKS NATURE EVEN IN THE DARK*. The work stretched over nine hundred feet and five buildings with the final three words rounding the corner of a fifth building.

The use of red - a colour evoking ideas of heat but also warning - could be seen from up to four miles way. One of the main goals of COP26 was to establish global agreements that secures improved economic and environmental conditions for the inhabitants of small island nations such as the Maldives. *indestructible language* spoke to such critical environmental conditions from the roof of The Schoolhouse, a historic Victorian building in the centre of Glasgow.

During our Polar Zero exhibition, I was not able to physically witness the work in close proximity, but could sense the power of Caroll's work from across the city, where the atmosphere was initially full of hope at a pivotal point of climatic transformation. I was listening/looking beyond the amplified glare, noise and infrequently limited attention spans of visiting intergovernmental COP26 delegates, politicians, delegates and was particularly struck by Carroll's earlier statement that 'global warming is a moral issue not a scientific fact' (Brown, 2014:227) *indestructible language* attempted to mitigate

41 Galileo in 1592 devised a crude temperature measuring instrument, but it had no scale and therefore no numerical readings. It was also affected by atmospheric pressure. Pearce , J. (2022) A brief history of the clinical thermometer , 95(4). doi:https://doi.org/10.1093/qjmed/95.4.251.

and invert the carbon effects of its own making by conserving energy and reducing greenhouse gas emissions through the technological use of lead-free glass, carbon neutral low-wattage neon bulbs, solar power, and energy efficient transformers. In addition, a charitable foundation donating carbon credits to offset any non-renewable energy, established the piece as an influential marker of how such work might address the important issue of producing inventive yet ecologically considered climate-related artwork in the contemporary moment. **John Gerrard**'s *Flare* (Oceania) 2021 was presented as a large-scale LED wall at the South Facade, University of Glasgow during COP26. The work is a polemic against the polluting impacts of burning fossils fuels, and is an artistic response to a statement from Tongan artist **Uili Lousi**, whose ancestral ocean is rapidly changing as a consequence of climate-heating emissions being created elsewhere in the world.

Fig.84. Oceania. John Gerrard

Like Gerard's 2023 work *Surrender Flag,* which I recently experienced at the *Dear Earth; Art and Hope In A Time of Crisis* exhibition at the Hayward Gallery, *Flare* reminds us of the unique ability of art to question the relationship between humanity and nature. Its vast scale and visceral impact was commensurate with a high-level climate summit such as COP26 and pointed the visitor towards why we must adapt and confront the most urgent challenge facing the globe today. Gerard's artworks act as thermometers of environmental devastation. They often take the form of simulations and initially appear to the eye as static photographic images. However, on closer attention, one is made aware that these works are neither still or moving images either, but are in-fact virtual worlds conjured up by Gerard from the use of video game technology and computer graphics.

Gabriel Fahrenheit (1686-1736) was the first person to make a thermometer using mercury. The more predictable expansion of mercury combined with improved glass working techniques led to a much more accurate thermometer.[42] Farenheit's first standard thermometer employed newly fixed points to devise the first standard temperature scale. Using a mixture of ice, salt and water, he divided the freezing and boiling points of water into 180 degrees. This was chosen as the figure for the lower fixed point as this produced a scale that would not fall below zero even when measuring the lowest possible temperatures that he could produce in his laboratory. The Fahrenheit scale is still in use today, known as Celsius, and formed the basis of 1.5 degree Celcius or 37.4 F benchmark set within the keynote statement delivered by UN Secretary-General António Guterres at the COP26 World Leaders Summit.[43]

Fig.85 No New Worlds. Still/Moving Projects

The instrumental operations of the thermometer and the thermal properties of heat can be found in the COP artwork of **Adam Laity**, **Joseph Rossano**, **Bamber Hawes**, **Morag Myerscough** and **Alan Gignoux**, all of whom developed distinctive ways of articulating the central role of temperature at the climate summit in Glasgow. Another LED installation by artist collective **Still/Moving Projects** delivered a series of illuminated text sculptures across the River Clyde. The collaborative work was made in 2021 in dialogue with community groups, indigenous representatives and with delegates at COP itself.

42 Pearce , J. (2022) A brief history of the clinical thermometer , 95(4). doi:https://doi.org/10.1093/qjmed/95.4.251.

43 https://unfccc.int/news/un-secretary-general-cop26-must-keep-15-degrees-celsius-goal-alive

Involving the illuminated use of the phase *No New Worlds*, the work reminded COP26 audiences that the global climate crisis presents a complex field of interdependent factors including the technological, social, moral, ethical, political, historical and the economic.

Contemporary Context: Art, polarity, building and dwelling at COP26

> We attain to dwelling, so it seems, only by means of building. The latter, building, has the former, dwelling, as its goal. Still, not every building is a dwelling...This thinking about building does not presume to discover architectural ideas, let alone to give rules for building. This venture in thought does not view building as an art or as a technique of construction; rather it traces building back into that domain to which everything that is belongs. (Heidegger as quoted in Leach, 2005: 95)

As discussed previously in the main thesis, I had previously read Pallasmaa's The Eyes of the Skin: Architecture and the Senses in which the author rejects the dominance of the eye in art and architecture. My Polar Zero collaborative exhibition at COP26, attempted to build a site of dwelling for visitors to inhabit through sound, light, taste and air. The exhibition arrived during a time of pandemic. Using science and engineering technology to collapse distances of time and place, the exhibition posed the question of what it means to touch and be in touch with the earth. Most humans do not have a tactile sense of inhabiting and belonging to the Arctic and Antarctic. Neither do we fully understand the difference between building and dwelling across ancestral time and contemporary place. My embodied understanding of building and dwelling within the COP26 exhibition space was directly transformed by my encounter with the Brazilian Representative of the Indigenous Peoples. She began speaking about Brazilian rainforests and the consequence of accelerating climatic changes to the daily lives of her fellow native indigenous peoples living there.

During our brief conversation which took place outside the Glasgow Science Centre, I learnt of the violent devastation to local indigenous tribes in sites that have remained relatively isolated from the outside world for centuries. I also learnt of the resilience of these tribes in their fight for survival, including strategies adopted by the Yanomami tribe who have inhabited a vast area of pristine forest and large, meandering rivers on the border between Brazil and Venezuela. The Yanomami – who number about 29,000 – are at serious risk of losing their lands, culture and traditional way of life due to the rush for valuable minerals that lay beneath their ancestral territory soils, which have now attracted illegal prospectors who ruthlessly cut down forests and poison rivers with mercury, while giving deadly diseases to the tribe. The conversation forced me to re-think Heidegeger's notion of dwelling in the context of the Arctic and Antarctic, and how our Polar Zero exhibition might mediate the building of time and place for visitors to inhabit in the architectural space. I also started to think about the distinction between building and dwelling in art and how our collaborative work at COP26 might be re-configured 'into that domain to which everything that is belongs'.

Fig.86 COP26. Image Pete Bucktrout/BAS

Greenwashing

French thinker Gilles Deleuze conceived of political matter and thought as a verb, that is, doing-something in the world as an enterprise of 'liberation and radical demystification'. For him, the individual and collective encounter with a specific time and place activates an immanent "set of affects, a kinetic determination, an impulse" that is "ontologically one, formally diverse". (Deleuze, 1992:72)

The inert and dormant energies of 'Greenwashing'[44]are latent in contemporary arts/culture in general and environmental culture in particular. Greenwashing is the cynical and ineffectual act used by many governments and finance sectors across the private and public sphere that involves the targeted rejection of scientific information to increase their profit.

The first Earth Day[45] was held on April 22, 1970. It encouraged many industries to promote themselves as being friendly to the environment with $300 million dollars used to advertise clean green companies. This figure was eight times more than the sum spent on pollution reduction research.[46]

The fossil fuel and energy industries can be understood to be the most complicit in the practice of greenwashing. Enron Corporation was an American energy, commodities, and services company based in Houston, Texas. Before its bankruptcy on December 2, 2001, Enron was a major electricity, natural gas, and communications corporation with purported revenues of nearly $101 billion during 2000. At the end of 2001, it was revealed that Enron's reported financial condition was sustained by an institutionalized and systematic mode of accounting fraud, known since as the Enron scandal.[47]

> There will be no greening of the economy, no redistribution of wealth, no enforcement or extension of rights without human dispositions, moods, and cultural ensembles hospitable to these affects. (Bennett, 2010:xii)

A 2017 article by Richard Maxwell & Toby Miller addresses some of the many limitations and failures within cultural policy regarding issues of sustainable development and greening. Citing an 'ambivalent philosophical heritage of anthropocentric worldviews', the authors link this theme to the polar relation of the human (culture) to the non human (nature) suggesting what they refer to as:

> 'weak environmentalism in the cultural policy arena, exemplified by surprisingly non-green cultural platforms espoused by green political parties. Green thinking is further hampered by the widespread adoption of digitisation within cultural organizations, which we contextualise in the broader political economy of digital capitalism and the attendant myth that high-tech culture is a low emissions business. Green cultural policy necessitates intensive self-examination of cultural institutions' environmental impact, at the same time these institutions deploy art, education, entertainment, sports awareness of ecological crisis and alternative models of economic activity. We cite the efforts of activist artists' resistance against fossil fuel corporations' sponsorship of arts and cultural organizations as a welcome provocation for greening cultural policy within cultural organizations and green political parties alike'.[48]

The Paris Agreement is a legally binding international treaty on climate change. Adopted by 196 Parties at the UN Climate Change Conference (COP21) in Paris, France, on 12 December 2015, the agreement moderates climate change mitigation, adaptation, and finance. It's findings indicated that world was heading towards 53 billion tonnes of carbon emissions by 2030. The formal publication of these statistics determined that to be able to keep within global warming temperatures of 1.5C degrees, an emissions cut of 25 billion tonnes was required. This left a carbon emissions gap of 28bn tonnes to be cut in the current decade.[49]

Climate change refers to long-term shifts in temperatures and weather patterns. The IPCC Climate Change Report: Impacts, Adaptation and Vulnerability was a 2022 policy contribution to the IPCC Sixth Assessment Report. Addressing the question of climate justice, the report critiqued the imbalance between the wealthier industrialised Western nations in the global north and the less well off countries in the global south.

The report discusses gaps and limits to climate adaptation. Maladaptation[50] and the underlying scientific evidence are explained to strengthen ecosystems that function in a rapidly changing global mate and atmosphere. A range of adaptation options were found within the water, food, nutrition and other nature-based industries. Adaptation to sea level rise is specifically discussed in the context of global coastal areas. Issues of climate justice and equity were noted to have a significant impact on how effective adaptation can be and are discussed as key issues that relate to policy decision-making processes.

The IPPC 2022 Sixth Annual Report[51] indicates the clearest understanding of how climate and social justice intersect. It outlined the temperature and weather system transitions and transformational adaptation that are now needed at a time of increased global warning, with G2 nations determined to have an ethical and moral responsibility. The Report indicates that scientific tools and engineering technology are already in place to avert climate disaster and articulates the position to reject apocalyptic headlines that impowers the political discourse, and that there is a positive opportunity for sustainable energy phase transition.

In a 2022 Forbes article Solitaire Townsend poses the question: *Could The IPCC Climate Report Unleash A New Type Of Greenwash?* Outlining the IPCC focal shift from 'demand' to 'supply,' the sustainability solutionist cautions: "The new IPCC Climate Report has included consumer action as

44 The term greenwashing was coined by New York environmentalist Jay Westerveld in a 1986. Motavalli, Jim [accessed 17.07.23] "A History of Greenwashing: How Dirty Towels Impacted the Green Movement

45 The first earth day (1970) History.com. Available at: https://www.history.com/this-day-in-history/the-first-earth-day. [accessed 17.07.23]

46 https://www.scientificamerican.com/article/exxon-knew-about-climate-change-almost-40-years-ago/ (Hall, 2015) [accessed 17.07.23]

47 https://web.archive.org/web/20200805181220/https://www.sjsu.edu/faculty/watkins/enron.htm. [accessed 17.07.23]

48 Richard Maxwell & Toby Miller (2017) Greening cultural policy, International Journal of Cultural Policy, 23:2, 174-185, DOI: 10.1080/10286632.2017.1280786

49 https://unfccc.int/process-and-meetings/the-paris-agreement

50 Maladaptation is the failure to adjust adequately or appropriately to the environment or situation

51 https://www.ipcc.ch/report/ar6/wg3/

a valid climate solution for the first time. But, we must beware this unleashing a new raft of 'sustainable lifestyle' campaigns that can't count (the carbon)".[52]'Greenwashing', 'Bluewashing' and 'Carbon Emissions Gaming' are synonymous with false marketing claims by corporate and intergovernmental bodies lacking environmental probity. Where bluewashing can be understood to denote deceptive marketing practices overstating a company's commitment to responsible social practices, the term 'carbon emission trading' involves the specifically deceptive strategy where the financial value of carbon is priced too low, or if large fossil fuel emitters are given "free credits".

The Arctic continent retains up to a hundred billion tons, equal to nearly a quarter of Earth's natural fossil fuels - all, or nearly all, of which are still untapped below its icy surface. The Arctic is home to 13 percent of the Earth's unexplored oil reserves and 30 percent of untapped natural gas, gold, silver, uranium, and diamonds.[53] Greenland's economy depends on its rare earth elements including the minerals lutetium, lanthanum and cerium that are used in the manufacture of smartphones, fibre-optics, hardrives, hybrid vehicles, microwaves and superconductors. (Tedesco, 2020).

With the rise of carbon trading schemes and the destructive building of environmentally polluting projects across the Arctic North, COP26 represented a sovereign call for Indigenous culture, with the decisions formulated at the Glasgow summit by international delegates having long term intergenerational implications for Circumpolar ancestral lands. Mexican climate activists Futuros Indígenas (Indigenous Futures) referred to the summit as a "death sentence" of political inaction and financial reaction that is globally designed by the wealthier fossil-dependent nations to further erode their social and economic equality.[54]

In the face of rapid climatic greenwashing, what can art do? As anticipated by Townsend, the IPCC Sixth Annual Report shift of focus raises key ethical questions about what will supplied and what will be demanded from the inevitable rush of consumer-driven products promoted by large corporations and big power in the coming years, as governments and businesses attempt to capitalise on the move away from the 'supply side' of climate change - oil, gas, forests.

With its solution based remit, the IPCC shift will have reductivist implications for activists working at the forefront of movements within and across environmental art, including **Susannah Sayler** and **Edward Morris**: "The problem with a lot of activism is that it's necessarily reductive. It's about consolidation of power. It's about reducing the message so that many people can get behind it, and there's a certain level of untruth in that reduction". (Susannah Sayler and Edward Morris as quoted in Brown, 2014)

52 https://www.forbes.com/sites/solitairetownsend/2022/04/05/could-the-ipcc-climate-report-unleash-a-new-type-of-greenwash/

53 The first diamond find in the Arctic was at the Pasvik River on the Russian-Finland-Norway border, which was followed by successive discoveries in the Yukutian diamoniferous province of Russia, the Somerset Canadian Arctic Archipelago and the southwestern region of Greenland. Geologists suggest that these deeply embedded diamond domains are the result of interstellar ancient bombardments 3.3 billion years ago. https://www.jstor.org/stable/24137838

54 https://www.theguardian.com/environment/2021/nov/16/indigenous-climate-activists-cop26-endangers-native-communities

The human financial dependence on fossil fuel energy[55] consumption has produced divergent modes of political activism and resistance in the domain of art, inciting a newly political wave of performative climate art dissent specifically directed at art museums and natural history museums. This mode of institutional critique and freedom of expression frequently involves site-based activist performances responding to the assembled force of global capitalism and the dispersed flows of environmental destruction.

Drawing direct links to the devastating Deepwater Horizon[56]oil-drilling rig explosion and the corporate sponsorship of BP, British feminist art collective **Liberate Tate** protested British Petroleum's lack of moral energy with the unauthorised guerilla art intervention *License to Spill.* Involving a re-enactment of BP's Gulf oil spill in the Gulf of Mexico twenty years previously, the group performance action at the Tate annual summer party was targeted campaign that rejected cultural promotion by an oil company.

In a recent ArtReview article, Marv Recinto asks 'What need is there for art that seeks merely to 'address', 'engage with' or 'respond to' climate crisis'? Made in response to the 2023 *Dear Earth* exhibition at the Hayward Gallery[57], he suggests, 'what feels very different however, about eco-critical art is that the very topic it engages with proposes widespread ruin and demands that action be immediately taken to counteract such an apocalypse'. Recinto argues for a concerted shift in ecological art, one that moves closer towards praxis, whereby speculative art makes way for 'action'.

55 Energy is the capacity for doing work including; potential, kinetic, thermal, electrical, chemical, nuclear. There are, moreover, heat and forms of work—i.e., energy in the process of transfer from one body to another. After it has been **transferred**, energy is always designated according to its nature. Hence, heat transferred may become thermal energy, while **work done** may manifest itself in the form of mechanical energy. All forms of energy are associated with **motion.**

56 The Deepwater Horizon oil spill was an industrial disaster that began on 20 April 2010 off of the coast of the United States in the Gulf of Mexico on the BP-operated Macondo Prospect.

57 https://artreview.com/ecocritical-art-hayward-dear-earth-climate-crisis-exhibition/

Fig.87 Peter Kennard. PhotoOp

The incisive work of political activist **Peter Kennard** has actively engaged the 'viewer' Recinto seeks for over four decades. As evidenced in his 2023 exhibition SILENT COUP, a new body of work based on a book by investigative journalists Claire Provost and son Matt Kennard, the artist has evolved a sustained and searing artistic corpus that moves beyond the simplistic impulse to 'address', 'engage with' or 'respond to'. Seminal works by Kennard including Earth Series (1988-2016), Union Mask (2003) and collaborative work PhotoOp made with Cat Phillipps (1985), have been key visual markers interrogating the extent to which capital resources are allocated, territories are governed, and justice is defined. Kennard's particular use of photomontage, text and print imagery re-examines the global corporate power nexus to deconstruct and reposition the political apparatus of government and super-corporations in functioning democracies.[58]

In the run up to COP26 summit and exhibition, I was asked to contribute to a number of media formats on the subject of climate change including the BBC Radio 3 programme Free Thinking, for the first in a series of 26 climate-themed programmes featuring artist **Olafur Eliasson** and curator **Hans Ulrich Obrist**. Made in partnership with the Arts and Humanities Research Council, the broadcast and subsequent series podcast explored the latest academic research and artistic ideas around understanding and responding to the current climate crisis. Contributing artist Olafur Eliasson stated, 'I don't think [politicians] can achieve a solution to the climate crisis,' while **Ai Weiwei** offered 'we cannot depend on one meeting'. During the broadcast, Obrist shared insights developed in his new publication Back to Earth[59], a project made in collaboration with Penguin Press. Involving 140 artists, scientists, architects, and filmmakers, the book features individual interventions on how the practice of art might be contribute towards an ecological and equitable future.

During COP26 related events in America, **Rashid Johnson**'s *Bruise Painting Or Down You Fall* (2021) was offered at Christie's New York on 9 November as part of the ongoing series, 'Artists for ClientEarth'. The work had a pre-sale estimate of US $650,000–850,0000, with proceeds going to the non-profit ClientEarth[60], an organisation which shapes and enforces laws to fight climate change. The first artwork in the auction series, **Cecily Brown**'s *There'll be bluebirds* (2019) realised £3,502,500 at Christie's evening sale in London on 15 October. Other artists who took part in the initiative, organised by the Gallery Climate Coalition[61]in partnership with Christie's, included **Anthony Gormley, Beatriz Milhazes,** and **Xie Nanxing**.

Polar Zero is located in and motivated by an impulse to make work that asks visitors to confront what is at stake in the natural world. Following the chemical and societal logics that can be found in the work of Hans Haake's *Condensation Cube* (1963)*,* **Roni Horn**'s *Library of Water* (2007) **Cecila Vicuna**'s (2023) *Brain Forest Quipu* exhibited at the Tate Modern, 1765-Antarctic-Air', 'Ice Core' and 'Ice Stories' mediated a materially discursive space of dialogue and exchange that late scientific

58 https://www.peterkennard.com

59 *Back to Earth* and the *General Ecology* project led by Kostas Stasinopoulos, Associate Curator, Live Programmes at Serpentine Galleries, London. https://www.serpentinegalleries.org/whats-on/back-to-earth/

60 https://www.clientearth.org

61 https://galleryclimatecoalition.org

scholar Susan Leigh Starr referred to as *boundary objects.*[62]Neither fixed geographic subjects or unbounded magnetic objects, the research attempted to give witness and testimony to a im/material form of absence and presence. As discussed previously in the thesis (p.81) the propagation of an unfounded or misleading environmentalist image spans that seismic moment in society and the self which **Christian Boltanski** captures notions of absence and presence in his 2014 large scale installation *Animitas.* Inspired by the work of Boltanski through a re-reading of Esther Leslie's polarisation of reactionary thought as 'always a hardening' and emancipation as 'always a melting', Polar Zero examined the release of ancient air as an experiential and emancipatory form of freezing and melting. It was also a mode of quiet activism and volumetric resistance that specifically explored visible and indivisible notions of chemical and societal phase change transition.

We are both the sweet cold water and the jar that pours- (Rumi, quoted in Stoller,1997:9)

Polar Zero followed immanent paths, circuits and energies and found in theories put forward by Rumi, Heidegger and Deleuze. Immanence is nominally contrasted with theories of transcendence, in which the divine is seen to be outside the material world. Integrating notions of pouring and containing, outside and inside, the exhibition explored ideas of building and dwelling *through* and *with* the internal and external boundaries of the work itself, visitors and exhibition space. In this context, the volume of air that is held and suspended in the fluid silicon void of my cylindrical glass sculpture '1765-Antarctic Air' intensifies the immanent idea that the further I attempt to reach towards a solid polar surface, the deeper the pull from the liquid core within.

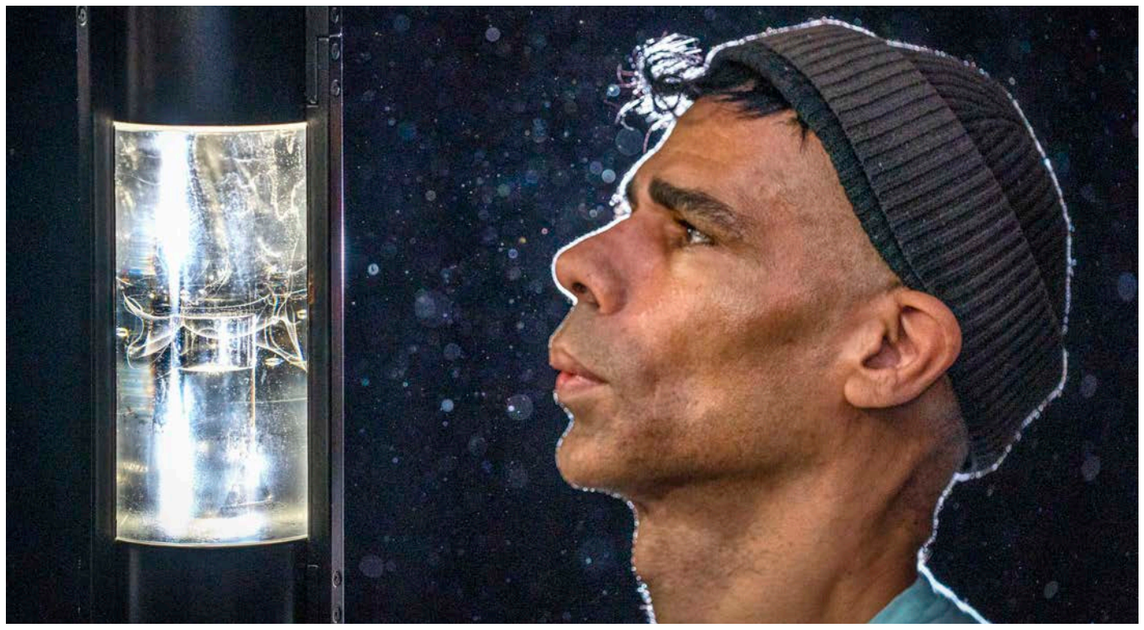


Fig.88 '1765 - Antarctic Air'. Jane Barlow. Guardian/PA

62 A boundary object is information, such as specimens, field notes, and maps, used in different ways by different communities for collaborative work through scales. Boundary Objects and Beyond – Working with Leigh Star. 2016. MIT Press

Widely held to be the philosopher of science who 're-activated' contemporary art theory, Latour's 2018 publication Down to Earth: Politics in the New Climatic Regime proposes that we examine three interrelated contradictions and deficiencies that he believes operate in the modern world. The first he identifies as processes of deregulation and globalisation. The second condition is that of rising inequalities, and the third is climate-change denial. For Latour, these three specific phenomena - which he refers to as 'diseases'- are deeply connected manifestations of a historical and political moment of crisis. "I believe it is necessary for the public, for the voters to become aware of these interdependencies and come up with, hopefully, an alternative to it. I would like the visitors to have, more or less, all the information they need in order to make sense of what they are exposed to".- Hans Haake.

The polar regions are charged geo-political territories where the positive and negative polarities of time and place both attract and repel, pull apart and coalesce. At COP26, Polar Zero posited an analytical and argumentative method of discursive formations and critical ideas. In this way the exhibition aimed to construct and deconstruct a newly active place of experience at the Glasgow Science Centre that formed a collective and individual investment in the finite yet infinite value of polar ice that was artistically informed by Hans Haake's idea of the affective capacity of art to expose systems of power.[63] Following insight advanced by art historian Brioni Fer in her discussion of the work of Roni Horn and Hans Haake, this ethical dimension of systems of power/value is directly calibrated within and across the contexual/critical evaluation of both my research writing and practice:

Fig.89 Hans Haake. Condensation Cube

63 https://www.tate.org.uk/art/artists/hans-haacke-2217/hans-haacke-exposing-systems-power

There was something very understated yet incisive about Hans Haake's Condensation Cube - a transparent box placed directly on the floor with a little water sealed within it, which condensed and evaporated in accordance with the amount of humidity in the air, which in turn could be the number of people in the room. Other works, some using ice, some using water, drew attention not only to the artwork but crucially the spectator's body as circulatory systems within a larger network of systems. It is the sense of a physical body as a nodal point in circulation rather than an observer from the outside, that is precisely the strand that was suppressed in high conceptualism. A work like VATNASAFN/ LIBRARY OF WATER reanimates it. Much delayed, an historical impasse has turned possibility in Roni Horn's radical expansion of the idea of systemic installation to engage the larger processes of weather, water and climate change. Glaciers have become potent symbols, precisely because they are the most clearly visible sign of global warming. We know they are receding and can actually see them melting - at an above, of course, via television or photographs or film, but nonetheless it feels like a ticking clock in the Arctic. I am not suggesting that LIBRARY OF WATER is a didactic work. It is a crucial aspect of the ethics of the installation that it leaves room for us to think on our own, and its force lies precisely in its refusal to make water a symbol of the earth's catastrophic future any more than it is possible to hold on the traditional view of water as a symbol of purity.

(Fer in Horn, 2009:29)

Fig.90 True North. (2004) Isaac Julien. Production stills

Navigating the poles

At the time of writing, magnetic north is currently located at 80.8N, 146.4E. In March 2020, the magnetic north was located 240 metres east of this co-ordination, and the *meridian*[64]where I arrived on that cold spring afternoon at the Royal Observatory Greenwich was empty. I was standing there waiting for the polar curator. I had arrived early. Every academic researcher knows this fix: A mixture of naive curiosity and latent obsession. Its the time of looking at maps, charts, itineraries and deadlines, of scrutinising oneself and the globe rotating around you, of inhaling the scent of discovery elicited a few months later on warmer summer's nights. In September 2019, for the first time in over 360 years, compasses at Greenwich pointed true north. I wanted to know what was the difference between 'True' north and 'magnetic' north, and if compasses don't actually point north, how do navigators use them to find their way in both the northern and southern oceans?[65]

I was hoping Royal Museums Greenwich senior curator Claire Warrior would help me navigate this rare occurrence, and that she could perhaps finally explain the difference between true and magnetic as I attempted to chart and align the polar correlation between the Indigenous Peoples of the Arctic North and the climate scientists in the Antarctic South. During my visit to the RMG I discovered a meridian[66] is a north-south line that was initially selected as the zero reference point for astronomical observations, and that in the 16th century sailors and navigators used the Pole Star or Polaris to determine speed and direction. I also learnt that compasses and charts in the early 17th century were not reliable and that although navigators could see Polaris, their compasses didn't always align with it and often did not always point north.

It was not clear to astronomers of the day as to what was causing this variation, or 'magnetic declination', so an international commission - known as the Longitude Act -[67] was set up by Astronomer Royal Edmund Halley in 1714 to solve the problem[68] of knowing both the precise longitude of ships and how the Earth's magnetic field changes over time and place. The issue of longitude was eventually resolved by English clockmaker John Harrision's H4 timepiece in 1776, whereupon the Prime Meridian at Greenwich became the centre of world time (GMT).[69] Every place on Earth was measured in terms of its distance east or west from this line, which divides the eastern and western hemispheres of the Earth - just as the Equator divides the northern and southern hemispheres. Where longitude is the distance east or west of the Prime Meridian line, latitude is measured by the distance north or south of the equator.

64 A meridian is a north-south line selected as a reference line for astronomical observations. The line in Greenwich represents the historic Prime Meridian of the World - Longitude 0º. Every place on Earth was measured in terms of its distance east or west from this line. The line itself divided the eastern and western hemispheres of the Earth - just as the Equator divides the northern and southern hemispheres. On The Line: The Story of the Greenwich Meridian. Louise Devoy. (2019) National Maritime Museum

66 By comparing multiple observations taken from the same meridian astronomers build up an accurate map of the sky.

67 https://www.rmg.co.uk/stories/topics/harrisons-clocks-longitude-problem. The Longitude Act was an act of parliament that offered money in return for the solution to the problem of finding a ship's precise longitude at sea.

68 In the late 19th century, 72% of the world's commerce depended on sea-charts which used Greenwich as the Prime Meridian.

69 On The Line: The Story of the Greenwich Meridian. Louise Devoy. (2019) National Maritime Museum

Art as navigation

Latitude and longitude are divided into degrees (°), minutes (′) and seconds (″), with sixty minutes in a degree and sixty seconds in a minute. Between 1984 and 1988 an entirely new set of coordinate systems were adopted based on satellite data which required a prime meridian that defined a plane passing through the centre of the Earth, now referred to as the agreed EIRS Reference Meridian or International Reference Meridian. Standing at the Prime Meridian at Greenwich, True north is the direction that points directly towards the geographic North Pole, which is a fixed point on the Earth's globe. Magnetic north is the direction that a compass needle points to as it aligns with the Earth's magnetic field. The magnetic North Pole shifts and changes over time in response to changes in the Earth's magnetic core and is not a fixed point.

True North is a 2004 film by Issac Julien.[70]Often seen on multiple screens in the space of the gallery and museum, it comprises a series of meditative images of the Arctic sublime using the landscape to posit art as a form of polar navigation. The work is based on events that took place on one of seven expeditions to the Arctic undertaken by the black American explorer, Matthew Henson (1866-1955). The work re-enacts and subverts the journey undertaken by Henson with white fellow American explorer Robert Peary as one of the first people to reach the geographic North Pole in 1909. The film opens with a lone male figure in fur skins who walks slowly down a mountain on foot against a brightly lit snowy vista. The transparency and bleached-out whiteness of the empty glacial landscape with its allusion to the turbulence of weather directs the viewer towards the psychological use of a mode of visual language that suggests what Russian structural formalist Victor Shklovsky terms a "blizzard of associations" or what spatial scholar Doreen Massey posits as a *product of interrelations* where ideas of space function as a *sphere of possibility* that is *always under construction.* (Massey, 2005:9)

To navigate is to plan and direct the course of a ship, aircraft, or other forms of transport, especially by using instruments or maps. Julien's specific use of multiple screens act as historical and contemporary portals that invite viewers to rethink the sublimated idea of the 'blank' that the polar regions appear to be, which, in turn, strongly resonates with Massey's deposition of the concept of space itself. Henson's navigational skills and mastery of the native dialects of the Indigenous Northern peoples were indispensable to the success of six expeditions with Peary that spanned over a quarter of century. Taking Henson's memoir A Negro Explorer at the North Pole (1912) as a critical starting point to rectify his omission from polar history,[71]Julien re-animates the story by casting a black female lead to reformulate how Henson defied racial and gender stereotypes in a period of intense social division and eventual discredit by Peary, whom he met while working as a sales clerk at a department store in Washington.[72]

70 True North was filmed in Iceland and Northern Sweden. https://www.isaacjulien.com/projects/true-north/

71 Peary: The North Pole. Robert E. Peary. Halycon books. (2001). In 1989, British explorer Wally Herbert published research that argued that their expedition records were unverifiable: The Polar World. Wally Herbert. (2007)

72 https://www.bbc.com/travel/article/20230418-matthew-henson-the-us-unsung-black-explorer

While Norwegian Roald Amundsen is universally accepted as the first person to reach the South Pole, the source of who was the first to reach the North Pole marks one of the most widely disputed controversies in polar history. In interviews, Henson consistently identified himself as the first member of the party to reach what they believed was the pole, which was strongly denied by Peary during his lifetime, claiming the first for himself.[73] In 1989, British explorer Wally Herbert published research that argued that their expedition records were unreliable. Wally suggested that Peary's log showed improbable distances and ice drifts. Both Peary and Wally's conclusions were later disputed by other polar explorers, including American Frederick Cook, who had been missing for a year when he sent out a telegram announcing he had reached the pole in 1908.[74]

The Arctic North is seeped in deep ancestral traditions and Indigenous ways of knowing that Julien insists cannot be filled with projected Western values and colonial fantasies of physical conquest. For Julien, the voyage to and from the Arctic is neither one of unconscious decent into the male (animus) heroic underworld but rather a conscious ascent and mythical rite of passage into the female (anima).[75] In True North, Julian positions this voyage as an archetypal journey involving reconcilliating planes of travel up into the labyrinth of lived indigenous experience that the final frames of the film suggest the heroine must traverse in order to rationalise the irrational 'muse' of the North formulated by Peary. True North made the additional subliminal point that while remaining apart, the sound and silence of the Indigenous Inuits belong together.[76] In contrast, western qualities of light and darkness are seen in the act of separating, giving the impression that although they are together, they belong apart.

In such alchemical interplay, Isaac's film uses a variety of linking and separating associations to mediate the various oppositional tensions of True North established within the piece. In this Jungian context, the film is an important framework through which re-write and make legible the history of the polar regions, with its implications for how black, gendered and indigenous knowledges are not fully recognised or valued. Read in these terms, True North stands with Julien's filmic installation Fantôme Afrique (2005) as both witness and testimony to that which exists on the outside of time and place. Here, Julien and Massey remind us that space is a 'product of relations-between, relations which are necessarily embedded in material practices that are always being carried out, it is always in the process of being made, it is never finished; never closed'. For both Massey and Julien then, notions of True North function as a transformative site of historical sublimation and contemporary deposition through which ideas of magnetic and geographical space are navigated and re-imagined as 'a simultaneity of 'stories-so-far'. (Massey, 2003:9)

73 The North Pole. Robert E. Peary. Halycon books. (2001). Henson was admitted as a member of the Explorers Club in 1937. Widely ignored during his lifetime, he eventually received honours from presidents Harry S Truman and Dwight D Eisenhower. Henson was interred at Arlington National Cemetery, where a special monument marks his central contribution to polar history, but it wasn't erected until 1988 – 33 years after his death. Historic landmarks named after him include the Matthew Henson State Park, several Maryland public schools and the USNS Henson, a 3,000 ton oceanographic surveying research vessel.

74 Henson bonded with the Inughuit, the northernmost people in North America and part of the Greenlandic Inuit peoples; he learned to build igloos and sledges, and he became fluent in the Inuktun language. He was also a gifted craftsmen who adapted tools that enabled him to hunt for provisions with a rifle, a life-saving team-skill in the Arctic.

75 For Jung, myths function as a form of pilgrimage for the subject that requires reconciliation between the various oppositions which generate tensions both in the self and in society. Jung, C. G. 1968. Psychology and Alchemy, Collected Works of C. G. Jung. Princeton, NJ: Princeton University Press.

76 *True North* foregrounds the significance of the four Inuit men - Egingwah, Utah, Ooqeath and Seeglo - These co-discoverers of geographic North who accompanied Peary and Henson on their final Arctic expedition in 1909 were posthumously admitted by the The Explorers Club Diversity, Equity and Inclusion Committee in 2022.

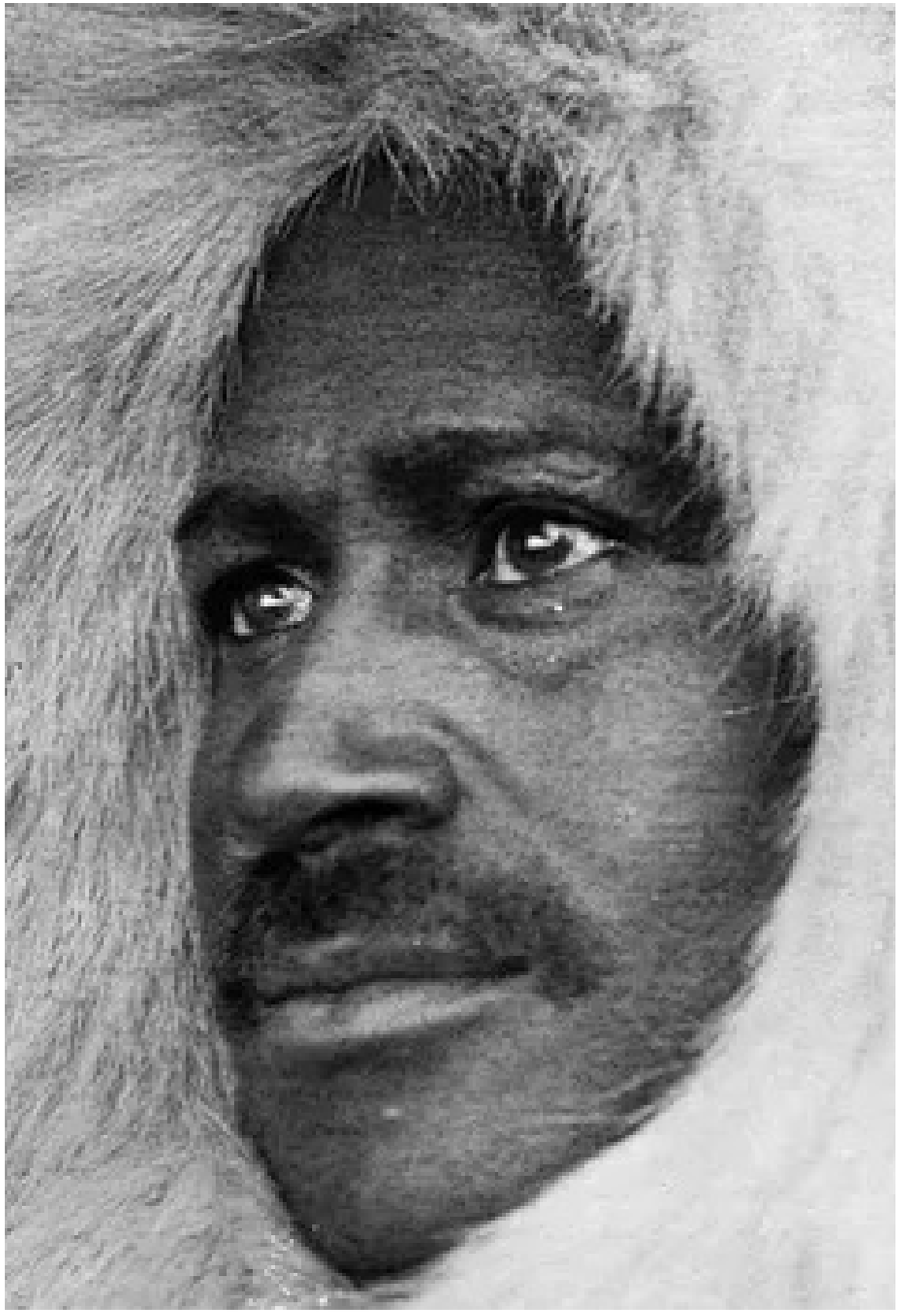


Fig.91 Matthew Henson. Image Nelly George

Fig.92 Ingrid Christensen along with her friend Mathilde Wegger, sitting on the deck of the M/S Thorshavn in 1931. Image: Sandefjord Whaling Museum

Fig. 93 Ingrid Christensen. Image: Sandefjord Whaling Museum

Trailblazers

Female scientific polar explorers

As pointed out by Francis Spufford in Ice and the English Imagination (2007) the so-called ‘Heroic Age’ of Antarctic Exploration is the term used to describe the primarily male period of polar exploration from 1897 to 1922 that involved expeditions during which the geographical and magnetic poles were both reached, much of the continent’s coastline was discovered and mapped, significant areas of its interior were explored and large amounts of scientific data and specimens were generated. In total, 16 major expeditions were launched from 8 different countries during this era. Each expedition took place before advances in transport and communication had revolutionised the work of exploration. Many explorers did not survive the experience. Literary and cultural texts of the day focussed on physical feats of male endurance with limited resources. As a result, the “heroic” label entered into the English cultural imagination and literary psyche.

The term *sublimation* is used to describe a specific mechanical process of printing onto a special sheet of paper, then transferring that image onto another material (usually polyester or a polyester mix). The ink is then heated until it disintegrates into the fabric. The work of Norwegian polar explorers **Ingrid Christensen** (1891-1976) and **Mathilde Wegger** disintegrates the heated fabric of historical accounts of female polar exploration that has been firmly imprinted and transferred into the English cultural psyche and literary imagination since the Edwardian era. Christensen made four trips to the Antarctic with her husband on the ship Thorshavn in the 1930s, becoming the first recorded woman to see Antarctica, the first to fly over it, and - arguably - the first woman to land on the Antarctic mainland. In 1931, Christensen sailed South with her friend Mathilde Wegger. The expedition sighted and named Bjerkö Head on 5th February 1931, making Christensen and Wegger the first women to experience the southernmost continent.[77]

It is a history that is spatial as much as it is political, it is also a national and international history of individual and collective quest to reach the South Pole or the much fabled Northwest Passage. [78]**Jackie Ronne** (1919-2009) was the first female working member of an Antarctic expedition (1947–48).[79] Along with fellow American Jennie Darlington, they were also the first women to winter in Antarctica. A quest is a long or arduous search for something, where conquest is the act of taking control through the use of force. For Ronne, Antarctica representated not a collective conquest of a space by force, but rather, represented an individual quest of space by autonomous self determination and the discovery of place by individual self belief.[80]

77 Elizabeth Chipman. (1986). Women on the ice : A history of women in the far south. Melbourne University Press

78 The Northwest Passage (NWP) is the sea lane between the Atlantic and Pacific oceans through the Arctic Ocean, along the northern coast of North America via waterways through the Canadian Arctic Archipelago. In the 1760s botanist Jeanne Baret was a member of Louis Antoine de Bougainville’s expedition on the ships La Boudeuse and Étoile in 1766–1769, travelling to the sub-Antarctic. She is the first recorded woman to circumnavigate the globe and the first female scientist to the sub-Antarctic region. Dunmore indicates that to gain passage, she dressed like a man. Louise Séguin sailed on the Roland with Yves Joseph de Kerguelen in 1773, becoming the first Western woman to visit the Antarctic region. See John Dunmore (1985). French Explorers in the Pacific (The Eighteenth Century) (v. 1) Oxford University Press

79 Jackie Ronne and Jennie Darlington joined private Ronne Antarctic Research Expedition (RARE) and overwinter on Stonington Island. Despite protest, they join. Ronne is the expedition’s historian and also the first American woman to work in the Antarctic. Ronne, Edith M. (1947) Antarctica’s First Lady: Memoirs of the First American Woman to Set Foot on the Antarctic Continent

80 Joanna Kafarowski. (2022) Antarctic Pioneer: The Trailblazing Life of Jackie Ronne. Dundurn Group Ltd

Fig.94 Jackie Ronne with Jennie Darlington aboard the military tug ATA-215. 1947. Image: Ronne Estate

Antarctica features a number of geographic locations named for trailblazing women including Queen Maud of Norway. Jackie Ronne is the namesake of the *Ronne–Filchner Ice Shelf*, which is an Antarctic ice shelf bordering the Weddell Sea. Named in 1957, the seaward side of the Filchner - Ronne ice shelf is divided into Eastern (Filchner) 79°00′S 40°00′W and the larger Western (Ronne) 78°30′S 61°00′W sections by Berkner Island. Covering some 430,000 km², it the second largest ice shelf in Antarctica (and on Earth). In law, the term *deposition* indicates the giving of sworn evidence, while in chemistry, the term *sublimation* refers to the passage or transformation that substances go through when passing from one state to another - for example solid to a gas. The opposite of this is deposition. In this context, the indexical naming and material existence of the Ronne Ice Shelf in honour of the pioneering female American explorer can be understood to be a legal deposition and chemical sublimation of literary and cultural accounts written by men during the earlier 'heroic' age.

Virginia Frances, Lady Twisleton-Wykeham-Fiennes (1947- 2004), was an English explorer and author. She was the first woman to be awarded the Polar Medal, and the first woman to be voted in to join the Antarctic Club in recognition of her research work for the British Antarctic Survey and University of Sheffield into very low frequency radio propagation. Fiennes took up deep-sea diving and was recruited to work for two years in Wester Ross for the National Trust for Scotland. In 1968, she organised the first ascent of the longest river in the world, the River Nile, by prototype hovercraft. In 1972, she devised a plan to circumnavigate the world along its polar axis, and ten years later her Transglobe Expedition team became the first to reach both poles, to cross Antarctica and the Arctic Ocean, through the North West Passage. In 2020 the Government of the British Antarctic Territory honoured the contribution she made to "furthering the understanding, protection and management of Antarctica" by naming Mount Fiennes.[81]

Professor Dame Jane Elizabeth Francis, DCMG FRS is the Director of the British Antarctic Survey. Following a distinguished scientific career she has been awarded the Polar Medal[82] (2002) and was made Dame Commander of the Order of St Michael and St George (2017) in recognition of services to UK polar science. Francis directs questions in polar science by working in interdisciplinary teams from within the BAS organisation and also in partnership with leading universities and research organisations from the UK and around the world. BAS teams include expertise in the interrelated fields of: Biodiversity, Evolution and Adaptation; Atmosphere, Ice and Climate; Space Weather and Atmosphere; Ice Dynamics and Palaeoclimate; Geology and Geophysics; Ecosystems; Palaeo Environments, Ice Sheets and Climate Change; Polar Oceans; Research Development and Support. Francis has undertaken research projects using fossil plants to determine the change from greenhouse to icehouse climates in the polar regions over the past 100 million years. She has undertaken over 15 scientific expeditions to the Arctic and Antarctica in search of fossil forests. Francis' principal research interests are palaeoclimatology and palaeobotany. She specialises in the study of fossil plants, especially woods, and their use as tools for climate interpretation and information about past biodiversity. Working alongside both male and female colleagues current work focuses on understanding past climate change during both greenhouse and icehouse periods.

81 In 1971, she organised the first transnavigation of British Columbia, entirely by river. Fiennes is survived by her husband polar explorer Sir Ranulph Fiennes.

82 The Polar Medal is a medal awarded by the Sovereign of the United Kingdom to individuals who have outstanding achievements in the field of polar research.

Fig.95 Professor Dame Jane Elizabeth Francis. Image. Pete Bucktrout/BAS

The Sámi Pavilion

Navigating Indigenous Art, Knowledge and Sovereignty through scent

> A smell is, after all, violation of oxygen balance, an invasion into it of other elements - methane?carbon?sulphur?nitrogen? Depending on that invasion's intention, you get a scent, a smell, a stench. It is a molecular affair, and happiness, I suppose, is the moment of spotting the elements of your own composition being free. There were quite a number of them out there, in a state of total freedom, and I felt I'd stepped into my own self portrait in the cold air. (Joseph Brodsky, 1993:9)

The Indigenous theory of interconnectedness follows the spatial idea that everything in the universe is connected. Spirit to world, world to mortal, sea to land, sky and earth. Where Julien's work navigates ideas of North through film and BAS scientists navigate ideas of South through the use of compasses, the work of Sámi Indigenous artists navigate the interconnected space of the poles through the exploration of scent and the seat of the reindeer stomach.

The Sámi Indigenous peoples of Norway, Sweden, Finland and the Kola Peninsula in Russia regard the scent of chemicals held in the stomach of the reindeer as a critical site of knowledge production and ancestral sovereignty. In direct counterpoint to this, the 'songlines' are the invisible pathways that traverse Australia, ancestral tracks connecting Indigenous communities and charting age-old boundaries. Along these lines Indigenous Aboriginals passed the songs which revealed the creation of the land and the secrets of the past.

The Nordic Pavilion in Venice was transformed into 'The Sámi Pavilion' in 2022, with a project commissioned by Office for Contemporary Art Norway (OCA) featuring the female Sámi artists **Pauliina Feodoroff, Anders Sunna and Máret Ánne Sara** during the 59th International Art Exhibition of La Biennale di Venezia. This transformation of the Nordic Pavilion celebrated the art and sovereignty of the Indigenous Sámi people, and was curated by a group consisting of Sámi scholar **Liisa-Rávná Finbog,** OCA's Director **Katya García-Antón** and Sámi land guardian **Beaska Niillas.**

The word Sámi denotes the origins of a culture that were traditionally fishermen, nomadic herders of caribou, and hunters of sea mammals. It is also used to indicate the way of life of the North Sámi *sápmi,* the Sámi homeland, and/or all of the closely related Finno-Ugric languages. Following the Sámi custom of learning from elders of the community, the selected artists of The Sámi Pavilion drew from the individual guidance of chosen elders **Karen Ellen Marie Siri Utsi, Asta Mitkijá Balto** and **Ánde Somby**.

The Sámi Pavillion involved three interrelated components: trans-generational relations, holistic Sámi knowledge and learning, and Sámi spiritual perspectives. The exhibition also foregrounded how the role story telling and sound functions within the interconnected spaces of land, art, knowledge and sovereignty across Sámi cultures. In partnership with Sámi University, The 'Sámi Pathfinders' programme brought together students from across Sámpi to act as mediators.

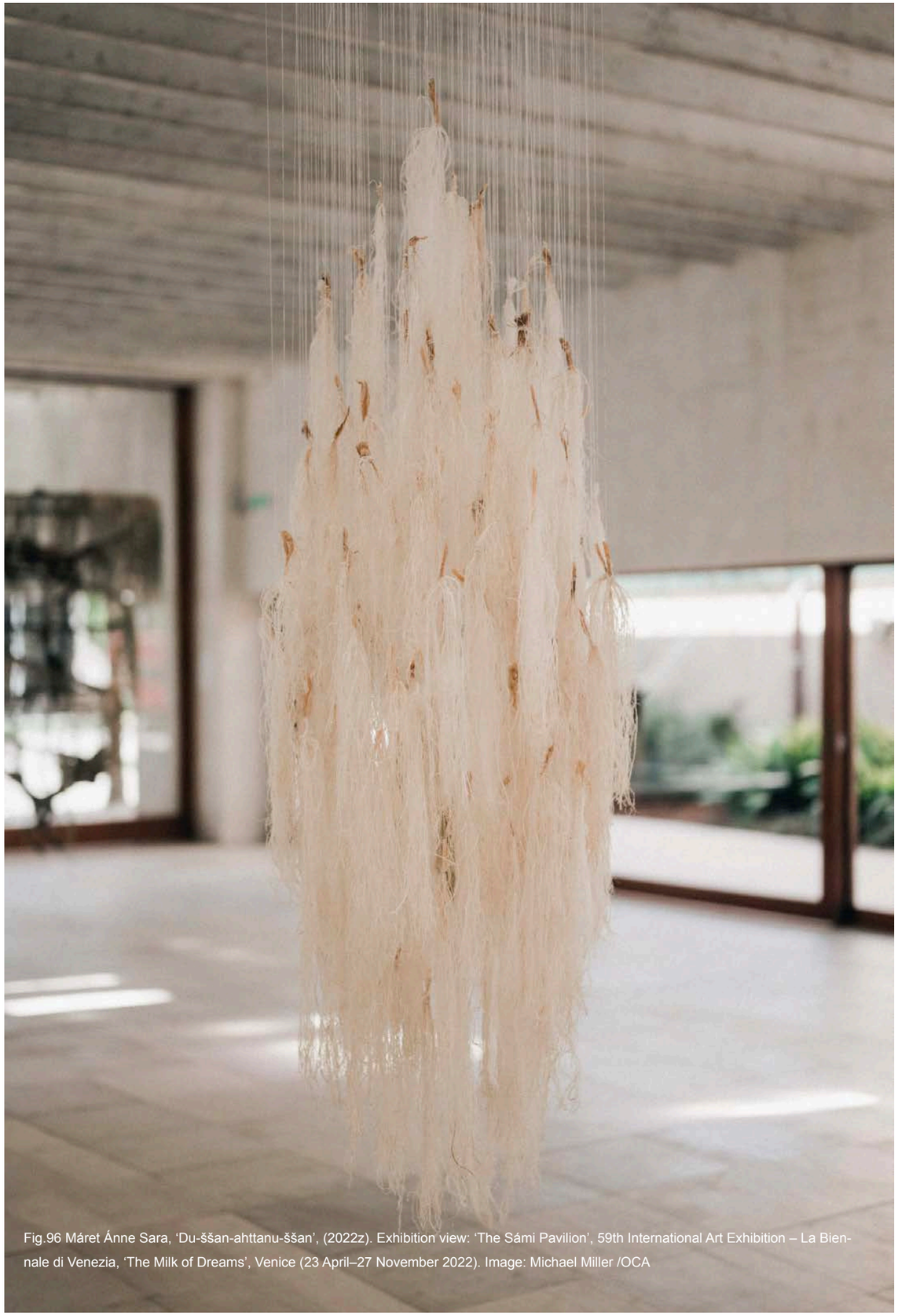


Fig.96 Máret Ánne Sara, 'Du-ššan-ahttanu-ššan', (2022z). Exhibition view: 'The Sámi Pavilion', 59th International Art Exhibition – La Biennale di Venezia, 'The Milk of Dreams', Venice (23 April–27 November 2022). Image: Michael Miller /OCA

Roman philosopher Lucretius (1st century BCE) speculated in his didactic poem De rerum natura (On the Nature of Things)[83] that different odours are attributed to different shapes and sizes of "atoms" that stimulate the olfactory organ.[84] His Epicurean and atomistic model is reflected in the contemporary scientific research of Linda B. Buck and Richard Axel, whose identifying of olfactory receptor proteins and subsequent pairing of odour molecules to specific receptor proteins was honoured by the 2004 Nobel Prize in Physiology or Medicine.[85] In counterpoint to its scientific and philosophical application, the affective capacity of scent to act as a critical navigational code across and within political and spatial boundaries is an important sovereign and spiritual aspect for Sámi artists and communities, whose reindeer herders are a fragile link to the land and their vanishing ancestral traditions.

> The stomachs: I think this was the first piece where I really started to navigate the huge political debate about the individual, and mental health issues in relation to society. It's not only in Sámi but in Indigenous culture in general. **-** Máret Ánne Saras[86]

Máret Ánne Sara's first olfactory work at the Pavilion Du-šŝan-ahttanu-šŝan' (2022) draws upon ecological, spiritual and political concerns, and was presented through two suspended, cloud-like forms of reindeer sinews. Created in collaboration with perfumier Nadjib Achaibou and smell installation artist Oswaldo Maciá, the scent in one sculptural form aims to conjure the ongoing stress and fear experienced by humans and animals such as the reindeer due to colonial processes; and in the other, the hope needed to resist and generate a new future. Du-šŝan-ahttanu-šŝan is a duet of composed liquid smells. The piece incorporates reindeer sinews, wax, molecular compositions to denote fear (reindeer under stress, reindeer stools, diesel motors) and hope (maternal breast milk, reindeer milk, newborns, tundra). Operating at the chemical and societal, the human and inhumane levels, the work functions as material form of Sámi healing and sensate sovereignty for the artist, whose non-verbal use of scent seeks to address the unsustainable and illegible way in which Nordic power views its relation to the land and animal life.

> Western communication takes place with a lot of words, with oral or written language, or with pictures, and in doing so, it undermines non-verbal communication. (Máret Ánne Sara as quoted in Finbog, 2002)

Sara (who has also shown at Documenta and the Venice Biennale) worked closely with Sámi Elders Fimben Áillo Gáren and Káren E. M. Siri Utsi in her embodied attempt to re-negotiate Indigenous forms of dispossession, being, doing and thinking. Forging the way Sámi peoples languages come alive through their obligations to kinships within a colonial economy in which nature is capitalised and Sámi lands are penalised through law, Du-šŝan-ahttanu-šŝan is an ambitious work that attends to the right to Indigenous health and well being, to Indigenous worldviews, and to a sovereign Sámi future:

83 On the Nature of Things: De rerum natura. Lucretius

84 Odour molecules in the modern understanding.

85 The discovery of the olfactory receptors (ORs) by Linda Buck and Richard Axel is the birth of olfaction as a model for neurobiology in which the largest multi-gene family in the mammalian genome was found. Buck was working as a post doc at the time of the method breakthrough. Ann-Sophie Barwich (Indiana University) Cell, Volume 181, Issue 4, 749 - 753.

86 Máret Ánne Sara as quoted in the film The Sámi Pavilion. Commissioned by OCA, 2021.

> After the long and hard struggle our family has been through against the Norwegian state to protect our reindeer against forced slaughtering while also fighting the same state against industrial ruting of our reindeer's lands, I have a strong need to seek and manifest hope...These exhausting experiences of constant fights within a structure of unbalanced and unjust power relations [...are] why I chose the stomach as an expressive material. It became central in telling the story of how we as beings react. ..Sometimes the stomach tears because it is fragile. (Máret Ánne Saras as quoted in Finbog, 2002:87)

The molecular formations of scent clusters found in Du-šŝan-ahttanu-šŝan were encountered at nose height by visitors to the Nordic Pavilion to operate as powerful activators of perception that scholars including Pallasmaa suggest inhabit a deeper level in our bodies than that which dominates the visual domain of Western art. For Pallasmaa, "a particular smell makes us unknowingly re-enter a space completely forgotten by the retinal memory; the nostrils awaken a forgotten image, and we are enticed to enter a vivid daydream". (Pallasmaa, 1996:54)

As inferred by Pallasmaa, it is not fully possible to attain the sense domain of scent from a photographic image alone. Sara's other work Gutted – Gávogálši (2022) consisted of linings of reindeer stomachs. Arranged in constellations suspended from the ceiling of the Nordic Pavilion, the work sought to activate an Indigenous mode of knowledge production known as gamus dovat (gut feeling) in Sami or what American anthropologist Stoeller (1997) refers to as a sensuous form of scholarship.

In Western medicine, the enteric nervous system (ENS) or intrinsic nervous system is one of the main divisions of the autonomic nervous system (ANS) and consists of a network system of neurons that moderates the function of the intestinal tract.[87] The system is comprised of thin layer of millions of cells that govern the control of motility, secretion and blood supply to function as a nexus of communication between the brain via the vagus nerve.[88] In counterpoint, Sara's smell duet installation examines a navigational form of human communication directly linked to the amagydala and the hippocampus, regions of the brain responsible for processing emotions and triggering memories outlined by Pallasmaa:

> We need only eight molecules of substance to trigger an impulse of smell in a nerve ending, and we can detect more than 10,000 different odours. Fishing towns are especially memorable because of the fusion of the smells of the sea and of the land; the powerful smell of seaweed makes one sense the depth and weight of the sea, and it turns any prosaic harbour town into the image of the lost Atlantis. (Pallasmaa, 1996:54-

87 The Enteric Nervous System. John Barton Furness. (2008) Wiley

88 The Vagus Nerve Gut Brain Connection: Wendy Hayden (2021) SWH Media

As pointed out by Lisa E Bloom in Gender On Ice (1993) and Climate Change and the New Polar Aesthetics: Artists Reimagine the Arctic and Antarctic (2022), the work of artists such as Connie Samaras, Judit Hersko, Anne Noble, Joyce Campbell, Katja Aglert and Isaac Julien, move critical debates of the poles and polarity from ideas of the 'heroic sublime to environments of global decline'. (Bloom, 2022:15). Bloom argues that these artists challenge and reconstruct ideologies of inclusion and exclusion across print and visual media that 'link regional climate change to gender, the relation of the human to the non human, questions of territory, knowledge production and empire'. (Bloom, 2022:15).

Following Bloom then, it might be argued that the work of both polar scientists and Indigenous artists including **Pauliina Feodoroff, Anders Sunna and Máret Ánne Sara** re-think what Bloom describes as 'disappearing landscapes' in feminist, inuit, and black cultural discourse. In dialogue with Massey's notion of space as a *product of interrelations* where ideas of space function as a *sphere of possibility* that is *always under construction* (Massey, 2005:9), it can therefore also be posited that my Antarctic exploration of the BAS laboratory, and the Sámi Arctic interrogation of indigenous lands, as both navigating vanishing 'archives of knowledge and loss'. (Bloom, 2022)

Bloom discusses the determination articulated by Indigenous scholars Zoe Todd and Heather Davis that 'climate justice does not involve simply an 'age of the human' dated to industrial development'. She also states that 'art in Antarctica should not solely be in the service of science'. Bloom goes on to suggest that the new polar aesthetics 'reconnects Indigenous perspectives with scientific research but challenge[s] Western traditions of discipline separation'. (Bloom, 2022:8). And so do I.

Here, I am in full accord with Barry et al in relation to their *three logics of interdisciplinarity* outlined earlier (p.166) when they argue 'while the three logics are interdependent, then, they are not reducible to each other'.

Paraphrasing this, my research posits that while the three logics of art, science and engineering are interdependent, they are mutually compatible and are not reducible to each other. Moving across interconnected interdisciplinary boundaries, I posit that this precisely aligned configuration of disciplines directly facilitated and enabled the research to explore innovative spheres of possibility impossible to achieve without the other.

Here, the research thinking was not collectively prescribed by methods imposed externally, but rather, was one always alive to individually inventive methods derived internally from within that were always open to risk, accident and discoveries made in the course of the research making itself. Barry et al define this non-erosion of disciplined boundaries as an ontological mode of *interdisciplinary autonomy:*

> In addition to the logics of accountability and innovation, we identify the logic of ontology, that is, an orientation apparent in diverse interdisciplinary practices in each of our three fields towards effecting ontological transformation in the objects and relations of research. While the three logics are interdependent, they are not reducible to each other and are differently entangled in each of the fields. We point to the potential for invention in such in

terdisciplinary practices and, against the equation of disciplinary research with autonomy, to the possibility of forms of interdisciplinary autonomy.

> Disciplines are not infallibly autonomous or inventive; they have unproductive phases and can exhibit inertial and anti-inventive dynamics...we refer to autonomy not in order to criticize this ideal, but to indicate the existence of forms of interdisciplinary autonomy and rigorous interdisciplinarity that lead to the production of new objects and practices of knowledge, practices that are irreducible both to previous disciplinary knowledge formations and to accountability and innovation. (Barry, Born & Weszkalnys, 2008:41)

Cecila Vicuña

Navigating geological and political divides through sounds, words and objects

Brain Forest Quipu is an artwork by Chilean artist and poet Cecilia Vicuña, whose artworks can be seen to invent and innovate. Her 2022 installation at the Tate Modern is based on the *quipu,* a knotted structure that Andean civilizations used as a counting and communication system. For Vicuña:

> the Turbine Hall is beautiful...the coolness and the dampness of whatever pollution contamination happened here is still with us. To work in a space like that, it's also a healing process. We cannot deny or negate what the industrial era has given us, we have to incorporate it but reorient it now. So that is a gift. Why does the quipu feel good there? It feels good, because it's bringing the breeze in, it's bringing the sound, the touch, the softness. And soft and hard work well together.[89]

Consisting of sea glass, hag stones, ceramic shards, driftwood, and bird bones fragments, Brain Forest Quipu is a carefully woven sculptural textile that soars 25 feet into the upper reaches of the Turbine Hall. While my first impression of the work was visual, a deeper and more visceral connection to the piece is navigated by the sonic, as Vicuña states: "I saw language as a living force as a teenager in Chile in the year 1966, which is the same year I began doing Quipus. And when I saw that words were condensations of energy that came together through oppositions between silence and sound and the ability that sound has to convey an image and an image of conveying sound, you know. So all these crosses and oppositions are involved in the composition of language as a tool that people have been using for thousands and thousands of years. But language exists between bacterias. Language exists between plants, chemical languages, vibrational languages, all kinds of languages is not the question that is just human. But our human language is very exquisite composition". - Cecila Vicuña".[90]

Following the death of President Salvador Allende and the 1973 Chilean coup d'état led by General Augusto Pinochet, Brain Forest Quipu is an activist mode of work first developed by Vicuña while living in exile in London during her time as a student at the Slade School of Fine Art. Vicuña's poetic writing made on paper frequently weaves together themes of language, memory, dissolution, extinction and exile. In this context, the two sculptural forms hanging from the ceiling at the Tate can be understood to navigate the indivisible polarities of geology and politics, absence and presence. Addressing the often neglected paths and trajectories of Indigenous knowledge systems, Brain Forest Quipu was conceived by Vicuña as a spiritual form of healing with one part imagined to be the mother, the other the child. She has exhibited at the Guggenheim Museum and Venice Biennale, and was the recipient Premio Velázquez de Artes Plásticas 2019, for eco-feminist devotion to "outstanding work as a poet, visual artist and activist" and her "multidimensional art that interacts with the earth, written language, and weaving".[91]

89 https://news.artnet.com/art-world/cecilia-vicuna-tate-2189372 [last accessed 1.08.23]

90 https://www.guggenheim.org/audio/track/palabrarmas-series. [last accessed 1.08.23]

91 https://www.artnews.com/art-news/news/cecilia-vicuna-premio-velazquez-art-prize-1202668667/ [last accessed 1.08.23]

Fig.97 Brain Forest Quipu Installation View at Tate Modern 2022. Image: @Tate Photography. (Matt Greenwood)

To heal is to become sound and healthy. Vicuña's poetic response to the human and non human condition has informed my navigation of the polarity between the Indigenous Arctic North and the scientific Antarctic South. It has specifically informed my ideas of the role of sound as a healing force capable of navigating time and place. Her precise use of textiles, and her Andean way of binding and bonding two objects at both ends of the Turbine Hall via knots, has also pointed me towards expanding and contracting ideas of 'archives of knowledge and loss'. While Vicuñas asymmetrical pair of circular, skeletal sculptures evoke sun-bleached notions of dead forests and hot and cold matter, her *quipu* have condensed my evaporating ideas of what it means to listen and re-imagine a healthy Arctic and Antarctic history.

When an Indigenous Inuit or native Aboriginal author inscribes a mark of the moon in the rock, it is not a depiction of the moon, for them, it *is* the moon and not merely a visual representation. There is also no equivalent Inuit word for 'art', which is a term historically ascribed to artefacts by Europeans to denote an entirely different point of conceived value and perceived meaning. In addition, for persons of European descent who are accustomed to seeing, owning, and living with Indigenous objects, many of the non verbal codes of making and thinking are completely alien to them and cannot be technically applied *stricto-sensu* in literal terms for they hold an entirely different form and function. In contrast, when an Inuit mother combs the hair of her child with an ivory comb carved with a celestial scene, the comb or carved artefact is used as a bonding process of knowledge transfer not only between mother and daughter but also as a spiritual form of healing between the past and future that guides and binds the Inuit with the earth, sky and sea in the present.

5,000 years ago, Northern Arctic peoples crossed the Bering Strait to settle in what is now Alaska. These Palaeolithic descendants then migrated eastwards across frosty plains nearly three million kilometres square to live a semi-nomadic life lit only by the warmth of Aurorae and the reflection of the moon. It is a landmass geologically connected to Vicuñas' Chile by virtue of the continent of Gondwana, which was named by the Austrian scientist Eduard Suess, after the region in central India of the same name, which is derived from Sanskrit for "forest of the Gonds".[92]

Gondwana was formed by the accretion of a large stable block of the earth's crust beginning c. 800 to 650 Ma with the collision of India and Madagascar with East Africa, and was completed c. 600 to 530 Ma with the overlapping collision of South America with Africa, and the addition of Australia and Antarctica, respectively.[93] Eventually, Gondwana became the largest piece of continental crust of the Palaeozoic Era, covering an area of about one-fifth of the Earth's surface. It fused with Euramerica during the Carboniferous[94] to form the supercontinent Pangea. It began to separate from northern Pangea during the Triassic[95], and started to fragment around 180 million years ago.

92 Chakrabarti, Pratik (2019). "Gondwana and the Politics of Deep Past". Past & Present. 242 (1): 119–153.

93 Meert, J. G.; Van der Voo, R. (1997). "The assembly of Gondwana 800-550 Ma". Journal of Geodynamics. 23 (3–4): 223–235.

94 The Carboniferous is a geologic period and system of the Paleozoic that spans 60 million years from the end of the Devonian Period 358.9 million years ago (Mya), to the beginning of the Permian Period, 298.9 million years ago. The name Carboniferous means "coal-bearing", from the Latin carbō ("coal") and ferō ("bear, carry"), and refers to the many coal beds formed globally during that time. Cossey, P.J.; Adams, A.E.; Purnell, M.A.; Whiteley, M.J.; Whyte, M.A.; Wright, V.P. (2004). British Lower Carboniferous Stratigraphy. Geological Conservation Review. Peterborough: Joint Nature Conservation Committee. p. 3.

95 The Triassic is a geologic period and system which spans 50.5 million years from the end of the Permian Period 251.902 million years ago (Mya), to the beginning of the Jurassic Period 201.4 Mya.

The final stages of break-up, involving the separation of Antarctica from South America (forming the Drake Passage) and Australia**,** occurred from around 66 to 23 million years ago (Mya). Vicuñas' mercurial constellation of wool, hemp, bark and bone fragments at the Tate pointed the viewer down towards this deep geological past, while also pointing upwards towards a vaporous cosmic future. *Brain Forest Quipu* also suggested to me the geological formations of stalactites hanging from the ceiling of a primal underwater cave, where the visitor to the Tate is the geothermal diver that navigates through the imagined cave system set up by Vicuñas.

Vicuña weaves across political and geological boundaries through the literal and metaphorical use of the knot, which can be evidenced in numerous works involving paper, sound, textiles and poetry to activate ideas of transformation and change. Drawing on the Aboriginal Songlines of Australia, Vicuña created the *Quipu Austral* on Cockatoo Island/Wareamah for the 12th Sydney Biennial in 2012. Consisting of multiple coloured floor-to-ceiling knotted textiles and written words by the late Australian Aboriginal leader Isabel Coe,[96] the piece was exhibited at the ancestral site of the Eora People:

> It is where the rivers join and is in the middle of where the sun rises and sets over the harbour. It is part of the milky way dreamtime stories. - Isabel Coe

Over the course of three years, Vicuña created *Quipu Mapocho*, a 2016-17 site-specific performance installation conceived as several knot-acts conducted through the course of the Mapocho River, from its birth at El Plomo Glacier to its mouth in Llolleo, Chile. Vicuña was born at the edge of the Mapocho, a river made sacred by ancient sacrifice which is now polluted by raw sewage and mining, contaminating the memory and once vibrant life force of the city of Santiago that lies in the valley below.[97]

The term knots has many applications for BAS polar research vessels and ships[98] where the term "knot", in reference to currents, is defined as one nautical mile per hour and is used to measure speed. To get to Antarctica, BAS teams fly from London via Puntas Arenas in Chile, before crossing the much feared Drakes Passage by air or ship to their Rothera Research Station.[99] In my final year of study, I was due travel to Puntas Arenas before traversing The Drake Passage, which is the body of water between South America's Cape Horn, Chile, Argentina and the South Shetland Islands of Antarctica. It connects the southwestern part of the Atlantic Ocean (Scotia Sea) with the southeastern part of the Pacific Ocean and extends into the Southern Ocean. Named after the 16th-century English explorer and privateer, The Drake Passage is considered one of the most treacherous voyages for ships to make. Currents at its latitude meet no resistance from any landmass, and waves top 40 feet (12 m), hence its reputation as "the most powerful convergence of seas".

96 Isabel Edie Coe (1951–2012) was a Wiradjuri woman who was a prominent Australian Aboriginal leader. Coe was one of the activists who monitored police brutality against Aboriginal people, which led to the establishment of the Aboriginal Legal Service (ALS) in 1970. Darryl Cronin (2021) Trapped by History: The Indigenous-State Relationship in Australia (Indigenous Nations and Collaborative Futures) Rowman & Littlefield Publishers

97 https://digital.artplay.com/products/quipu-mapocho

98 A nautical mile is slightly more than a standard mile. 1 nautical mile = 1.15 miles = 1.85 kilometers. 1 knot = 1.15 miles per hour = 1.85 kilometers per hour; 1 knot = 20.251969 inches per second = 51.44 centimeters per second. In British nautical and maritime usage, the general purpose of knots was to protect parts of ships and boats.

99 https://www.bas.ac.uk/polar-operations/sites-and-facilities/facility/rothera/

As the Drake Passage is the narrowest passage around Antarctica, its existence and shape strongly influence the circulation of water around Antarctica and the global oceanic circulation, as well as the global climate. The bathymetry of the Drake Passage plays an important role in the global mixing of oceanic waters, and I considered my passage between Chile and Antarctica across the Drake as an important way to tie, knot, bond and navigate divergent and convergent forms of Indigenous and Scientific knowledge across spatial and temporal boundaries.

As discussed earlier in the thesis, the eventual cancellation of my field visit to Rothera in my final year of study resulted in a significant set back to the cohesive and adhesive[100]bonds that I had forged to date. In an attempt to mitigate the loss of primary sources, I reviewed and consolidated a newly argumentative and analytic approach to the contemporary writing of polar history, including a focus on the central role of temperature within the research. Everything in the universe exists on a vast scale from cold to hot. The earth, the stars and the universe itself exist due the polarities of hot and cold. My journey into the densities and intensities of climatic and atmospheric temperature began in Iceland, a geothermal island sculpted by the interplay between of hot and cold.

Arctic Iceland has a high concentration of active volcanic activity due to its location on the mid- Atlantic Ridge.[101]In 1783-4, at Lakagígar, southern Iceland, a twenty-five kilometres long fissure opened up in the ground and a huge amount of lava flooded out, in an event that lasted eight months.[102] It is thought that over five hundred square kilometres were covered in molten red rock. When the lava came out of the ground it was about 850 degrees Celsius, but it met cool air and heat flowed from hot to cold. As the lava cooled, it froze. The serrated glacial landscape of Iceland is what occurs when the hot interior meets cold exterior, resulting in a fixed solid form.

As noted by the IPCC Fourth Assessment Report, The Arctic is “the world’s climate change barometer” and indigenous peoples “the mercury in that barometer”.[103] A barometer is a scientific instrument that measures atmospheric pressure. The atmosphere is the layers of air wrapped around the earth. That air has a weight and presses against everything it touches as gravity pulls it to Earth. In this context, the art of the Indigenous Inuit, including the Chipewyan, Nenets,Yupik, Cree, Eskimo and Nuktitut can be understood as a measure of the climatic and atmospheric pressure exerted on a resilient and highly adaptive culture of a travelling people who have thrived and survived within largely egalitarian or non-judgemental societies. For them, ideas of land and artefacts have a sacred quality connected to ancient layers of knowledge established in the ancestral ‘trade’ routes and songlines. Within this atmospheric and climatic conception, an object made by a Khanty, Greenlandic, Gwich’in, Inuvialuit and Yup’ik Indigenous person can be perceived to press against everything it touches as gravity pulls it to Earth.

100 Cohesion is the bonding attraction of molecules for other molecules of the same kind. Adhesion is the bonding attraction of molecules for other molecules of a different kind.

101 The Mid-Atlantic Ridge is a mid-ocean ridge located along the floor of the Atlantic Ocean, and part of the longest mountain range in the world. Although the Mid-Atlantic Ridge is mostly an underwater feature, portions of it have enough elevation to extend above sea level in Iceland.

102 Gudmundsson, Magnús T.; Thórdís Högnadóttir (January 2007). “Volcanic systems and calderas in the Vatnajökull region, central Iceland: Constraints on crustal structure from gravity data”. Journal of Geodynamics. 43 (1): 153–169.

103 IPCC (2007b), 56.

While the United Nations 2009 State of the World’s Indigenous Peoples Report indicates that ‘the resilience of indigenous populations is being severely challenged when combined with demographic, socio-economic and lifestyle changes,[104] it also states that the:

> Arctic region is predicted to lose whole ecosystems, which will have implications for the use, protection and management of wildlife, fisheries, and forests, affecting the customary uses of culturally and economically important species and resources. Arctic indigenous communities—as well as First Nations communities in Canada are already experiencing a decline in traditional food sources, such as ringed seal and caribou, which are mainstays of their traditional diet. Some communities are being forced to relocate because the thawing permafrost is damaging the road and building infrastructure.
>
> Throughout the region, travel is becoming dangerous and more expensive as a consequence of thinning sea ice, unpredictable freezing and thawing of rivers and lakes, and the delay in opening winter roads (roads that can be used only when the land is frozen).[105] Changes in animal populations have also had an impact, and some indigenous communities are observing new species moving into their territories (“climate refugees”) as well as a decline in both the health and number of existing species that are staple foods and also have traditional economic value. The resources available to indigenous peoples to counter these threats are limited.[106]

The first Paleo-Eskimo artefacts were discovered in 1948 in Greenland and Alaska. Made in finely worked stone, these objects carved 3,500 years ago included flint micro-blades and arrowheads, which are known as the Arctic Small Tool tradition. Here, the geological and political art of Cecilia Vicuña can be understood to have followed paths and songlines laid down by ancestral groups from northern Alaska that moved into Canada and Greenland around 800 years ago (ca. 1200 CE). In roughly a century, some of these early Inuit groups rapidly migrated across what’s now the Northwest Territories, Nunavut and Greenland. By roughly the 15th century CE, early Inuit groups lived throughout the Eastern Arctic. (Hessel, 1998)

The early Inuit are distinct from the Dorset[107]and Pre-Dorset. Although where they lived slightly changed throughout time, these early Inuit represent the direct ancestors of Inuit today.[108] Into this frozen tribal world of tundra, shaman and permafrost, there was a proliferation of finely made carved sculptural forms made in stone, wood and ivory but no ‘paintings’ in the European sense of the term north of the 60th parallel[109]but rather visual works that are referred to by contemporary Aboriginal authors including Naminapu as ‘bark paintings’. Often made with striking iridescent blue and coral pigments, these works are strictly dependent on how much seasonal variation there is in the avail-

104 IPCC (2007b), 63.

105 IPCC (2007b), 63

106 Centre for Indigenous Environmental Resources (2007), 16.

107 The Dorset was a Paleo-Eskimo culture, lasting from 500 BCE to between 1000 CE and 1500 CE, that followed the Pre-Dorset and preceded the Thule people (proto-Inuit) in the North American Arctic.

108 Owen K. Mason and T. Max Friesen, Out of the Cold: Archaeology on the Arctic Rim of North America (2018). Kenn Harper, In Those Days: Inuit Lives, bk. 1 of Collected Writings on Arctic History (2013).Robert McGhee, Ancient People of the Arctic (1996).

109 The 60th parallel north is a circle of latitude that is 60 degrees north of Earth’s equator.

ability of tree barks from year to year: “Normally we would try and get more bark, but it was a really shitty wet season. It has to be wet to get enough to harvest barks. The bark grows according to how much it thinks the tree is going to grow. If it’s a dry year and it thinks the tree is not going to grow much the bark is going to be hard to get off the trunk—it won’t have expanded. We won’t really collect bark this year”.[110]

The motifs inscribed into the bark paintings are frequently considered by their Indigenous authors to transmit multiple interconnections to Ancestral beings who travelled out to sea from the Milngiya River, where they gave themselves as offerings to become stars in the void of the Milky Way. Along the eastern Australian coastline, Delissa Walker (KukuYalinji) continues weaving traditional Indigenous knowledges through her textile-fibre practice through a spiritual calling located in rainforest Ancestral lands. Her ongoing body of Kanka - basket from black palm - are grounded in the insights transmitted and carried across elemental time and place. Other Walker works are made from stripped and prepared red cedar bark, where the weft consists of bands woven from twined coconut hull fibre, wool and lau hala (pandanus leaf).

Vicuña worked with composer Ricardo Gallo to create a compositional structure in line with the visual object displayed. As Tate Director Frances Morris points out in the catalogue to the Brain Forest Quipu, Gallo weaved Vicuña’s singing and spoken voice into the sonic fabric of the piece, which was relayed via loudspeakers into the vast industrial space of the Turbine Hall. Yet, it was in moments of silence, where there was an intentional absence of sound, that I felt the work was able to more fully navigate themes and subjects found in Inuit ‘art’ such as the convergent and divergent polarities of inclusion and exclusion, access and denial. It was in these precise moments of carefully calibrated sonic absence or presence, that I felt the alluring promise of invitation or rejection, safety and refuge - ideas that can be concurrently found co-existing within artefacts made between 1770s to the 1940s, marking what polar scholars including Hesell (1998) refer to as the Inuit Art of the Historic Period.

While Inuit culture is thousands of years old, the idea of Inuit ‘art’ is fifty years old to outsiders. The years 1949-1955 mark a brief technological period when the loss of the human capacity to make with our hands can be evidenced in the ‘discovery’ and promotion of carved Inuit sculpture in the West. The critical loss of analogue skill across human culture is addressed by Vicuña in her *‘Digital Quipu*’, which channels the activist voices of climate scientists in the Amazon forests - a primary site of oxygen on the planet which is under serious threat. Vicuñas’ *Quipu of Encounters* is another series of works addressing the analogue/digital issue, and involves a series of textile ‘knot-actions’ or global events where poetry functions to mitigate inclusive Indigenous ways of working and knowing. Here, the critical agency of Vicuna’s recorded voice strongly resonates with the analogue/digital work of photographer Richard Mosse, whose compelling use of military-grade thermographic cameras documents the loss of the Brazilian Amazon.

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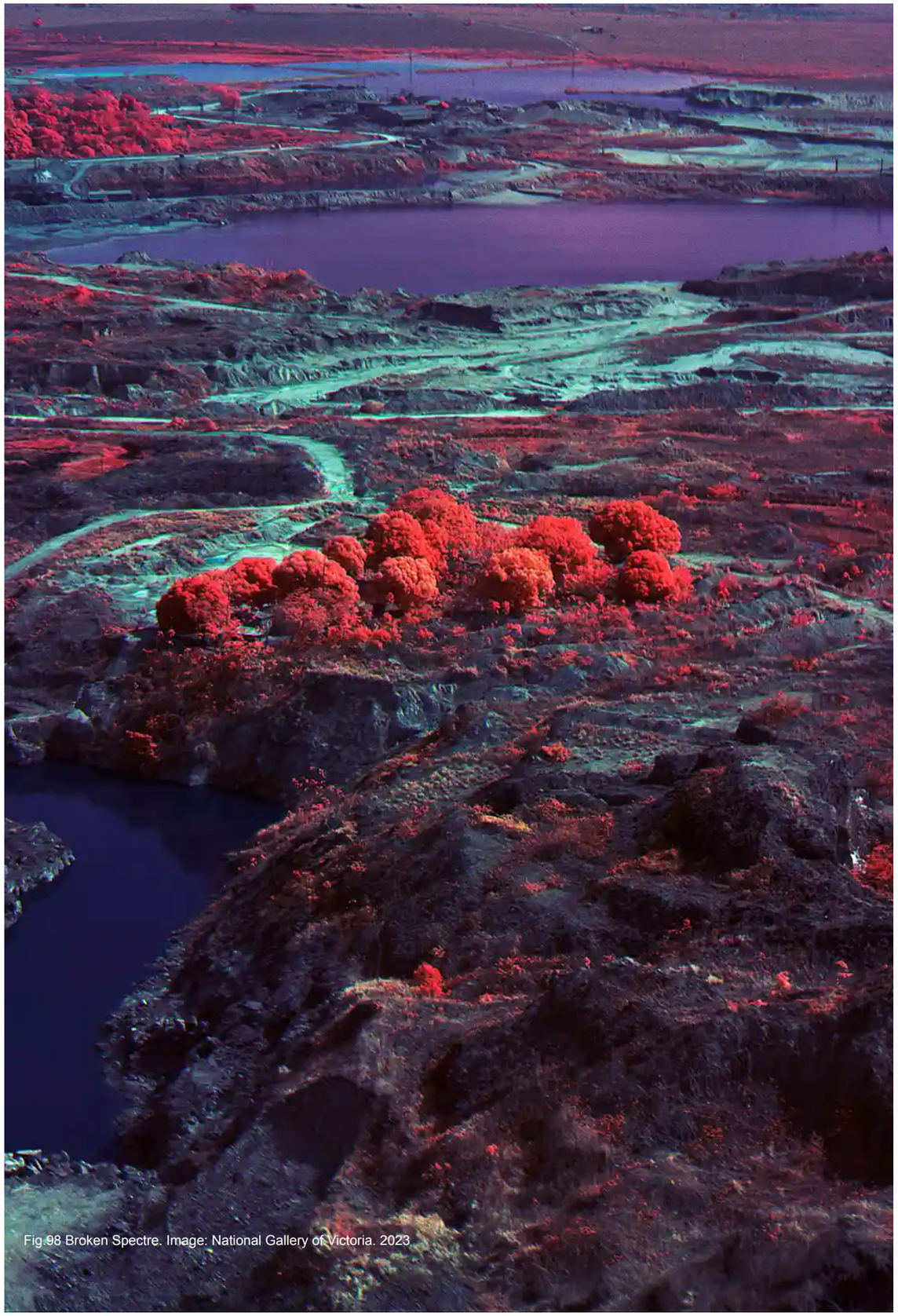

Fig.98 Broken Spectre. Image: National Gallery of Victoria. 2023

In the world of economics, divergence and convergence are terms used to denote the directional relationship of two statistical trends, while in geology, divergence and convergence are constructive and destructive zones where two tectonic plates move towards or away from one another.[111] Vicuña describes her 2014 work *Kuntur Ko* as 'poems for the spirit of water'. Made in volcanic response to the tectonic destruction of glaciers in Chile, the poems navigate the convergent and divergent passage of ancestral time and contemporary place.

> In this set of songs/poems I enter the space of the death of the glaciers, the slow disappearance of "agua dulce," sweet water in the Andes and the world. I offer a prayer, a call for us to return to a relationship with water that protects its cycle from ocean to glacier and back. Composed by combining the names for water in Quechua and Mapuche, as seen from the perspective of Spanish and English, and the confluence of the Spanish words for gold (oro) and prayer, the poems create sound reflections of the circulation / transformation of water.

111 https://www.cambridge.org/core/books/abs/glaciers/glaciers-and-volcanoes/6C69A7498310D776B7F3A40495D4741B. Tectonic plates are said to be 'constructive' or 'destructive' boundaries because new crust is either generated or destroyed by magma pushing up from the mantle as the plates pull away or towards from each other.