Earth Indices

ENG

Processing the Anthropocene

Giulia Bruno & Armin Linke

May 19 – Oct 17 2022

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I Sensing Reality and Possibility in the New Geological Epoch *The Partnership between Haus der Kulturen der Welt and the Anthropocene Working Group*

We find ourselves in an existential planetary crisis. A rationalist-technological worldview, combined with a capitalist economic system, has led and is leading to, among other things, climate change, a decline in biodiversity, the acidification of the oceans and the devastation of entire landscapes. In light of these developments, climate and Earth system scientists have proposed the thesis that we are living in a new geological epoch, the Anthropocene.

According to this thesis, humankind no longer just intervenes in nature and changes it; instead, over the last century, humanity has in fact released energies that go so far as to destabilize the Holocene state of the Earth system, which was the basis for social developments over the last 12,000 years. By profoundly changing the planet, humankind's history becomes Earth history. Conversely, the changes to the material circuits of the "Earth's" spheres have also resulted in dramatic social upheavals. The bases for the existence of whole societies are eroding, resulting in flight and struggles over resources of all kinds.

Since the nineteenth century, the natural sciences have shaped our understanding of the physical world. And it is scientists who now claim that this physical reality is being fundamentally altered as a result of human interventions. Since 2009, at the behest of the International Commission on Stratigraphy, the Anthropocene Working Group (AWG) has been examining whether there is sufficient evidence for officially including the Anthropocene in the International Chronostratigraphic Chart.

Haus der Kulturen der Welt (HKW) began working with the AWG back in 2012, in other words, at a very early stage in this process. In the context of engagement with climate change, our institution encountered the Anthropocene thesis. The explosive power of this thesis was immediately clear to us: from a cultural perspective, it's not just about the engagement with one important problem; rather, it provides a frame of reference for our thoughts and actions. In light of the profound interweaving of human actions and material processes in the Anthropocene world, it is no longer possible to maintain the dualism between nature and culture that has shaped Western thought for centuries—and thus contributed to the Anthropocene crisis, in its existing form.

This crisis has fundamental consequences for the production of knowledge. In an age in which the spheres of nature and culture are fundamentally changing, where a second nature generated by means of scientific knowledge has become the object of scientific research and artistic exploration, where the natural sciences analyze data and thus symbols and where artists visualize material processes, new forms of cooperation between scientists and cultural agents are required. This was the starting point for the long-standing and trustful collaboration between the HKW and the AWG.

Even though the sciences and cultural fields converge with respect to subject matter, their working methods and perspectives on the world remain different. The challenge we are faced with is encapsulated in a sentence from the philosopher Günther Anders: "Our actions extend further than our eyes can see." The Anthropocene world is characterized by a surfeit of action that our understanding is struggling to keep up with. The exploitation of fossil energies, technological innovations and accelerated capitalism have created new worlds with increasing rapidity, whose logics we understand less and less. We create worlds without having the appropriate language to deal with their new phenomena. Given this situation, the task is to open up new approaches to the world.

In his novel *The Man Without Qualities*, Robert Musil distinguishes between two modes of relating to the world: the sense of reality and the sense of possibility. The sense of reality refers to the natural sciences. They make statements about the way the world is. They provide evidence in order to determine what is true. The sense of possibility refers to the arts. They help us imagine alternative worlds. In transition periods, when traditional systems of categorization no longer function, the task is

to integrate the two modes: new evidence can inspire new imaginations, new imaginations can spur a rearticulation of existing evidence.

The partnership between the HKW and the AWG also needs to be seen in this context. The AWG's research process is evidence-driven. Here, the epistemological crisis in which we find ourselves becomes tangible. On the one hand, the AWG is following established procedures in order to determine a new geological epoch. On the other hand, it becomes clear that these procedures were developed to determine the planet's deep time: time periods that encompass millions of years, and, above all, that occurred long before far-reaching human interventions became a significant global factor.

However, the Anthropocene links this planetary deep time with our present, and this has fundamental implications for the formalization process of the new geological epoch: for the first time, scientists are defining a geological epoch that they themselves belong to—in which they are not just observers but also important protagonists. By defining the new geological epoch, they simultaneously change it, as the knowledge that they generate gives rise to new actions by way of feedback loops. And, ultimately, as we have already seen, the fundamental concepts of the scientific framework within which scientists work, such as the nature/culture distinction, themselves become questioned as a result of the evidence. Consequently, this is an antagonistic process driven by the tension between the existing epistemological frame of reference and a new one that is yet to be developed.

The significance of the AWG's work is that, with their profound understanding of existing scientific procedures, the scientists' research showcases the generation of a new geological epoch that requires new modes of thought and action. Their work forms the basis that we need in order to leap into this new world of thought. And it is the exhibition *Earth Indices* by the artists Giulia Bruno and Armin Linke that, by placing this leap in context, opens up the "possibility" spaces that Musil speaks of. Here, the scientists' images no longer serve as evidence documenting a thesis; they become the material starting point for new sign relations.

Finally, I would like to express my sincere gratitude to the artists Giulia Bruno and Armin Linke for providing this new perspective on the material and intellectual world of the Anthropocene. I would like to thank the many scientists involved in the geologic research for their trust and dedication that made this work possible. Last but not least, I would like to thank Katrin Klingan and Janek Müller, Christoph Rosol and the team at Haus der Kulturen der Welt for their conceptual and organizational direction of the overall project.

— Bernd Scherer

II A Geology of the Present
The Earth Indices Exhibition

How do we make sense of the transformations in the Earth system? Who is writing the chronicles of the planet? What are the tools and practices that allow us to read Earth's changes? Over the course of two years, artists Giulia Bruno and Armin Linke have closely followed the Anthropocene Working Group's research on the geological evidence for the new Earth epoch of the Anthropocene. *Earth Indices* portrays both the natural landscapes from which anthropogenic sediments are laboriously extracted as well as the complexities of laboratory processes and the inscription devices they employ to transform the sediment into data that can be interpreted. The exhibition focuses on the spaces of social interaction in which this scientific research takes place, shedding light on the specific procedures and tasks involved in the production of geological evidence. In this way, a multilayered archive is created that relates the anthropogenic traces in the Earth system to the emerging body of knowledge of a new geological epoch.

We can read the history of the planet in Earth's archives. The composition and layering of stones, sediments and fossils provide indications of climactic states, tectonic shifts and ecological conditions in the distant past. The task of geochronology is to classify this planetary deep time, dividing it into sections and identifying moments of transition. By employing this methodology, geologists have written a chronicle of the planet that provides information on the events and epochs of Earth's history. But what does geology know about the present? The upheavals in the Earth system over the last decades show that planetary temporalities and dynamics are inextricably linked with social and political processes. The necessity of thinking about planet and society as one proves especially important when it comes to the task of incorporating the Anthropocene into the Earth's timescale as the current geological epoch. Since 2009, the Anthropocene Working Group (AWG) has pursued the goal of having the Anthropocene officially recognized as the new geological epoch and thus included in the International Chronostratigraphic Chart. The precondition for this inclusion is the identification of a so-called golden spike: a specific location in the world where the planetary transition from one geological epoch to the next can be clearly seen in the stratigraphic record.

In search of this golden spike for the Anthropocene, geologists are analyzing the most recent layers in the Earth archive. In the process, they encounter tiny traces of chemical, biological and physical residues that point to human-made changes on a planetary scale. In 2019, the AWG commissioned the examination of twelve possible sites for the Anthropocene golden spike. To this end, geological samples were taken, including from the Antarctic ice sheet, the sediments of a northeastern Chinese volcanic lake, corals off Australia's east coast and a peatland on the Polish side of Śnieżka mountain. In the lower layers of these geological samples, anthropogenic signals are barely perceptible. However, the higher one ascends in the stratigraphic layers—approaching the present—the clearer these signals become.

With the glaring acceleration and globalization of economic growth and ecological devastation, the industrial activities of an increasing proportion of humanity have left a distinctive chemical imprint in the terrestrial archive. In 2019, after ten years of research work, the AWG has come to the consensus that the beginning of the Anthropocene dates to the middle of the twentieth century—the beginning of the so-called Great Acceleration. From this time period onward, the planetary consequences of this Great Acceleration on life, the air, the seas, lakes and rivers, and the sea ice and glaciers have become clearly visible and measurable. For the first time, chronostratigraphers are now faced with the difficult task of defining a geological epoch whose starting point, for some of them, is located within their own childhood.

How can this inextricable interlacing of the researchers and their object be presented? How are the geological materials transformed as they pass through laboratories and the hands of the scientists? What exchange and translation processes lie at the root of the production of geological evidence for the Anthropocene?

How is the thesis of the new geological era operationalized—how is the Anthropocene "processed"?

The *Earth Indices* exhibition is the result of an intensive two-year cooperation between the artists Giulia Bruno and Armin Linke and the many scientists who have participated in the stratigraphic research into the Anthropocene. Bruno and Linke look back on a decade of artistic engagement with the Anthropocene. As early as 2013–14 in their work *Anthropocene Observatory*, developed together with Territorial Agency and Anselm Franke for the HKW, they have explored the effects of the new Earth epoch on societal infrastructures, forms of governance and communities. Since then, the two artists have continuously addressed questions of agency and research in the Anthropocene.

Earth Indices is both an exhibition and an experimental system in which not just the sediments of the new geological era but also the instruments, procedures and practices employed for the production of geological knowledge are made visible. The artists have intensely accompanied the AWG's investigations, selected documents and materials from the research process and invited the scientists to comment on them. *Earth Indices* shows photographs, sketches, scans and data sets from all phases of the project, from views of the landscapes where the stratigraphic samples were taken, to recordings of the work processes in the participating laboratories, through to microscopic photographs and jotted-down notes. Low-tech instruments and everyday utensils such as shovels and plastic film stand next to high-tech mass spectrometers and other analysis equipment.

In cooperation with the designer Linda van Deursen, Bruno and Linke have developed a type of registry that precisely allocates the individual documents to a specific position and function in the scientific process. Functioning like large-format index cards, the works that make up *Earth Indices* register individual elements and moments of the research work. The exhibition, through the inclusion of supposedly secondary details, records the means and processes of production that flow into the scientific establishment of the new geological epoch. In the schematic unification of these elements, this registry highlights the scope and diversity of the available material and, at the same time, the complexity of the exchange process between sediments, laboratories and researchers that forms the basis for the production of evidence.

Overlaying the registry is a delicate, almost poetic, trace of the scientists' comments, instructions and notes, generated during discussions with the artists. These notes unlock the technical and anecdotal knowledge hidden in the documents and reflect the praxis of the scientists' own work. The notes are echoes of the intense engagement with the stratigraphic material and the attempt to process the knowledge stored within them—to convert the noise into clear signals. This layering of registry and commentary is the tool that Bruno and Linke use in order to bring the artistic, anthropological and scientific approaches involved in the AWG project into contact with one another.

The symptoms of the Anthropocene are already visible in the different spheres of the Earth system and in society as disturbance, interruption and uncertainty. Until now, there has been a lack of images, languages and grammars with which to make this process understandable and negotiable. Giulia Bruno and Armin Linke's exhibition is a proposal for filling this gap. In presenting an ensemble of Anthropocene knowledge production, *Earth Indices* attempts to make the production conditions of the new geological epoch visible and readable.

— Katrin Klingan

III Processing the Anthropocene
An Interview with Giulia Bruno and Armin Linke

Giulia Bruno in dialogue with Simon Turner (scientific coordinator for the AWG research project) in September 2021 at HKW. During a workshop with members of the twelve Anthropocene GSSP research teams, they discuss the types of metadata to be included in the documents presented in *Earth Indices*.

Earth Indices incorporates documents and materials from the stratigraphic research on the Anthropocene. You selected and developed these documents in very close collaboration with the scientists involved in the research. Can you describe your working process?

Over the past two or three years, we've been working with the twelve research groups supporting the Anthropocene Working Group's (AWG) proposal to include the Anthropocene as a new unit on the International Chrono-stratigraphic Chart. We were in continuous conversation with the scientists. Ours was definitely not a neutral position, not the kind imagined by a traditional understanding of documentary photography as "recording from a detached, objective standpoint"—that is pure ideology. Documentation is never neutral; it is always also a framing. We first spent several months in an intense learning process, to understand their work, the procedures they use in their practices. In a series of Zoom meetings, we then asked the scientists to collect and produce images: of the extraction of cores and sediments, the sectioning of samples, the conservation of them, their analysis, as well as images produced by the laboratory instruments and equipment such as microscopes and scanners. We also asked them to photograph the images on the equipment screens. Some were taken with analog cameras, a while back. Other photographs were taken during the Zoom meetings, with some guidance from us. We preselected some of the collected images and then discussed them with each group in separate workshops. To better understand the information held by these images, we asked the scientists to create inscriptions using

In October 2014, HKW hosts the first meeting of the Anthropocene Working Group. Giulia Bruno and Armin Linke document the meeting.

graphic gestures from their practices—marking, commenting, annotating—in PDF documents.

> The exhibition comprises a large variety of images and documents that are framed by a standardized visual register. What is the nature of this register?

Together with Linda van Deursen, we created the graphic design concept for a standardized image template based on the PDF file format, as the standard for the production and distribution of scientific papers. In September 2021, we held a physical studio session with the scientists to present the way we'd like them to do the PDF notations. We also shared a spreadsheet for the input of metadata. When we received this material, we curated it again, always checking with the scientists for errors.

We now have about 500 images, of which 150 are included in the exhibition; all are composed into image PDFs containing metadata, the collected photographs and comments. Metadata is treated as image. Linda's graphic design concept provides a structure for composing the metadata: the scientists supply institutional data, technical and core analysis data, dates, location, marker, media equipment, file formats, geographical coordinates, analysis details and the relevant copyright. The standardized structure allows the public to see both how the different groups worked together and the differences between their work. This layout is a kind of a "strati-graph," with different layers. We are playing with stratigraphy as a sort of digging into the process.

We translated the PDF images into several scales for the exhibition, so the audience is able to zoom in and out of the images. There are large, blown-up prints laid out over two sheets of paper, as diptychs of sorts. We have set up the exhibition space to let a dialogue unfold through the index card system—between this gesture of archive-making as history is being created, on the one hand, and books and other reference materials produced by the scientists as part of their past and ongoing research, on the other. The index cards include all 500 images so as to supply the overall context of the exhibition. This full selection will also form part of a PDF publication available for download at www.anthropocene-curriculum.org

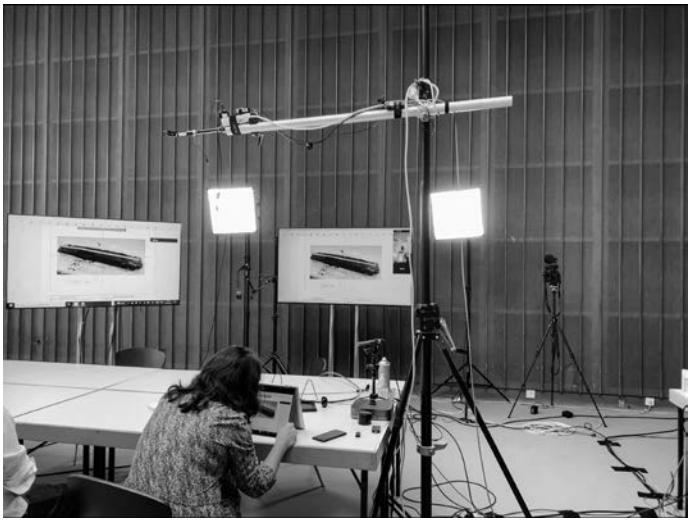
> The individual works of *Earth Indices* show mostly photographs, but also notes, sketches and graphs. What is the nature of these images—what kinds of information do they transmit?

Many of these images have an operational function. It is important to understand how they function as a gesture of science, how data are obtained and how this kind of image enters scientific analysis. A graph is an image, and so too is a core sample, since often it is not the material core that is analyzed but rather images of it. In science, you cannot see something without relating it to context: an image without the metadata and the source is nothing.

It is extremely interesting to look at the landscapes surrounding the core extraction sites in their context. For instance, the backdrop to the core site in Poland is this mountain that looks like pristine landscape. But it was selected as a research site because it lies in the so-called Black Triangle between Poland, the Czech Republic, and Germany, subjected, for decades, to severe environmental pollution. Some of these places and landscapes point

to a cultural imaginary of depictions of nature. The drone images of the Searsville Reservoir site above San Francisco are spectacular. On a raft in the middle of the lake, we see the scientists pulling up a sediment core. It is a trompe l'oeil: the drone lets us see this is human-made "nature" by connecting this human-made lake to Silicon Valley and the Pacific Ocean. We understand that this core is bound within the anthropocenic geopolitical landscape—a result of the colonization and exploitation of the land in the nineteenth and twentieth centuries. This is what emerges when you observe and merge all this information. Every image should have its cultural quality; automatically, this is also an aesthetic quality. We hope that this juxtaposing of text with images can be a trigger for political reflection on the contexts.

> Although the scientists took some of the photographs upon your suggestion, most were produced within the scientific process, without any kind of greater public in mind. Could you elaborate on the function of these images in the scientific work?



Workshop with Barbara Fiałkiewicz-Kozieł, principal investigator of the Śnieżka peatland GSSP in Poland, at HKW in September 2021.

The materiality of the core describes time, technology, climate change, changes to Earth—it partitions these changes into something a bit like a musical score. To read and interpret this score, you need different media technologies, photographs and chemical processes, which are transformed into data and then analyzed again. As photographers and artists, we're interested in seeing how all these instruments, not just the most spectacular ones, form part of the larger set of information and culture production. And, perhaps, we're interested in destabilizing the hierarchy of spectacularity—in understanding where the image, the photography, fails. We asked for images beyond those normally submitted with a scientific paper, such as images from the scientists' mobile phones, and we asked many questions about them.

For previous projects, such as *Prospecting Oceans* (2018), we looked at the history of the mapping of the seafloor. Once sonar technology was developed for military purposes, underwater maps were created. These maps delivered the information that the seabed also holds geological potential for extraction. Geological imaging technology thus created the problem, triggering political negotiation on how to colonize these resources through the creation of the International Seabed Authority. It was interesting to us that imaging technology created a politico-economic and geopolitical situation.

> How does your way of looking at these images differ from the practices of scientific observation?

Scientific observation is about using the tools at one's disposal: despite the different technologies used for scientific versus aesthetic ways of looking, the result is quite similar. We are interested in more of an anthropological approach to the history of science and media science—a process of making it as it takes place. It is this multiplicity or variability of commenting, layering and inscribing that interests us. We, together with the scientists, are proposing just one layer, but we hope this material is also used for future readings and interpretations, by other stakeholders and communities with different approaches.

> There are at least three layers discernible in the *Earth Indices* documents. There are the photographs, then there is a recurring grid containing the metadata and, finally, there are comments of a very different tone and typography. Can you explain what these three layers are and how they relate to each other?

The last layer, the comments, are personal gestures by the scientists, part of a specific artistic and graphic tradition of annotation. There is also this notion of the logbook. Every scientist has one. Even in the most sophisticated astrophysics, DNA research and geological laboratories, you still make notes by hand. We like the idea of taking this fundamental laboratory practice and saying that this exhibition is a kind of a poetic collective logbook of the process—an open logbook, too, as we could add pages and other notes, as a stratigraphic gesture, in future.

The metadata, on the other hand, is the institutional information, approved by the scientists. Metadata and comments are just as important as the photographs: to understand a photograph, you need this contextualizing information. Metadata is part of this system of language creation, of a stratigraphy of coding: the image, as a result, comes from a code. Metadata also protects the source. We adapted the IPTC Photo Metadata standard into a system that, along with the PDF standard, protects scientists against misinterpretation, protects knowledge. If you quote the image, you must quote the text. We also wanted to highlight that every image we produce in our daily life, say with our mobile phones, contains metadata and encoded information embedded and distributed with the file; we often forget this.

The handwritten comments, on the other hand, have a sort of a poetry and lightness, an interpretational hint at personal storytelling for the public. This is not romantic; rather, it's the contrary.

> So, these interacting layers are contained within the individual works. The exhibition comprises a vast collection of these works. How, then, do they interact with each other?

We are working with this concept of scale in the exhibition. Core sampling is an attempt at scaling time. Geological time used to be very expanded—measured over millions of years—and now it is compressed to minuscule layers in rocks and sediments. This scale has a materiality: the scientists examining changes at the planetary scale do so by looking at minuscule particles. The cores come in different sizes: the ice core is 133 meters in length, and the coral cores mere centimeters. From the scientists, we've learned that we are, basically, reading rocks as a book of timescale. The scientific process translates into a sculptural concept through the change of the state of matter. Some of the rocks need to be turned in to gas for ion analysis, ice needs to be melted and so on.

Our exhibition display system merges two materialities: the two-dimensional, unframed paper prints, and the three-dimensional, sculptural metal structure hanging from the ceiling. This choreographic system, with images grouped into narrative islands, juxtaposes the different technologies with the materialities of the processes. The *Earth Indices* installation is conceived of as an artistic exhibition but also as a tool for a performative and active reading of the entirety of the AWG scientists' work. This process is not closed, and so the exhibition will continue to evolve until the AWG officially presents its proposal.

Selecting documents for the *Earth Indices* exhibition during a session at Studio Giulia Bruno & Armin Linke, Berlin.

IV How to Define a New Earth Epoch? *Putting the Anthropocene on the Chronostratigraphic Chart*

Defining the Anthropocene by a point in a geological deposit is a small but significant step in understanding the evolution of our planet and our species. The history of Earth is recorded in layers of rock that allow geologists to read what conditions were like in the past. Breaking down the story of a constantly changing planet into understandable, defined time periods has been a common feature in the development of human thought and critical in the development of geological science. Geologists use differences (and similarities) in rocks and sediment sequences to infer environmental changes that occurred in the past.

There is no one location on Earth where the whole of geological history can be found. The conditions that enable preservation are highly variable and produce a record that is fragmented and complex. Stratigraphy is the methodological tool by which physical information of the past—blurred and distorted by time and space—is systematically recorded and put into order. Geological science, since its inception, has used stratigraphy to build a picture of our planet's formation and development from crustal evidence. The search for the stratigraphic onset of the Anthropocene is a continuation of this process.

Vast timescales are critical to our understanding of the sequence of events and processes leading to the formation of strata and their variability over time and space. Beginning very soon after the planet formed, waves have washed onto beaches, rivers have dumped mud in deltas, wind and rain have eroded mountains and volcanic dust has settled at great depths in remote reaches of the ocean. While such physical processes may be separated by thousands of kilometers and differ in nature due to the geological complexity of our planet, they are unified by time. Temporal connections allow scientists to correctly order physical stratigraphic associations, even after our restless planet has buried, uplifted and scattered layers far from where they originally formed.

As the science of stratigraphy developed, geologists used changes in rock types and the fossil record to define major units of geological time; for example, in a certain cliff, trilobite fossils (which are from the early Cambrian, 521 million years ago) that appear in vertically oriented deep-sea mudstones occur only at the base, while dinosaur remains (from the Triassic period, around 250 million years ago) in terrestrial muds at a different tectonic orientation occur only in higher deposits, above the trilobites. Type sections of strata where such astonishing changes could be observed and named became reference locations against which changes elsewhere could be assessed. This process has continued through geologists refining known and new stratigraphic details using the increasingly advanced technology and analytical tools at their disposal. The development of absolute dating methods during the twentieth century has been critical, since they are far more accurate than the former methods, which relied on superposition and fossil occurrence.

Centuries of geological research are represented by the International Chronostratigraphic Chart, produced by the International Commission on Stratigraphy (ICS). This chart (https://stratigraphy.org/chart) illustrates time boundaries and groupings of significant geological changes agreed upon by international teams of geologists. Since the 1970s, the ICS has worked toward defining the base of boundaries—that is, the starting point of new eras and epochs—by identifying Global Boundary Stratotype Section and Points (GSSPs), informally known as "golden spikes." This process involves teams of scientists with in-depth knowledge of the relevant stratigraphy using empirical evidence to define a point in geological time at a specific location that can mark a boundary. The locations of GSSPs are not origin points: the Jurassic (200 million years ago) did not begin in Tyrol, Austria, and the Holocene (beginning 11,700 BCE) did not commence 1.5 kilometers below the Greenland ice cap. But the timings and evidence recorded at these locations provide reference sections of changes that are found across the globe. The ICS divides its work between seventeen subcommissions, each comprising a committee

of geologists who focus their attention on defining and researching specific periods of geological time. The Subcommission on Quaternary Stratigraphy (SQS) is tasked with defining geological time within the Quaternary period—the last 2.58 million years—which is formed of the Pleistocene and Holocene epochs.

The notion of the Anthropocene as a new unit of geological time in which human beings have significantly altered the planet was famously put forward by atmospheric chemist Paul Crutzen in 2000, and the idea has since gained traction across a variety of academic fields and beyond. But the Anthropocene has not (yet) been ratified by the ICS.

The Anthropocene Working Group (AWG) was established and tasked by the SQS in 2009 to examine the Anthropocene as a chronostratigraphic unit, following its growing usage in the Earth system science community and preliminary analysis by the Stratigraphy Commission of the Geological Society of London. The proposed definition of a stratigraphic Anthropocene signifies that human activity has become a global geological force that has altered planetary conditions to such an extent that we no longer live in the Holocene. The AWG proposes that this transition occurred in the mid-twentieth century, with unprecedented changes to planetary systems created by industrialization, technology advancement and globalization.

Since 2019, the AWG has examined twelve sites across the planet as possible locations for the Anthropocene GSSP. These sites include a variety of environments with unique geological characteristics and deposition types, but all record high-resolution archives of human impacts over at least the last century. For an extensive description of the twelve sites in question, please see the individual guides to each site in this publication and on www.anthropocene-curriculum.org

In 2022, we are at a critical moment in the process of defining the Anthropocene. In May 2022, the AWG researchers present the result of their analysis at Haus der Kulturen der Welt, Berlin. In the following months, the AWG will jointly assess the findings and identify the site most suitable for further evaluation by the SQS and eventually potential ratification by the ICS. A final decision on whether the Anthropocene will be incorporated into the International Chronostratigraphic Chart is expected in the next two to three years.

— Simon Turner

V Twelve Perspectives on the Anthropocene
A Site Guide to the Earth Indices

Map


Reef, Australia
FLI01A_0307A: Flinders
1992+
Peninsula, Antarctica
PALMER: Anvil Cove
2012/2/9 24

Since 2019, twelve sites across the planet have been intensively examined as possible locations for the Anthropocene Global Stratotype Section and Point (GSSP). These dozen sites include deep lakes, marine basins, coral reefs, a river estuary, a cave, an ice sheet, a human-made reservoir, a mountain peatland and an urban archaeological site. The cores taken from them range from an enormous 133 meters long to a mere forty-five centimeters, and each site has its own unique environmental and geological characteristics. But what unites them is that they constitute high-resolution archives of at least the last century and record global as well as local anthropogenic signals, including traces of mid-century nuclear bomb testing, fossil fuel combustion, industrialization, agriculture and ecosystem change.

Locating geological sections that record a century or more in enough detail that individual years can be identified requires a deep understanding of the conditions and characteristics of potential sites. This is the type of understanding found in the work of scientists who study such sites and geological successions in order to track past environmental and climatic conditions. So, in 2016, members of the Anthropocene Working Group (AWG) began reviewing existing literature to determine whether environmental archives containing proposed markers for the so-called Great Acceleration existed with high enough resolution to see annual changes. Since most analytical work is destructive, the groups were asked if large enough samples existed for multiple analyses to occur with sufficient core remaining intact to act as an archive following analysis (a requirement for a GSSP to allow future research). Some teams proposed sites to the AWG and were willing to take part in further research, while others were approached because of their previous publications.

Up until 2019, no specific financial support was provided for this research; contributors thus worked on sections as part of their existing academic research, as an offshoot of their doctoral research or as part of other funded projects. Therefore, the sites do not represent a spatially balanced global selection but rather reflect both individual and institutional interests as well as the financial, cultural and practical constraints that shape environmental science research. The scientific work on the geologic Anthropocene is thus both a legacy and a continuation of the social, cultural and economic systems that have tipped us into a new geological epoch. In the Anthropocene, geology and history are no longer separate disciplines.

Antarctic Peninsula, Antarctica

In 2012, British Antarctic Survey researcher Liz Thomas and her team recovered an ice core from the Antarctic Peninsula. Originally, the drill core was to be used to extend knowledge of climate history in Antarctica by several centuries. This knowledge had until then been based on satellite images, and consequently was limited to only a few decades. With the approximately 130-meter-long Palmer ice core, scientists have been able to explore an archive of the past 400 years of Earth history. The results of the core analyses demonstrate the extent to which climate history—recorded in the recovered ice core back to 1617—is bound up with human history. Air bubbles trapped in the Antarctic ice document not only the dynamics of the regional Antarctic climate but also atmospheric compositional changes from global human activity. Subannual evidence over the past centuries has been collected from the ice core with the help of high-resolution sampling and measuring instruments such as a continuous flow analyzer, which melts the ice and measures chemical changes using mass spectrometry along the length of the core sample. The Palmer ice core contains a high-resolution record of snow accumulation (in this part of Antarctica, snowfall has doubled between 1850 and 2007), within which substances such as carbon dioxide, methane, spheroidal carbonaceous particles (fly ash) and nuclear isotopes are trapped, constituting a record of anthropogenic influences from the beginning of the Industrial Revolution to the global impacts of the Great Acceleration.

GSSP Candidate
PALMER: Antarctic Peninsula, Antarctica

Principal Investigator:
Elizabeth Thomas, *British Antarctic Survey*

Contributing Scientists/ Researchers:
Andy Cundy, *University of Southampton*, Plutonium analysis
Daniel Emanuelsson, *British Antarctic Survey*, Ice core analysis
Jack Humby, *British Antarctic Survey*, Ice core analysis
Shaun Miller, *British Antarctic Survey*, Ice core technician
Julius Rix, *British Antarctic Survey*, Ice core drilling engineer
Sarah Roberts, *University College London*, SCP analysis
Neil Rose, *University College London*, SCP analysis
Diana Vladimirova, *British Antarctic Survey*, Ice core analysis

Beppu Bay, Japan

The sediments of Beppu Bay, on the north-eastern coast of Kyushu Island, Japan, contain well-preserved archives of historical contaminants from the last century, and they have therefore been intensely studied. Multiple sediment cores from this area document a large variety of well-resolved, independently dated chemical, biological and physical sediment records.

Beppu Bay sediments provide a high-resolution record of the events of the Industrial Revolution from the late nineteenth century as well as of the transformative effects of the mid-twentieth-century Great Acceleration on Japanese geography and society. Increased population density and industrial activity along the coastline of the bay is symptomatic of the restructuring following the Second World War and the expansion of Japanese industry, in terms of both scale and technological innovation. As a result, Beppu Bay has received waste effluent from multiple industrial zones with numerous steel, petrochemical and electronics plants. As a consequence, much work has been conducted on the accumulation of persistent organic pollutants such as polychlorinated biphenyls (PCBs). PCBs were intensively used up until the 1970s, when environmental regulations were introduced in recognition of their toxicity. A substantial increase in fruit orchards around the bay has also contributed to unprecedented eutrophication from the 1960s.

GSSP Candidate
BMC19 S1-4: Beppu Bay, Japan

Principal Investigators:
Michinobu Kuwae, *Ehime University*
Yoshiki Saito, *Shimane University*

Contributing Scientists/ Researchers:
Tetsuro Agusa, *Prefectural University of Kumamoto*, Heavy metals, lead isotopes
Atsuko Amano, *National Institute of Advanced Industrial Science and Technology*, Heavy metal geochemistry
Takahiro Aze, *University of Tokyo*, Plutonium isotopes analysis
L. Keith Fifield, *Australian National University*, Plutonium isotopes analysis
Bruce P. Finney, *Idaho State University*, Carbon and nitrogen stable isotope analysis
Michaela Froehlich, *Australian National University*, Plutonium isotopes analysis
Akira Hayashida, *Doshisha University*, Magnetostratigraphy
Tsuyoshi Haraguchi, *Osaka City University*, Bathymetry, Tectonics
Hirofumi Hinata, *Ehime University*, Microplastic analysis
Ken Ikehara, *National Institute of Advanced Industrial Science and Technology*, Event stratigraphy
Jun Inoue, *Osaka City University*, Fly ash (SCP) analysis
Tomohisa Irino, *Hokkaido University*, Sedimentology
Peter R. Leavitt, *University of Regina*, Pigment analysis
Kazumi Matsuoka, *Nagasaki University*, Palynomorph analysis
Takayuki Omori, *University of Tokyo*, Radiocarbon analysis
Aya Sakaguchi, *University of Tsukuba*, Actinoides/iodine analysis
Yoshiaki Suzuki, *National Institute of Advanced Industrial Science and Technology*, Varve analysis
Hikaru Takahara, *Kyoto Prefectural University*, Pollen analysis
Shin Takahashi, *Ehime University*, Organic compound analysis
Keiji Takemura, *Kyoto University*, Tectonics
Stephen Tims, *Australian National University*, Plutonium isotopes analysis
Narumi K. Tsugeki, *Matsuyama University*, Biotic markers
Daisuke Ueno, *Saga University*, Organic compound analysis
Keitaro Yamada, *Ritsumeikan University*, Stratigraphic analysis
Masanobu Yamamoto, *Hokkaido University*, Environmental DNA
Yusuke Yokoyama, *The University of Tokyo*, Plutonium isotopes analysis

Crawford Lake, Canada

Crawford Lake in Ontario, Canada, is included as a GSSP candidate because of its special limnology and sedimentology. Intensive research since the 1970s has found that Crawford Lake is what is known as a meromictic body of water; that is, since it is relatively deep compared to its small surface area, the bottom layer of water does not mix with the upper layers as occurs in most lakes. It is this phenomenon that produces the unusually clear stratification in the sediment of Crawford Lake. During the course of stratigraphic investigations, 600-year-old corn pollen was identified in sediment cores, which also sparked archaeological interest in this lake. The subsequent excavation resulted in the discovery of eleven Iroquoian (and later Wyandot) longhouses and revealed two distinct phases of settlement between 1268 and 1486.

Obtained by a freeze-coring process that extracts soft sediments without deformation, the cores reveal a visible record of hundreds of layers. These sediment layers (varves) form due to seasonal changes in lake conditions and inputs from environmental influences on the lake. Environmental events such as the US Dust Bowl of the 1930s and other major regional storms appear as layers visible to the naked eye, while other chemical markers, such as those connected to the Great Acceleration, require additional analytical techniques. Discerning the global from the regional or local is always technically challenging in lake sediment studies, but Crawford Lake provides ideal conditions due to its precise sediment chronology. It is possible to compare known global historical events, such as the onset of atmospheric nuclear weapons testing and global distribution of specific radioisotopes, with locally generated anthropogenic markers.

GSSP Candidate
CRW19-2FT-B2: Crawford Lake, Canada

Principal Investigators:
Martin Head, *Brock University*
Francine McCarthy, *Brock University*
Tim Patterson, *Carleton University*

Contributing Scientists/ Researchers:
Aaron Anderson, *Brock University*, Algal palynomorph analysis
Stephane Aube, *Carleton University*, Core subsampling
Brenna Bartley, *Conservation Halton*, Fieldwork and education
Arnoud Boom, *University of Leicester*, Stable isotope (C/N) analysis
Max Boreux, *Queen's University*, 210Pb radionuclide dating
Joe Boyce, *McMaster University*, ITRAX core analysis
Uwe Brand, *Brock University*, Water and sediment chemistry
Soren Brothers, *Royal Ontario Museum*, Curator
Roslin Chen, *University of Ottawa*, Core sub-sampling
Carley Crann, *University of Ottawa*, Radiocarbon analysis
Brian Cumming, *Queen's University*, 210Pb radionuclide dating and siliceous microfossil analysis
Andy Cundy, *University of Southampton*, Plutonium analysis
Emily Farlam-Williams, *Carleton University*, Siliceous microfossil analysis
Bill Finlayson, *Wilfrid Laurier University*, Site and regional archaeology
Monica Garvie, *Queen's University*, Siliceous microfossil analysis
Cale Gushulak, *Queen's University/now University of Regina*, Fossil pigment and stable isotope analysis; siliceous microfossil analysis
Paul Hamilton, *Canadian Museum of Nature*, Freeze core curation
Autumn Heyde, *Brock University,* Zooplankton and non-palynomorph analysis
Andrea Krueger, *Brock University*, Algal palynomorph analysis
Brendan Llew-Williams, *Brock University*, Hydrology and water chemistry
Krysten Lafond (formerly Serack), *Carleton University*, Varve imagery and analysis
Peter Leavitt, *University of Regina*, Fossil pigment and stable isotope analysis
Bangyu Liu, *Carleton University*, Core subsampling
Jock McAndrews, *University of Toronto*, Lake paleolimnology
Mike MacKinnon, *OSPM Solutions*, Water and sediment chemistry
Andrew Macumber, *Carleton University*, Core collection and fieldwork
Matthew Marshall, *Queen's University/now Carleton University*, Siliceous microfossil (chrysophytes) analysis
Deborah Metsger, *Royal Ontario Museum*, Curator
Sarah Murseli, *University of Ottawa*, Radiocarbon analysis
Nawaf Nasser, *Carleton University*, Freeze core sampling and analysis
Ben O'Reilly, *Conservation Halton*, Fieldwork
Ms. Katherine Peacock, *Carleton University*, Core subsampling
Paul Michael Pilkington, *Brock University*, Algae analysis
Michael Pisaric, *Brock University*, Core collection
Eduard Reinhardt, *McMaster University*, Core collection and fieldwork
Nicholas Riddick, *McMaster University/now Brock University*, ITRAX core and non-pollen palynomorph analysis
Sarah Roberts, *University College London*, SCP analysis
Neil Rose, *University College London*, SCP analysis
Riley Steele, *McMaster University*, Core collection and fieldwork
Catherine Tammaro, *TAMMARO ART/ Design*, Wendat Elder/ Knowledge Keeper
Joe Viscek, *Brock University*, Core collection
Carling Walsh, *Carleton University*, Varve imagery and (wavelet) analysis

East Gotland Basin, Baltic Sea

The Baltic Sea has a long and extensive history of anthropogenic activity. Overfished and impacted by the industry and agriculture of the nine countries surrounding it, the Baltic Sea features sediments that act as a sink for regional and global markers of the Anthropocene. Scientists are analyzing these sediments through a sediment core collected in 2018 from the Baltic Sea's East Gotland Basin at a water depth of 241 meters. The seabed there is a silt plain, surrounded by mud-covered rocky hills, and the water is not moved by wave energy or current activity from the surface. The Baltic's deep water is very low in oxygen, making it inhospitable to most aquatic life forms. This means that the fine silt and clay of the seafloor remains undisturbed, preserving the organic and chemical markers deposited in the sediments.

The forty-five-centimeter-long core records a story from around 1840 to 2018. The research team used event stratigraphy to define time markers, among them the increased caesium-137 of the Chernobyl accident (1986), the appearance of DDT pesticides (1950) and the onset of coal combustion. The team could then use these markers to date the traces that appear at other positions in the core. Around 1955, there is a sharp increase in various anthropogenic markers, including lead and other metals, organic carbon, DDT derivatives, radionuclide fallout signals, microplastics and fly ash—some of which peak in the 1970s and '80s. The microparticles of plastics include a range of polymer types that reflect the widespread and various uses of plastics since the twentieth century.

GSSP Candidate
EMB201/7-4: East Gotland Basin, Baltic Sea

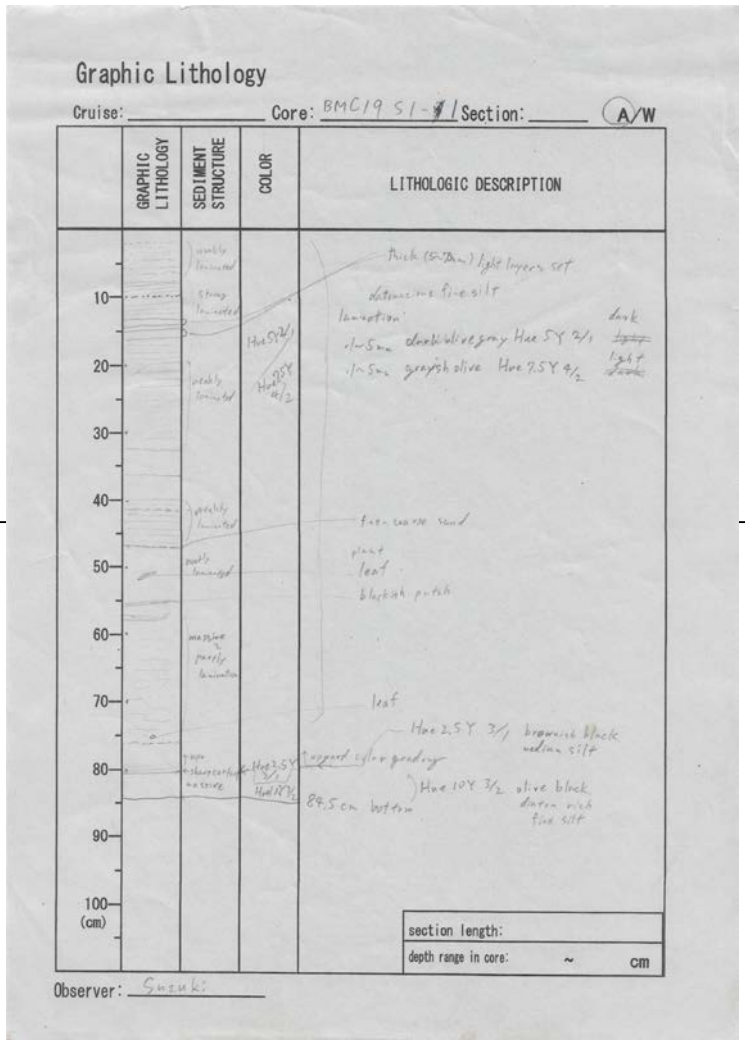
Principal Investigators:
Jérôme Kaiser, *Leibniz Institute for Baltic Sea Research*
Juliana A. Ivar do Sul, *Leibniz Institute for Baltic Sea Research*

Contributing Scientists/ Researchers:
Serena Abel, *Alfred Wegener Institute*, Microplastic analysis
Helge W. Arz, *Leibniz Institute for Baltic Sea Research*, XRF analysis
Andy Cundy, *University of Southampton*, Pu isotope analysis
Olaf Dellwig, *Leibniz Institute for Baltic Sea Research*, Metal analysis
Gunnar Gerdts, *Alfred Wegener Institute*, Microplastic analysis
Irka Hajdas, *ETH Zurich*, Radiocarbon analysis
Nadine Hollmann, *Leibniz Institute for Baltic Sea Research*, Biomarker analysis
Anne Köhler, *Leibniz Institute for Baltic Sea Research*, Metal analysis
Matthias Labrenz, *Leibniz Institute for Baltic Sea Research*, Microplastic analysis
Iris Liskow, *Leibniz Institute for Baltic Sea Research*, Nitrogen and Carbon analysis
Matthias Moros, *Leibniz Institute for Baltic Sea Research*, Radionuclide analysis
Sebastian Primpke, *Alfred Wegener Institute*, Microplastic analysis
Sarah Roberts, *University College London*, SCP analysis
Neil Rose, *University College London*, SCP analysis
Ines Scherff, *Leibniz Institute for Baltic Sea Research*, Metal (Hg) analysis
Maren Voß, *Leibniz Institute for Baltic Sea Research*, Nitrogen and carbon analysis

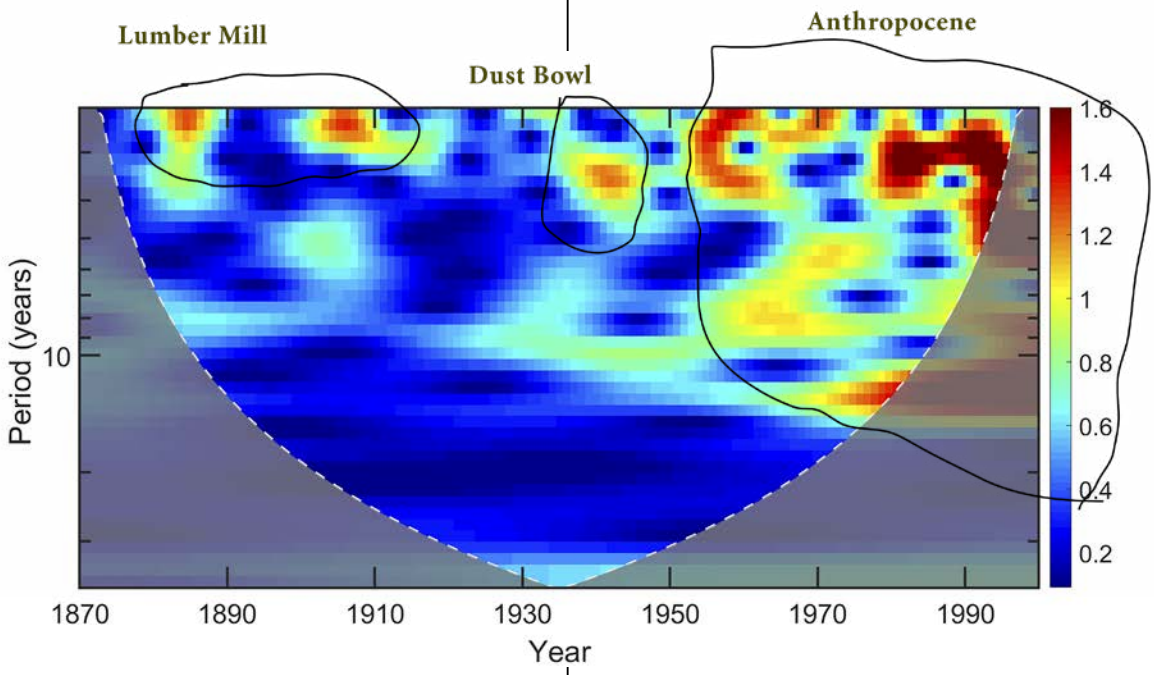
1	institutional data
project title	PALMER: Antarctic Peninsula, Antarctica 24-29/12/2012
institution	British Antarctic Survey, Natural Environment Research Council, UK Research and Innovation
department	Ice core research group
researcher(s)	Principal investigators (listed alphabetically): Elizabeth Thomas, British Antarctic Survey Core team (listed alphabetically): Daniel Emanuelsson, British Antarctic Survey / Diana Vladimirova, British Antarctic Survey / Jack Humby, British Antarctic Survey / Sarah Roberts, University College London / Andy Cundy, University of Southampton / Neil Rose, University College London / Simon Turner, University College London Extended team (listed alphabetically): Shaun Miller, British Antarctic Survey / Julius Rix, British Antarctic Survey
city country	Cambridge United Kingdom

2	technical data
file name size creation date	7317B906-2B61-4667-91F2-0573DFCB9917.jpg n/a 16/04/2020
media type equipment	Photograph Digital camera (iPhone)
GPS metadata	52° 12′ 45″ N, 0° 04′ 50″E
software	n/a

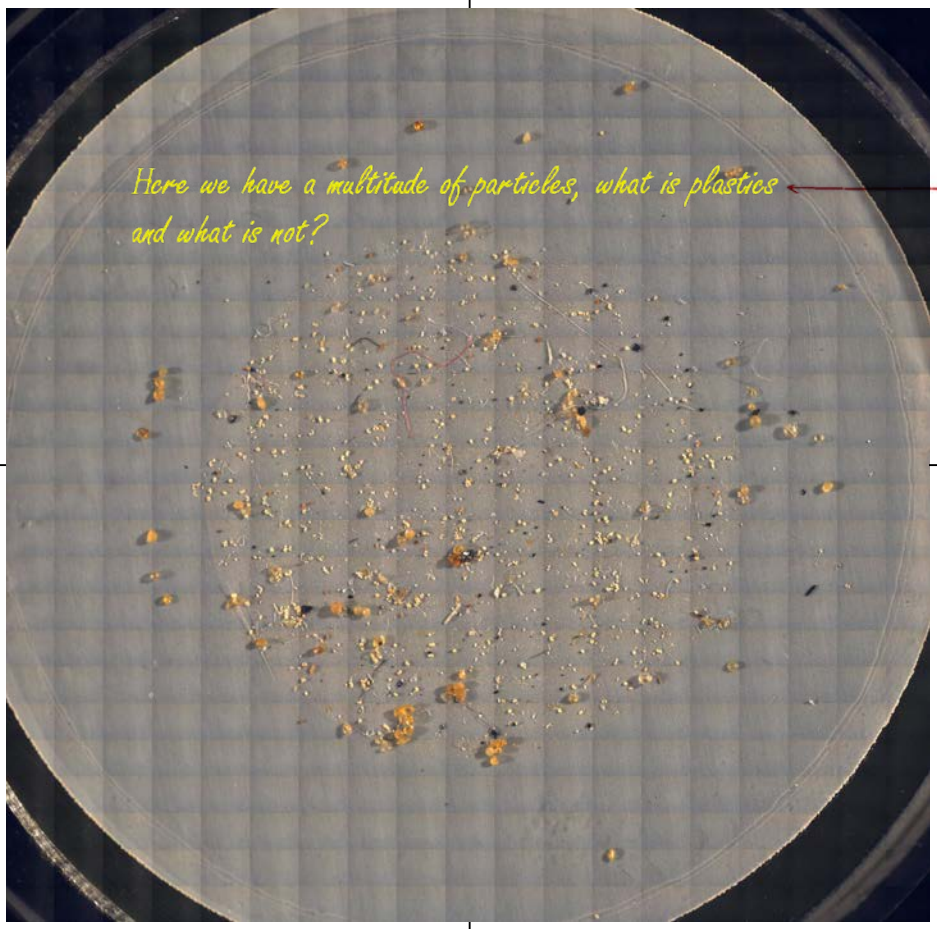
3	coring and analysis data
referent name	Liz Thomas, Daniel Emanuelsson, Diana Vladimirova
location	British Antarctic Survey, High Cross, Madingley Road, CAMBRIDGE, CB3 0ET
core name date of coring date of analysis	PALMER 24-29/12/2012 16/04/2020
marker analysis	Chemistry. Stable water isotopes, methane Core preperation
description	Boxes stacked in our freezer containing the Palmer ice core.
sampling notes	n/a
additional notes	Freezer temperature -25°C
© original image	Liz Thomas



1	institutional data	2	technical data
project title	2019 BMC19 S1-4: Beppu Bay, Japan 10-09-2019	file name size creation date	三千宣 加 - BMC19 BG19 BHR19 description 1.pdf n/a 18/09/2019
institution	National Institute of Advanced Industrial Science and Technology	media type equipment	Sketch Scanner
department	Geological Survey of Japan	GPS metadata	33°33'15"N,133°40'33"E
researcher(s)	Yoshiaki Suzuki	software	AktKey, OKI
city country	Tsukuba Japan		
		3	coring and analysis data
		referent name	Michinobu Kuwae
		location	200, Monobe, Nankoku, Kochi
		core name date of coring date of analysis	BMC19 S1-1 10/09/2019
		marker analysis	Elements, varves for chronology Visual inspection
		description	BMC19 S1-1の岩相記載 BMC19 Description of S1-1 Lythology.
		sampling notes	n/a
		additional notes	n/a
		© original image	Yoshiaki Suzuki



1	institutional data	2	technical data
project title	CRW19-2FT-B2: Crawford Lake, Canada 2019	file name size creation date	1870-present_couplet_wavelet.png 911 px x 1920 px 96 px/inch 21/10/2020
institution	Carleton University	media type equipment	Diagram MatLab
department	Earth Sciences	GPS metadata	45.38N/ 75.70W
researcher(s)	Ms. Krysten Serack (Lafond), Dr. Nawaf Nasser, Carling Walsh, Dr. R. Timothy Patterson	software	MatLab
city country	Ottawa Canada		
		3	coring and analysis data
		referent name	Carling Walsh, Krysten Serack (Lafond), Nawaf Nasser, Tim Patterson
		location	Patterson Lab, Carleton University, 1125 Colonel By Dr, Ottawa, ON K1S 5B12
		core name date of coring date of analysis	CRW19-2FT-B2 20/02/2019 21/10/2020
		marker analysis	Wavelet analysis of varve record periodicity Continuous Wavelet Transform
		description	Continous wavelet transform of the varve thickness record from the Crawford Lake core (1496-2000).
		sampling notes	Analysis indicates time-varying periodic components of the varve record.
		additional notes	Thickness of organic dark and inorganic light couplet reflects changes in productivity in water column of lake and temperature/aridity. A wavelet transform shows the frequency of reoccuring cycles recorded in the environment and when these cycles are prominent.
		© original image	Carling Walsh

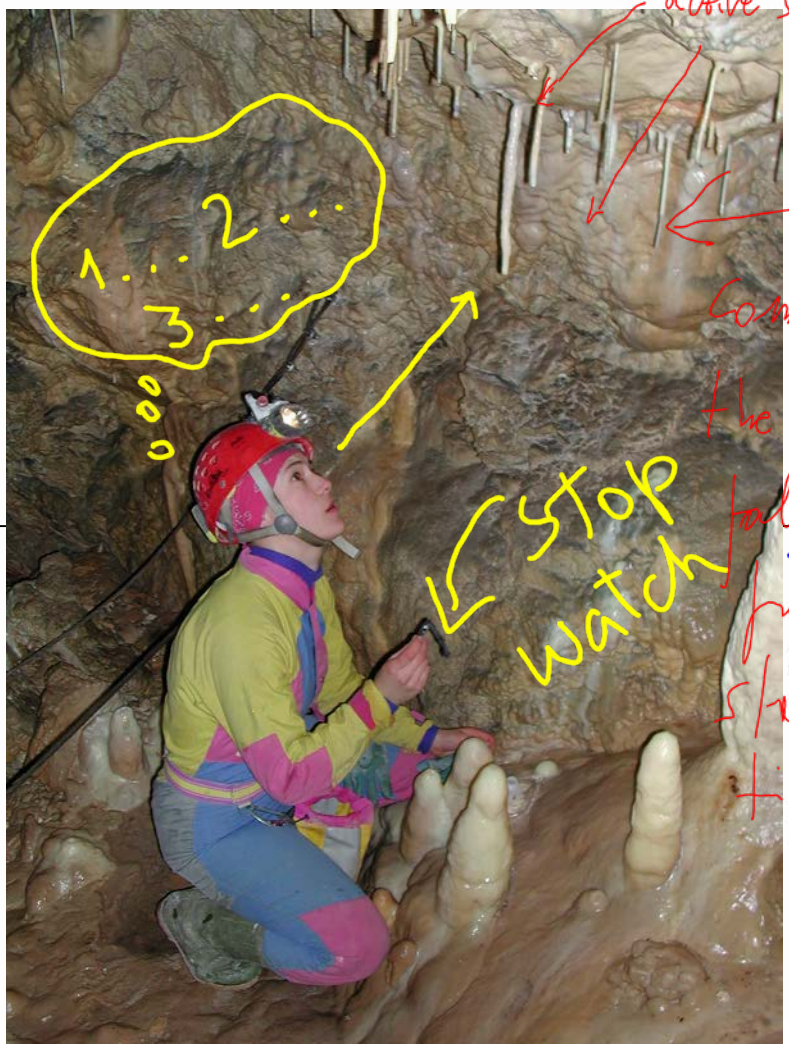


This filter has 47mm in diameter. It is quite small. So imagine how small are the particles here! Most of them are smaller than 100mμ (much smaller than a grain of rice for example). Within this size scale, it is hard to identify what is plastic and what is not plastic. That is why we use spectroscopic methods to do it. The name might be complicated, but it involves the splitting of light into its constituent wavelengths–it is pretty much like a prism splits light into a rainbow of colors!

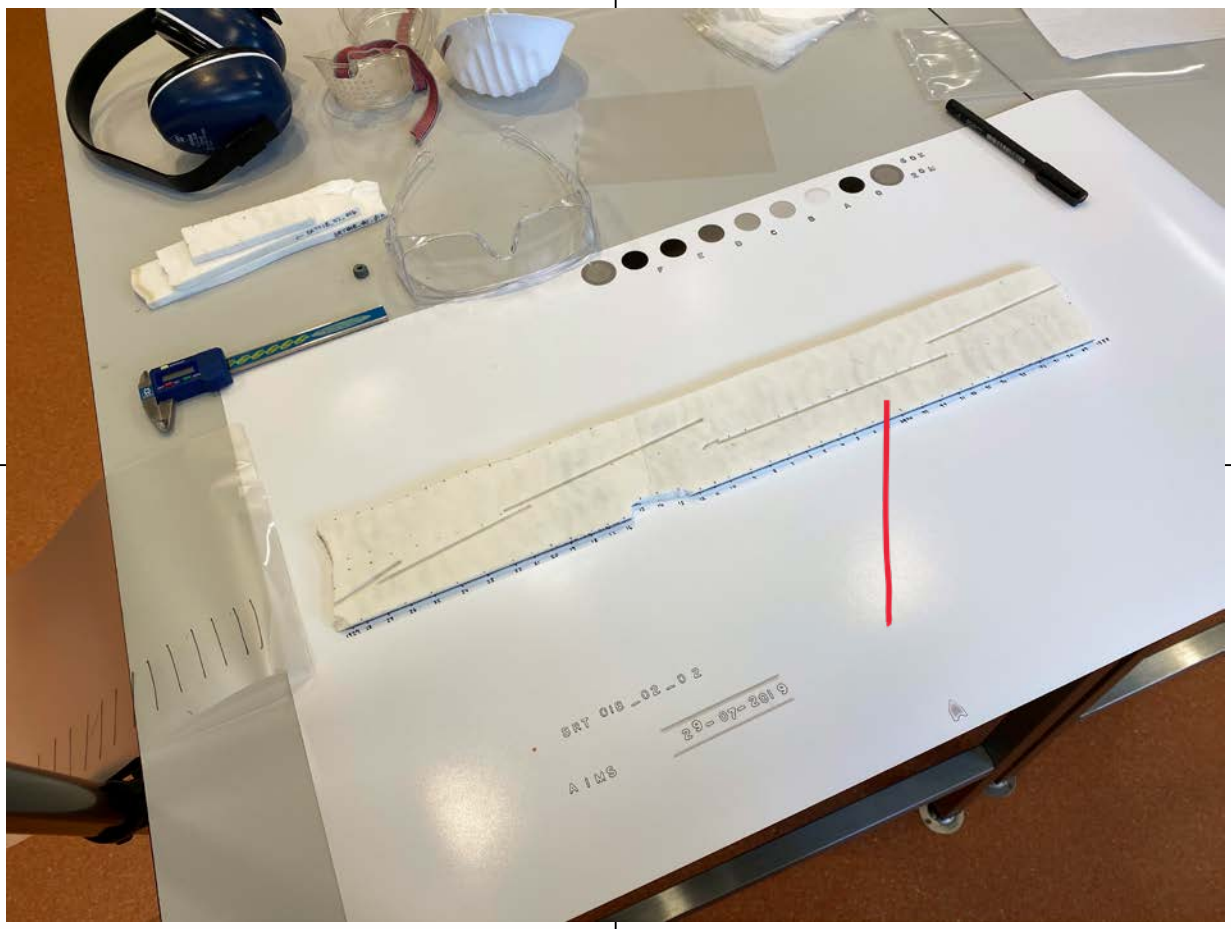
1	institutional data
project title	EMB201/7-4: East Gotland Basin, Baltic Sea 06-12-2018
institution	Leibniz Institut für Ostseeforschung - Warnemünde (IOW)
department	Marine Biology, Marine Geology
researcher(s)	Juliana Ivar do Sul, Jérôme Kaiser
city country	Rostock-Warnemünde Germany

2	technical data
file name size creation date	GSSP_10.jpg 3931 px x 4000 px 96 px/inch
media type equipment	Photograph Photo camera
GPS metadata	54°10'45 N; 07°52'57 E
software	None used.

3	coring and analysis data
referent name	Juliana Ivar do Sul, Jérôme Kaiser
location	IOW
core name date of coring date of analysis	EMB201/7-4 06/12/2018 05/08/2019–25/10/2019
marker analysis	Microplastics FTIR, Raman microspectroscopy
description	Glass filter with purified sampled to be chemically analysed for microplastics.
sampling notes	Filter analysed under a μFTIR microscopy.
additional notes	Natural organic and inorganic particles not removed during the pipeline method are visible on the filter.
© original image	Serena Abel



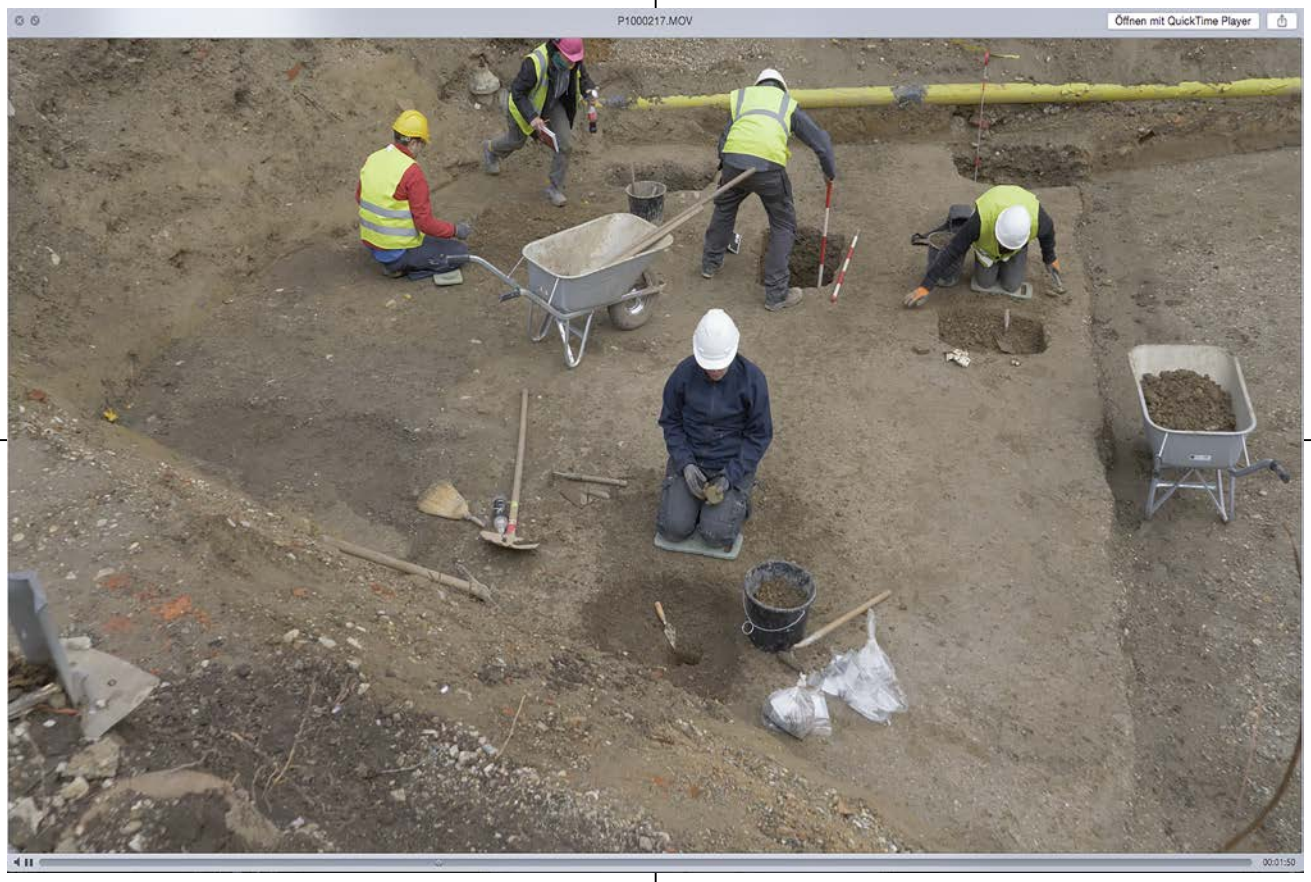
1	institutional data	2	technical data
project title	ER77-78: Ernesto Cave, Italy 1995/2000	file name size creation date	Ernesto24.jpg 2048 px x 1536 px 300 px/inch 22/03/2002
institution	Museo delle Scienze di Trento, Italy; University of Newcastle, Australia; University of Birmingham, United Kingdom; Heidelberg Academy of Sciences, Germany.	media type equipment	Photograph Nikon Coolpix P5000
department	Geology Section; School of Environmental and Life Sciences; School of Geography, Earth and Environmental Sciences; Institute for Environmental Physics	GPS metadata	45°58'38" N, 11°39'25" E
researcher(s)	Principal investigators (listed alphabetically): Andrea Borsato, Museo delle Scienze di Trento and University of Newcastle, Australia / Silvia Frisia, Museo delle Scienze di Trento and	software	n/a
	University of Newcastle, Australia / Ian Fairchild, AWG, University of Birmingham, United Kingdom Core team (listed alphabetically):		
	Peter Wynn, University of Birmingham, UK / Jens Fohlmeister, University of Heidelberg, Germany / Renza Miorandi, Museo delle Scienze di Trento, Italy	3	coring and analysis data
city country	Trento, Newcastle (AUS), Birmingham, Heidelberg Italy, Australia, United Kingdom, Germany	referent name	Andrea Borsato, Museo delle Scienze di Trento and University of Newcastle, Australia / Silvia Frisia, Museo delle Scienze di Trento and University of Newcastle, Australia / Ian Fairchild, AWG, University of Birmingham
		location	Ernesto Cave, Italy
		core name date of coring date of analysis	ER77-78 ER76: 06/1993 09/2007
		marker analysis	δ13C & δ18O MS (δ13C & δ18O), U/Th MS
		description	R. Miorandi measuring the drip rates of stalactites.
		sampling notes	ER76: -8m from the entrance; ER77 and ER78: -15m from the cave entrance elevation.
		additional notes	n/a
		© original image	A. Borsato



1	institutional data
project title	FLI01A_05A: Flinders Reef, Australia 2017+1992
institution	Australian Institute of Marine Science
department	Australian Institute of Marine Science
researcher(s)	PI Prof. Jens Zinke; PI Dr. Arnoud Boom; Dr. Genna Tyrell; MSc Molly Agg; Sue Sampson; Dr. Adam Cox; Dr. Irka Hajdas; Prof. A. Cundy; Dr. Simon Turner; Dr. Neal Cantin; Grace Frank; Dr. Nicolas Duprey; Dr. Alfredo Martinez-Garcia; Prof. Neil Rose; Dr. Sarah Roberts
city	Townsville
country	Australia

2	technical data
file name	IMG_7212.heic
size	3024 px x 4032 px 72 px/inch
creation date	n/a
media type	Photograph
equipment	iPhone
GPS metadata	n/a
software	n/a

3	coring and analysis data
referent name	Neal Cantin
location	Australian Institute of Marine Science, PMB 3, Townsville MC QLD 4810, Australia
core name	FLI01A_05A
date of coring	2017; 1992
date of analysis	2021
marker	Chronology assignment
analysis	IRMS, ICP-MS, AMS
description	Grace Frank working on assigning the coral core chronology.
sampling notes	n/a
additional notes	n/a
© original image	Neal Cantin, Grace Frank

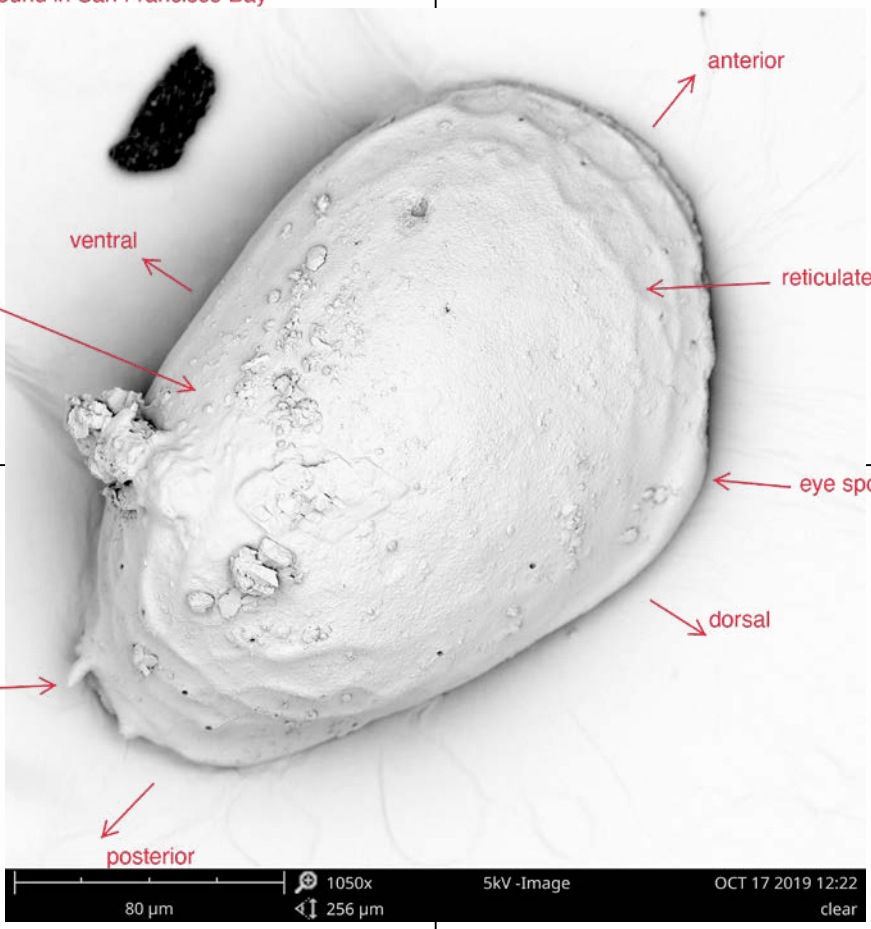


1	institutional data
project title	18-04-2019 2019_26: Karlsplatz, Wien Museum, Vienna, Austria
institution	University of Vienna & University of Applied Arts, Vienna
department	Department of Geology
researcher(s)	Michael Wagreich, Karin M. Hain, Katrin Hornek, Veronika Koukal, Kira Lappé, Constance Litschauer, Maria Meszar, Martin Mosser, Nikolaos Piperakis
city	Vienna
country	Austria

2	technical data
file name	Bildschirmfoto 08/11/2019 um 19.04.13.png
size	997 px x 1676 px 72 px/inch
creation date	08/11/2019
media type	Screenshot
equipment	Camera/Computer
GPS metadata	N 48°11'57.0'', E 16°22'21.4''
software	n/a

3	coring and analysis data
referent name	Katrin Hornek, Kira Lappé, Maria Meszar, Michael Wagreich
location	Karlsplatz, Vienna, Austria
core name	18-04-2019 2019_26
date of coring	n/a
date of analysis	n/a
marker	Plutonium isotopes
analysis	Stratigraphic excavation
description	n/a
sampling notes	n/a
additional notes	n/a
© original image	Katrin Hornek

Scanning electron microscope image of the ostracod Bicornucythere bisanensis, a species nature to the West Pacific, but now found in San Francisco Bay

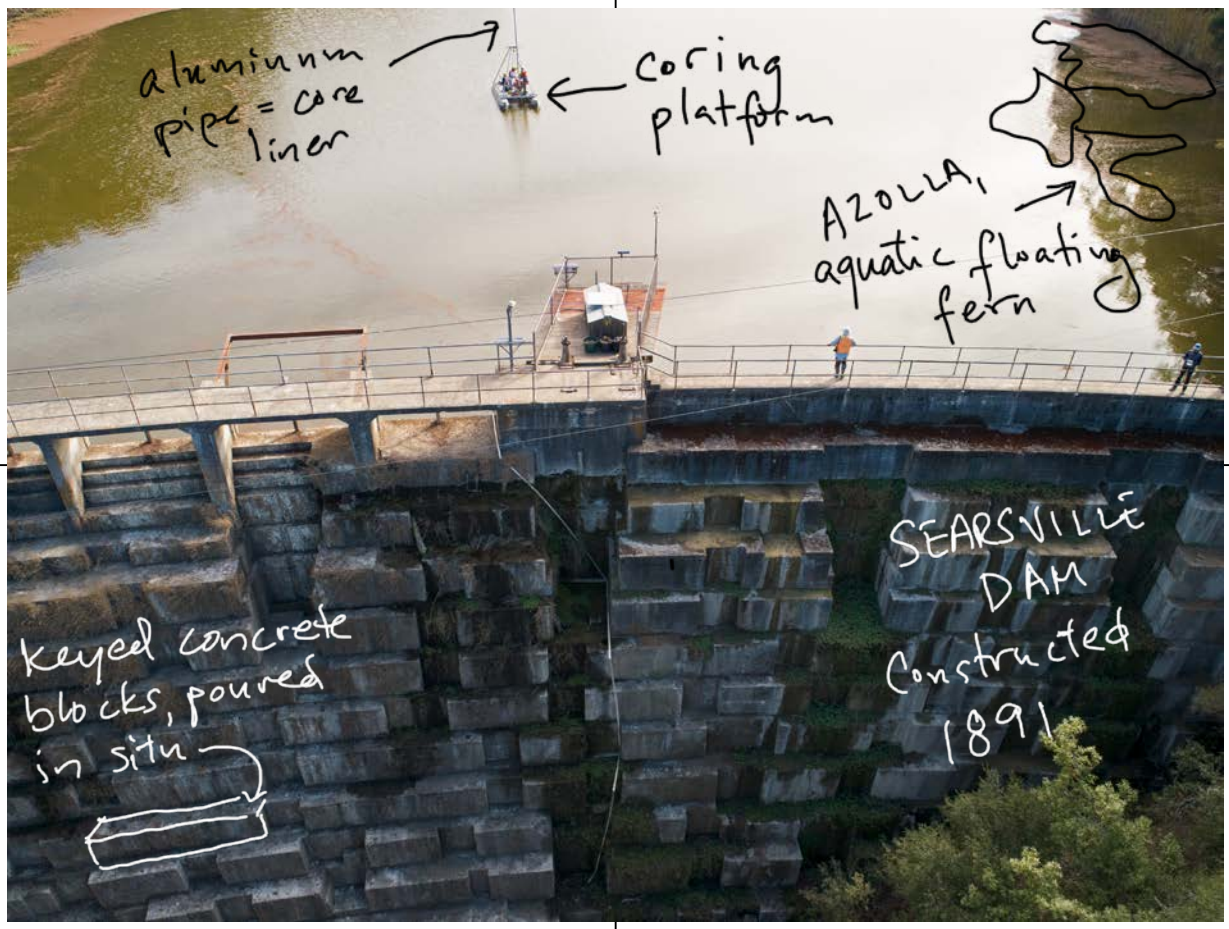


The orientation of the image is irregular, with the dorsal to the bottom. This is because of the position of the ostracod when it was scanned in the electron microscope

1	institutional data
project title	2019SFB-20A: San Francisco Estuary, USA
institution	University of Leicester
department	Geography, Geology and the Environment
researcher(s)	Stephen Himson, Mark Williams, Ian wilkinson, Mary McGann
city country	Leicester United Kingdom

2	technical data
file name size creation date	clear0003.tiff 2176 px x 2048 px 72 px/inch 15/08/2019
media type equipment	Photograph Scanning electron microscope and photo camera
GPS metadata	52.623214,-1.122661
software	Adobe Photoshop

3	coring and analysis data
referent name	Stephen Himson, Mark Williams, Colin Waters
location	School of Geography, Geology and the Environment, University of Leicester, Leicester, LE1 7RH, UK
core name date of coring date of analysis	2019SFB-20A 18/04/2019 15/08/2019
marker analysis	Microfossils Microfossil analysis, optical microscopy, scanning electron microscopy
description	The shell of the introduced ostracod Bicornucythere bisanensis from a core in San Francisco Bay.
sampling notes	67 cm depth from core SFB-20A.
additional notes	n/a
© original image	Stephen Himson, Mark Williams, Ian Wilkinson, Mary McGann



1	institutional data
project title	JRBP2018-VC01 B: Searsville Reservoir, USA 29-10-2018
institution	Stanford University United States Geological Survey
department	Jasper Ridge Biological Preserve, Stanford Earthquake Science Center, United States Geological Survey, Pacific Coastal and Marine Science Center, United States Geological Survey
researcher(s)	M. Allison Stegner, Elizabeth A. Hadly, Anthony D. Barnosky, SeanPaul La Selle, Brian Sherrod, Scott Anderson, Bryan Black, Irka Hajdas, Sergio Redondo, Neil Rose, Trisha Spanbauer, Maria Viteri
city country	Woodside, CA United States

2	technical data
file name size creation date	DJI_0006.tiff 3640 px x 4845 px 300 px/inch 29/10/2018
media type equipment	Photograph Drone camera
GPS metadata	37.41, -122.24
software	Adobe Photoshop

3	coring and analysis data
referent name	M. Allison Stegner, Elizabeth A. Hadly, Anthony D. Barnosky
location	Jasper Ridge Biological Preserve, Stanford University, 4001 Sand Hill Rd, Woodside, CA 94062
core name date of coring date of analysis	JRBP2018-VC01 B 29/10/2018 n/a
marker analysis	Core collection Vibracoring
description	Vibracoring Searsville Reservoir.
sampling notes	n/a
additional notes	Searsville Dam, constructed in 1891, is in the foreground.
© original image	Nona Chiariello

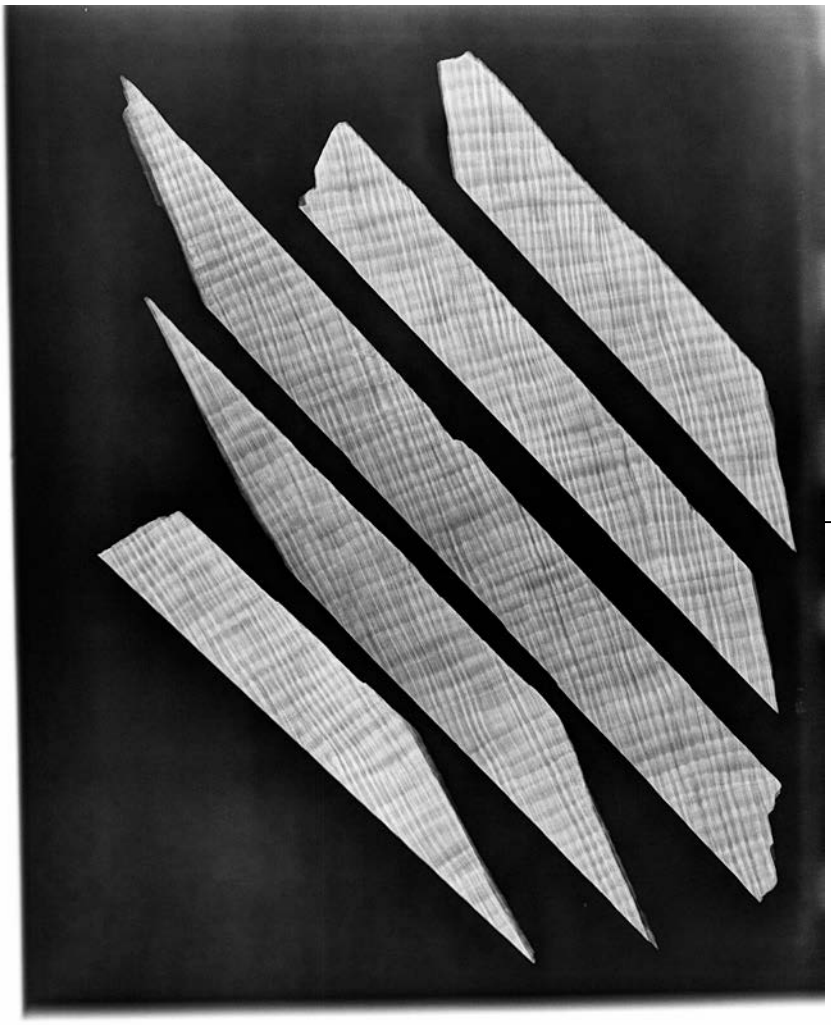
1	institutional data	2	technical data
project title	SHLW-maar: Sihailongwan Lake, China 26-02-2021	file name size creation date	core strips impregnated with resin.png n/a 19/09/2021
institution	Aerosol and Environmental Division State Key Laboratory of Loess & Quaternary Geology Chinese Academy of Sciences; National Natural Science Foundation of	media type equipment	Photograph Phone (HUAWEI PCT AL-10)
	China (NSFC; Grant Number: 41991250)	GPS metadata	34°13'N,109°00'E
department	Institute of Earth Environment	software	n/a
researcher(s)	Principal investigators (listed alphabetically): Yongming Han, AWG, Institute of Earth Environment, Chinese Academy of Sciences (IEECAS) / An Zhisheng, AWG, Institute of Earth		
	Environment, Chinese Academy of Sciences (IEECAS) Core team (listed alphabetically): Dewen Lei, Institute of Earth Environment, Chinese Academy of	3	coring and analysis data
	Sciences (IEECAS) / Yalan Tang, Institute of Earth Environment, Chinese Academy of Sciences (IEECAS) / Xue Zhao, Institute of Earth Environment, Chinese Academy of Sciences (IEECAS) / Luyuan Zhang,	referent name	Yongming Han, Dewen Lei, Yalan Tang, Huan Yao, Jing Chen, Tianli Wan, Xue Zhao
	Institute of Earth Environment, Chinese Academy of Sciences (IEECAS) Jianghu Lan, Institute of Earth Environment, Chinese Academy of Sciences (IEECAS)	location	Institute of Earth Environment, Chinese Academy of Sciences, 97 YanxiangRoad, Xi'an, Shanxi Province, China
	Extended team (listed alphabetically): Tong Zhang, Institute of Earth Environment, Chinese Academy of Sciences (IEECAS) / Tianli Wang, Institute of Earth Environment,	core name date of coring date of analysis	SHLW21-Fr-13 26/02/2021–28/02/2021 09/19/2021
	Chinese Academy of Sciences (IEECAS) / Xin Xu, Institute of Earth Environment, Chinese Academy of Sciences (IEECAS) Mei Han, Institute of Earth Environment, Chinese Academy of Sciences	marker analysis	Varve analysis Hardened core strips for making thin sections.
	(IEECAS) / Huan Yao, Institute of Earth Environment, Chinese Academy of Sciences (IEECAS) / Ping Wang, Institute of Earth Environment, Chinese Academy of Sciences (IEECAS) / Jing Chen, Institute of Earth	description	冷冻干燥后的样品条，浸渍在环氧树脂中。烘烤硬化后可制作薄片。 The frozen dried core strips sample dipped in epoxy resin.
	Environment, Chinese Academy of Sciences (IEECAS) / Bo Liu, Institute of Earth Environment, Chinese Academy of Sciences (IEECAS) / Ning Chen, Institute of Earth Environment, Chinese Academy of	sampling notes	环氧树脂和固化剂以10:1-8:1混合，120°C烘烤20分钟以降低树脂混合液黏度，将冻干的岩芯条浸渍在树脂中，抽真空三次，使树脂完全渗透到样品中。50°C烘烤48小时，使样品硬化。Epoxy resin and curing agent are
	Sciences (IEECAS)		mixed at 10:1-8:1, baked at 120°C for 20 minutes to reduce the viscosity of the resin mixture, immersed the freeze-dried core strip in the resin, and vacuumed three times to make the resin completely penetrate into
city country	Xi'an China		the sample. Bake at 50°C for 48 hours to harden the sample.
		additional notes © original image	没有更多需要补充的信息。nothing to add Dewen Lei

1	institutional data
project title	SN0: Śnieżka peatland, The Sudetes, Poland 29-08-2020
institution	(NCN) 2011/01/D/ST10/02579 IGIG, Adam Mickiewicz University funds for scientific activity
department	BIOGEOCHEMISTRY Research Group
researcher(s)	Principal investigators (listed alphabetically): Barbara Fiałkiewicz-Kozieł, Adam Mickiewicz University / Simon Turner, University College London
	Core team (listed alphabetically): Edyta Łokas, Institute of Nuclear Physics, PAN / Beata Smieja-Król, University of Silesia / Mariusz Gałka, University of Lodz / Piotr Kołaczek,
	Adam Mickiewicz University / Mariusz Lamentowicz, Adam Mickiewicz University / François De Vleeschouwer, Universidad de Buenos Aires Michał Woszczyk, Adam Mickiewicz University / Neil Rose, University
	College London / Andy Cundy, University of Southampton Arnoud Boom, University of Leicester / Sarah Roberts, University College London
	Extended team (listed alphabetically): Tomasz Mróz, Jagiellonian University / Tomasz Krzykawski, University of Silesia / Jolanta Dopieralska, Isotopic Laboratory, Poznań
	Agnieszka Bondyra, Adam Mickiewicz University / Katarzyna Marcisz, Adam Mickiewicz University / Marcin Siepak, Adam Mickiewicz University / Gael Le Roux, Université de Toulouse
city country	Poznań Poland

2	technical data
file name size creation date	20200923_123643.jpg 2539 px x 4102 px 72 px/inch 2020.09.
media type equipment	Photograph Mobile phone
GPS metadata	50°44.20.90 N, 15°42.28.03 E
software	n/a

3	coring and analysis data
referent name	Barbara Fiałkiewicz-Kozieł
location	Lab., Krygowskiego 10, 61-618 Poznań
core name date of coring date of analysis	SN0 29/08/2020 23/09/2020
marker analysis	This is a photo of core, where all markers were measured. Bags of peat for posting. Subsampling of core.
description	This is a photo of sampling SN0 for plutonium analysis and others using carbon steel knife, very thin, washed with deionized water during each slicing.
sampling notes	Subsampling using carbon steel knives and bags.
additional notes	Photo of single sphagnum moss, every branch of which records enviromental changes.
© original image	Adrian Sitarz

Each light and dark band in the X-ray is a year.



In this image, we are adjusting X-ray system settings to make the bands more prominent.

1	institutional data
project title	0FWFGB3-1: West Flower Garden Bank Reef, USA 2005
institution	Louisiana State University, Texas A&M, and California State University at Sacremento
department	Geography and Anthropology
researcher(s)	Principal investigators (listed alphabetically): Kristine DeLong, Louisiana State University / Jens Zinke, AWG, University of Leicester
	Core team (listed alphabetically): Amy Wagner, California State University Sacramento / Mudith Weerabaddana, Louisiana State University and University of Arizona /
	Kylie Palmer, Louisiana State University Extended team (listed alphabetically): Niall Slowey, Texas A&M University / Irka Hajdas, ETH Zurich /
	Andy Cundy, University of Southampton / Neil Rose, University College London / Simon Turner, University College London / Nicolas Duprey, MPI Mainz, Germany / Alfredo Martinez-Garcia, MPI Mainz, Germany
city country	Baton Rouge USA

2	technical data
file name size creation date	4.tiff 4248 px x 3480 px 72 px/inch 2015
media type equipment	Photograph Digital X-ray machine
GPS metadata	30.411607°N, 91.178627°W
software	Photoshop

3	coring and analysis data
referent name	Kristine DeLong
location	E313 Howe Russell Geoscience Complex, Louisiana State University, Louisiana, USA
core name date of coring date of analysis	0FWFGB3-1 05/2005 2015
marker analysis	Chronology assignment IRMS, ICP-OES, ICP-MS, AMS
description	05WFGB3-1 X-radiograph: West Flower Garden Bank Reef, USA
sampling notes	180 dots/inch image, X-ray settings are 48 kV for 0.4 s and then processed by an Agfa CR35-X digital processor.
additional notes	Annual density bands in the X-ray image allow us to count the years to determine the chronology.
© original image	Kristine DeLong

Ernesto Cave, Italy

Ernesto Cave, near Trento, Italy, was inhabited by humans during the Mesolithic era and in 1983 was rediscovered by chance during road construction work. Ernesto Cave has been closed to the public since its rediscovery to avoid contamination by humans and other animals, as well as to preserve the atmospheric conditions within the cave. The stalagmites of Ernesto Cave have been used previously to study past Earth epochs. However, unlike these earlier studies of the Pleistocene and early Holocene, the stalagmite analyses for the Anthropocene focused only on the last half centimeter of growth. Despite the very small amount of material that accounts for the Holocene–Anthropocene transition, microscopy can precisely map annual layers using high-resolution analytical techniques.

Both global and local events can be read in this crystalline archive. Local events include the clearing of the forest above the cave during the First World War, while global events include changes in atmospheric composition, such as traces of atomic weapons testing and emissions from industrialization. These records are inscribed into annual layers of calcite and other minerals dissolved from the overlying rocks and soils before being precipitated in the cave. Due to the time it takes for the water to percolate into the cave, a delay occurs between signal and response, event and record. For example, peak radiocarbon from nuclear testing does not show up in the stalagmite until about 1970, although the actual atmospheric peak was triggered a decade earlier as nations rushed to complete atmospheric testing before an international ban.

GSSP Candidate
ER77-78: Ernesto Cave, Italy

Principal Investigators:
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Contributing Scientists/ Researchers:
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Flavio Corradin, *Fondazione Edmund Mach*, Sulphur analyses
John Craven, *Edinburgh Ion Microprobe Facility*, Ion microprobe analysis
Anna de Momi, *University of Birmingham*, Environmental monitoring and sampling
Jens Fohlmeister, *University of Heidelberg, Potsdam Institute for Climate Impact Research, Germany* Radiocarbon analysis
Adam Hartland, *University of Birmingham/now University of Waikato*, Trace element analysis (colloids)
Richard Hinton, *Edinburgh Ion Microprobe Facility,* Ion microprobe analysis
Bernd Kromer, *University of Heidelberg*, Radiocarbon analysis
Jonathan Lageard, *Manchester Metropolitan University*, Dendrochronology
Nicola La Porta, *Fondazione Edmund Mach*, Dendrochronology
Neil Loader, *University of Swansea*, Carbon isotope analysis
Augusto Mangini, *University of Heidelberg*, Project coordination
Frank McDermott, *University College Dublin, Ireland*, Project coordination
Renza Miorandi, *Museo delle Scienze di Trento*, Cave environmental monitoring
Manfred Mudelsee, *Climate Risk Analysis, Hannover*, Statistical analysis
Nereo Preto, *University of Padova*, Statistical analysis
Denis Scholz, *Johannes Gutenberg University Mainz*, Stable isotope analysis
Andrea Schröder-Ritzrau, *University of Heidelberg*, Radiocarbon analysis
Andrea Somogyi, *European Synchrotron Radiation Facility*, Beamline trace element analyses
Christoph Spoetl, *University of Innsbruck*, Stable isotope analysis
Jean Susini, *European Synchrotron Radiation Facility*, Beamline sulphur analyses
Peter Thomas, *Keele University*, Dendrochronology
Peter Wynn, *University of Birmingham and University of Lancaster*, Sulphur, Sulphur isotope analysis
Michele Zandonati, *Museo delle Scienze di Trento*, Environmental monitoring and sampling

Flinders Reef, Australia

Flinders Reef is an oceanic reef in the Coral Sea off the northeast coast of Australia. It is around 120 kilometers further out than the main band of the Great Barrier Reef.

To obtain the most unbiased data possible on the impact of the Anthropocene, researchers faced the challenge of finding a site that is sensitive to global pressures while being as untouched as possible by local human influences. Since Flinders Reef is 200 kilometers from the Australian coast, it is less vulnerable to impacts from tourism and fishing than the main band of the Great Barrier Reef, making it an ideal site for this purpose.

The coral cores being used for the Anthropocene formalization process were collected between 1980 and 2017 and provide a timescale extending 500 years into the past. The top layer of the living coral is established as the present and the successive annual layers can be counted like tree rings to determine a chronology. Growing corals also continuously incorporate into their skeletons isotopes and trace elements that have been transported from all over the world via atmospheric transport and ocean currents. The onset and peak of atmospheric nuclear weapons testing, as well as the global combustion of fossil fuels, are read through measurements of carbon isotopes incorporated in the coral skeleton. Sea-surface temperatures and regional evaporation and precipitation patterns are derived from precise measurements of variations in oxygen isotopes stored in the coral.

GSSP Candidate
FLI01A: Flinders Reef, Australia

Principal Investigator:
Jens Zinke, *University of Leicester*

Contributing Scientists/ Researchers:
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Arnoud Boom, *University of Leicester*, Stable isotope analysis
Neal Cantin, *Australian Institute of Marine Science*, Core collection and analysis
Adam Cox, *University of Leicester*, ICP-MS analysis
Andy Cundy, *University College London*, Plutonium isotope analysis
Nicolas Duprey, *Max Planck Institute for Chemistry Mainz*, Nitrogen isotope analysis
Grace Frank, *Australian Institute of Marine Sciences*, Core collection and analysis
Irka Hajdas, *ETH Zurich*, Radiocarbon analysis
Janice Lough, *Australian Institute of Marine Sciences*, Core collection and analysis
Alfredo Martinez-Garcia, *Max Planck Institute for Chemistry Mainz*, Nitrogen isotope analysis
Sarah Roberts, *University College London*, SCP analysis
Neil Rose, *University College London*, SCP analysis
Sue Sampson, *University of Leicester*, ICP-MS analysis
Genna Tyrell, *University of Leicester*, Stable isotope analysis
Handong Yang, *University College London*, 210Pb, 137Cs isotope analysis

Karlsplatz, Wien Museum, Vienna, Austria

Karlsplatz is a square in Austria's capital city, Vienna. Today it is home to the Wien Museum, adjacent to which is the research site. In 2019, renovations of the museum exposed the urban sediments that are now being studied as an auxiliary stratotype for the Anthropocene. The sediments at the Karlsplatz site are a mixture of rubble, gritty soils and technofossils including shards of glass and relics of the Second World War. Remains, descriptions and photographs of the site's different historical stages allow the various excavated layers to be dated with a resolution of five to twenty years, especially within the more recent layers that cover the proposed Holocene–Anthropocene transition.

The walls and basement of a market hall (built 1921–22) form the base for the Anthropocene stratigraphic section. The Second World War rubble—which fills the remains of this construction—contains significantly high concentrations of lead, zinc and copper. The rubble and the overlying finer-grained artificial ground and soil represent a few years of ongoing renovation after 1945. In the upper soil layers (up to 1959, the year of the opening of the museum), high concentrations of radionuclides appear, reflecting fallout from atmospheric nuclear bomb testing. The appearance of these markers in coarse urban anthropogenic sediments of big cities demonstrates the globally synchronous appearance of these radionuclides, which makes them exemplary for defining the Anthropocene.

Unlike the other sites being studied for markers of the Anthropocene, the Karlsplatz site is not a candidate GSSP since it does not fulfill all the criteria needed to define the lower boundary of a geological epoch, as specified by the International Commission on Stratigraphy. There are no annual layers in anthropogenic sediments, since deposition rates are highly variable and the layers can get mixed and reworked during different construction phases.

GSSP Candidate
2019_26: Karlsplatz, Wien Museum, Vienna, Austria

Principal Investigator:
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Contributing Scientists/ Researchers:
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Veronika Koukal, *University of Vienna*, Trace metal analysis
Kira Lappé, *University of Vienna*, GIS modeling, archaeology
Constance Litschauer, *Wien Museum*, Site archaeology
Maria Meszar, *University of Vienna*, Lithostratigraphy, trace metal
Martin Mosser, *Wien Museum*, Archaeological stratigraphy
Nikolaos Piperakis, *Wien Museum*, Site archaeology
Janis Wolf, *University of Vienna*, Radionuclide analysis

Institutions/Funding bodies:
University of Vienna, Austria
Vienna Municipal Department 29- Road Management and Construction, Austria
WWTF - Vienna Science and Technology Fund, Austria

San Francisco Estuary, USA

Since the discovery of gold in California in 1848, San Francisco Bay has undergone rapid development to become the largest port on the Pacific West Coast. This GSSP candidate is particularly interesting because anthropogenic transformation of the bay along with increased global trade have precipitated a massive rise in non-native species: San Francisco Bay is now considered one of the “most invaded” ecosystems in the world.

Transpacific shipping over the past thirty-five years has vastly increased the proportion of previously non-native species so that neobiota now represent 97 percent of the bay’s organisms and 99 percent of its biomass. Thus, the human impact on the marine ecosystem is noticeable stratigraphically through neobiota, the increase of which coincides temporally with the Great Acceleration. One of the species that the biostratigraphic analysis focused on is the invasive *Trochammina hadai* (a foraminifera native to Japan), which, due to shipping traffic, became established in San Francisco Bay in 1983 and is now the dominant foraminifera species there. These unicellular organisms build their shells using material from the sediment, thus bodily archiving the anthropogenic markers found in the environment they inhabit. In addition to biochemical signals, the research team is examining a total of twenty-one cores for other geochemical signals including the mid-centruy nuclear bomb spike and traces of fossil fuel combustion.

GSSP Candidate
2019SFB-20A: San Francisco Estuary, USA

Principal Investigators:
Mark Williams, *University of Leicester*
Stephen Himson, *University of Leicester*

Contributing Scientists/ Researchers:
Arnoud Boom, *University of Leicester*, Carbon and nitrogen isotopes
Juan Carlos Berrio, *University of Leicester*, Pollen analysis
Peter Dal Ferro, *United States Geological Survey*, Core collection
Theresa Fregoso, *United States Geological Survey*, Core collection/surveying
Irka Hajdas, *ETH Zurich*, Radiocarbon analysis
Rachael Holmes, *University of Leicester*, Pollen analysis
Juliana Ivar do Sul, *IOW Leibniz*, Microplastic analysis
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Mary McGann, *United States Geological Survey*, Coring and micropalaeontology
Jennifer McKee, *United States Geological Survey*, Core collection
Daniel Powers, *United States Geological Survey*, Core collection
Cerin Pye, *University of Leicester*, Pollen analysis
Neil Rose, *University College London*, SCP analysis (supervision)
Sue Sampson, *University of Leicester*, Mercury analysis
Colin Waters, *University of Leicester*, PhD advisor to Stephen Himson
Ian Wilkinson, *British Geological Survey*, Ostracod analysis
Handong Yang, *University College London*, 210Pb dating (UCL)
Jan Zalasiewicz, *University of Leicester*, Stratigraphical analysis

Searsville Reservoir, USA

Searsville Reservoir is a human-made reservoir located around ten kilometers upstream from San Francisco Bay. Completed in 1892, Searsville Dam was built with the goal of forming a reservoir to secure San Francisco's water supply. However, it soon became apparent that the water was not suitable for drinking, and nearby Stanford University acquired the reservoir in 1919. It is now part of the university's Jasper Ridge Biological Preserve. The research team has spent years studying the human and environmental history of this landscape, which is surrounded by suburban settlements.

Since construction, the area of the reservoir behind the Searsville Dam has filled with over eleven meters of sediment, and the entire reservoir is now 95 percent silted up. The dam can no longer be used for local irrigation, does not provide flood protection and is not suitable for hydroelectric power generation. While the reservoir no longer fulfills any of its original intended functions, it does preserve sedimentation that is unique in its precision. The first cores taken to assess the sedimentation rate in 1998 revealed pesticide and herbicide residues and disturbance to the sediment from earthquakes. The core used for the current GSSP research was collected in 2018 and constitutes an archive of the previous 127 years. The core has been investigated using X-ray fluorescence scanning, and sediment structures have been explored using computerized tomography (CT scans). The cores are also being analyzed for microfossils (diatoms, ostracods, pollen), mercury, traces of nuclear testing, traces of fossil fuel combustion and stable carbon and nitrogen isotopes.

GSSP Candidate
JRBP2018-VC01B: Searsville Reservoir, USA

Principal Investigators:
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Irka Hajdas, *ETH Zurich*, Radiocarbon, Dating
Sergio Redondo, *Stanford University*, Mercury
Neil Rose, *University College London*, SCPs
Trisha Spanbauer, *University of Toledo*, Diatoms
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Technical and Logistical Assistants:
Nona Chiariello, *Stanford University*, Key logistics and drone photography
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Peter Dal Ferro, *United States Geological Survey*, Coring
Steven Gomez, *Stanford University*, Key logistics
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David Mucciarone, *Stanford University*, Stable isotopes
Brandon Nasr, *United States Geological Survey*, Core collection, scanning and sediment description
Daniel Powers, *United States Geological Survey*, Coring
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Simon Turner, *University College London*, SCPs
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Volunteers:
Kelly Chauvin, *Stanford University*, Coring
Tanvi Dutta Gupta, *Stanford University*, Historical data collection
Lucy Edy, *Stanford University*, Historical data collection
Mary Ellen Hannibal, *Independent scientist/ researcher*, Coring
Avery Hill, *Stanford University*, Coring
Kate Lagerstrom, *Stanford University*, Coring
Jordana Meyers, *Stanford University*, Coring
Simon Morgan, *Stanford University*, Coring
Olivia Partamian, *Stanford University*, Core sampling and sediment description
Lucas Pavan, *Stanford University*, Coring

Sihailongwan Lake, China

Located in Jilin province, northeastern China, Sihailongwan Lake is a maar formed in a crater left over from volcanic activity. Since it is fed exclusively by rainwater, it is minimally affected by local anthropogenic signals and represents an ideal location to identify atmospheric signals. The lake is approximately fifty meters deep and (like at Crawford Lake in Canada) the seasonal water chemistry, ice cover and zero bioturbation due to low oxygen levels at depth result in sediments with exceptionally well-preserved annual layers.

The sediments from the bottom of the lake were retrieved using the freeze-coring method to preserve the micro-scale structures. These layers have been investigated using high-resolution optical and X-ray fluorescence scanning and by thin-section microscopic analysis. This latter technique replaces the ice in the sediment with a resin that solidifies, enabling scientists to slice the sediment into microscope slides. The changing mineralogy, particle size and microfossil content within each layer can then be determined. Other global markers of the Anthropocene being analyzed include plutonium and iodine radioisotopes and the spectrum of black-carbon particles released from fossil fuel combustion. Complementary work on Huguangyan Maar Lake in southern China by members of the GSSP team shows that a significant increase in the concentrations of charcoal and soot particles in both lakes occurred around 1950—coinciding with the founding of the People's Republic of China, the beginning of China's industrialization and the global Great Acceleration.

GSSP Candidate
SHLW-maar: Sihailongwan Lake, China

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An Zhisheng, *Institute of Earth Environment, Chinese Academy of Sciences*

Contributing Scientists/ Researchers:
Yunning Cao, *Institute of Earth Environment, Chinese Academy of Sciences*, Organic carbon stable isotope analysis
Uli Dusek, *Energy and Sustainability Research Institute Groningen*, Soot 14C analysis
Xuewu Fu, *Guiyang Geochemistry Institute, Chinese Academy of Sciences*, Hg concentration and Hg isotope analysis
Jing Hu, *Institute of Earth Environment, Chinese Academy of Sciences*, Nitrogen stable isotope analysis
Jianghu La, *Institute of Earth Environment, Chinese Academy of Sciences*, Freeze coring, 210Pb and 137Cs analysis
Dewen Lei, *Institute of Earth Environment, Chinese Academy of Sciences*, Freeze coring, varve dating analysis
Bo Liu, *Institute of Earth Environment, Chinese Academy of Sciences*, XRF core scanning
Sarah Roberts, *University College London*, SCP analysis
Yalan Tang, *Institute of Earth Environment, Chinese Academy of Sciences*, Varve dating analysis
Huan Yao, *Institute of Earth Environment, Chinese Academy of Sciences*, Sample pre-treatment and black carbon pretreatment
Xue Zhao, *Institute of Earth Environment, Chinese Academy of Sciences*, Plutonium isotope analysis
Luyuan Zhang, *Institute of Earth Environment, Chinese Academy of Sciences*, Iodine isotope analysis

Śnieżka Peatland, the Sudetes, Poland

A peat core collected from the upland bog landscape on the southern, Polish side of Śnieżka mountain forms a GSSP candidate composed of preserved sphagnum moss. This region—in the border area of Poland, the Czech Republic and Germany—is known as the Black Triangle due to a concentration of heavy industry and high levels of air pollution. After the discovery of silver in the twelfth century, mining of metals such as cobalt, copper, nickel, silver, tin, zinc and lead served as a driver of the region's economic development, which continued until recently.

The fifty-centimeter-long Śnieżka peatland core contains a record that extends from 1931 to 2020, when it was collected on a high plateau (~1350–1450 meters above sea level) close to Śnieżka's peak. This peat archive provides a particularly useful geological record since it is exclusively rain-fed (so does not get local signals from groundwater), is on a flat plateau (so that deposited water stays in place) and has a relatively fast accumulation rate (which provides lots of material for analysis). Mount Śnieżka's position as a high peak means that the site is sensitive to signals from long-range sources as well as regional industry in the Black Triangle area. Atmospheric emissions of sulphur dioxide, nitrogen oxides and particulate matter, produced by the combustion of fossil fuels for power generation and industry, have been deposited over time at the site of the peat core. Analyses of lead isotopes combined with the history of coal production and prevailing wind patterns enabled the source of some traces to be identified.

GSSP Candidate
SN0: Śnieżka Peatland, the Sudetes, Poland

Principal Investigators:
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Arnoud Boom, *University of Leicester*, Carbon and nitrogen isotopes
Andy Cundy, *University of Southampton*, Pu isotopes (inter-laboratory comparison)
Francois De Vleeschouwer, *Universidad de Buenos Aires*, REE and PCA analysis
Jolanta Dopieralska, *Isotopic Laboratory, Poznan*, Pb stable isotopes
Mariusz Gałka, *University of Lodz*, Macrofossils analysis
Piotr Kołaczek, *Adam Mickiewicz University*, Pollen analysis
Tomasz Krzykawski, *Silesian University*, XRD analysis
Mariusz Lamentowicz, *Adam Mickiewicz University*, Testate amoebae analysis
Gael Le Roux, *Université de Toulouse*, ICP measurements
Katarzyna Marcisz, *Adam Mickiewicz University*, Testate amoebae analysis
Tomasz Mróz, *Jagiellonian University*, 210Pb analysis
Sarah Roberts, *University College London*, SCP analysis
Neil Rose, *University College London*, SCP analysis
Marcin Siepak, *Adam Mickiewicz University*, ICP measurements
Beata Smieja-Król, *Silesian University*, SEM mineralogical analysis
Michał Woszczyk, *Adam Mickiewicz University*, Carbon, nitrogen, sulphur analysis

West Flower Garden Bank Reef, USA

The Gulf of Mexico is a crucible for anthropogenic and natural environmental pressures. US petrochemical industries—which have been a significant force in the creation of the Anthropocene—dominate the economies of the gulf-bounding states, and their infrastructures pepper the low-lying, hurricane-afflicted shorelines. The Gulf of Mexico's dominant source of freshwater—the Mississippi River system—accounts for 64 percent of the total discharge to the gulf and also transports many traces of the Anthropocene.

The same geological process of salt-dome uplift that have created vast petroleum reservoirs in the Gulf of Mexico also provide a substrate for some of the most pristine coral reefs in US waters. The West Flower Garden Bank is situated on an offshore salt dome that brings coral to within twenty meters of the sea surface. This coral reef is located around 185 kilometers south of the Louisiana–Texas state line, and it is therefore far from direct human impacts from land. The core was taken from a *Siderastrea siderea,* a stony coral that grows in large boulder-like structures sometimes reaching more than two meters across. The 174-centimeter-long core constitutes an archive that extends from 1752 to 2005. It records traces of fossil fuel combustion, starting in the early 1800s with the burning of coal and then accelerating in the twentieth century with the burning of oil. Coral cores also record an indirect effect of the oil industry: an increase in barium in seawater, which comes from the discarded drilling mud used in ocean oil drilling.

GSSP Candidate
0FWFGB3-1: West Flower Garden Bank Reef, USA

Principal Investigators:
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Jens Zinke, *University of Leicester*

Contributing Scientists/ Researchers:
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Nicolas Duprey, *Max-Planck Institute for Chemistry Mainz*, Nitrogen isotope analysis
Irka Hajdas, *ETH Zurich*, Radiocarbon analysis
Achim Herrman, *Louisiana State University*, Trace element analysis
Alfredo Martinez-Garcia, *Max Planck Institute for Chemistry*, Nitrogen isotope analysis
Kylie Palmer, *Louisiana State University*, Trace element analysis
Sarah Roberts, *University College London*, SCP analysis
Neil Rose, *University College London*, SCP analysis
Niall Slowey, *Texas A&M University*, Coral core collection
Amy Wagner, *California State University, Sacramento*, Co-investigator, core collection
Mudith Weerabaddana, *Louisiana State University and University of Arizona*, Trace element analysis
Handong Yang, *University College London*, 210Pb, 137Cs isotope analysis

Participating Laboratories

The following laboratories have supported the stratigraphic exploration of the Anthropocene by analyzing specific anthropogenic markers:

^{14}C: ETH Zurich, Switzerland
Radiocarbon analysis

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Karin Wyss Heeb, *Laboratory of Ion Beam Physics, ETH Zurich*, Radiocarbon sample preparation
Lukas Wacker, *Laboratory of Ion Beam Physics, ETH Zurich*, AMS analysis

Stable C/N/O: University of Leicester, UK
Stable C/N/O isotope analysis

Principal Investigator:
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Contributing Scientists/ Researchers:
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Genna Tyrrell, *Leicester Environmental Stable Isotope Laboratory, University of Leicester*, Sample preparation

Plutonium Isotopes: University of Southampton, UK
Plutonium isotope analysis

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Phil Warwick, *University of Southampton/GAU-Radioanalytical*, Co-investigator

Contributing Scientists/ Researchers:
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Pawel Gaca, *University of Southampton/GAU-Radioanalytical*, Plutonium isotope separations and measurements
J. Andy Milton, *University of Southampton*, Plutonium isotope determinations (ICP-MS)
David Reading, *University of Southampton/GAU-Radioanalytical*, Sample pre-preparation and handling

SCPs, Mercury, Natural and Artificial Radionuclides: University College London, UK
Natural and artificial radionuclides (^{210}Pb/^{137}Cs/^{241}Am): UCL, UK

Principal Investigator:
Neil Rose, *Environmental Change Research Centre, University College London Geography*

Contributing Scientists/ Researchers:
Sarah Roberts, *Environmental Change Research Centre, University College London Geography*, SCP analysis
Simon Turner, *Environmental Change Research Centre, University College London Geography*, SCP analysis
Handong Yang, *UCL Environmental Radiometric Facility, Environmental Change Research Centre, University College London Geography*, 210Pb, 137Cs, 134Cs, 241Am radionuclide analysis

VI Evidence & Experiment. *Events and Research into the Anthropocene at the HKW*

The exhibition *Earth Indices* is presented in the framework of the project *Evidence & Experiment*, a program that throughout 2022 examines the research of the Anthropocene Working Group (AWG) and explores the geological record of the Anthropocene as well as its sociopolitical implications.

Evidence & Experiment is the culmination of a decade of work on the Anthropocene at the HKW. In a multitude of exhibitions, installations, conferences, workshops, performances and publications, the HKW has continually attempted to make the planetary and crisis-ridden transformations of the new geological epoch understandable, experienceable and shapeable.

A central element of this work is the *Anthropocene Curriculum* project, which has been developed since 2013 in cooperation with the Max Planck Institute for the History of Science, Berlin. Together with numerous project partners worldwide, the *Anthropocene Curriculum* attempts to test and enable new forms of collaborative knowledge production and cooperation between science, art and activism. The research platform www.anthropocene-curriculum.org provides a comprehensive overview of the ongoing activity of the project.

As a complement to the exhibitions and events held at the HKW within the framework of *Evidence & Experiment*, the online platform offers comprehensive information on the stratigraphic research of the AWG and its sociopolitical contextualization. Among other things, the platform hosts an extended version of the guide to the twelve sites of geological research into the Anthropocene.

Throughout its duration, *Earth Indices* will be accompanied by guided exhibition tours and public discussions. Up-to-date information on the program and schedule can be found at www.hkw.de/indices

Earth Indices will be framed by the two multi-day events *Unearthing the Present* (May 19–22, 2022) and *Where is the Planetary?* (October 12–16, 2022), which will offer an intensive exploration of the stratigraphic traces of the Anthropocene, examining them with respect to their significance for the Earth system, for political agency and for our cosmological assumptions. Up-to-date information on events within the framework of *Evidence & Experiment* can be found at www.hkw.de.

VII Biographies

Giulia Bruno studied biology, photography and filmmaking. Her work as a photographer and filmmaker focuses on issues of identity, technology, language and architecture. Furthermore, she deals with the boundary between the artificial and the natural. Her short film *Capital* was awarded first prize at Visioni Italiane 2015. In 2018, her work was selected for *ArtReview*'s Future Greats.

Linda van Deursen is a graphic designer. Together with Armand Mevis, she founded the graphic design studio Mevis & van Deursen. Since 1990, she has taught graphic design at various institutions such as the Gerrit Rietveld Academie, Amsterdam, where she was head of the department until 2015. She currently teaches at Yale School of Art and NLN at the Royal Academy of Art in The Hague.

Katrin Klingan is a literary scholar, curator and producer of art, and cultural projects. Since 2011, she has been a curator at Haus der Kulturen der Welt developing research projects that explore the entanglement between human culture, natural environments and global technologies, as well as structures of inequality and asymmetrical power relations. Together with Christoph Rosol, she heads the *Anthropocene Curriculum* (since 2013), a project that explores pathways toward a new interdisciplinary culture of knowledge and education in an experimental and collaborative manner.

Armin Linke is a photographer and filmmaker. His work is dedicated to documenting how humanity uses technologies and knowledge to transform Earth's surface. His works have been exhibited internationally including the Centre Pompidou in Paris, ZKM Karlsruhe, Venice Biennale of Architecture and many more. Currently he is a visiting professor at ISIA Urbino, Italy. His project *Image Capital* was awarded the Kubus. Sparda Art Prize in 2019.

Janek Müller works as a project developer and artistic consultant for projects between science, art and discourse and has been a dramaturg and scenographer at Haus der Kulturen der Welt since 2010. He has worked as a curator for Volksbühne am Rosa-Luxemburg-Platz, Berlin; Kunstfest Weimar; and Bauhaus Dessau Foundation, among others. He is also a curatorial advisor for the German Federal Cultural Foundation.

Bernd Scherer is the director of Haus der Kulturen der Welt (HKW), Berlin. Since 2012, Scherer has headed *The Anthropocene Project*. In his tenure at HKW, Scherer has guided its conceptual development from an institution that presented non-European cultures into one dedicated to the "curating of ideas in the making," in a world that is changing not only globally but also in planetary terms. His latest publication is *Der Angriff der Zeichen. Denkbilder und Handlungsmuster des Anthropozäns* (Matthes & Seitz).

Simon Turner is a senior research fellow in geography at University College London. He investigates the changing composition of sediments, illustrating the range of human activities that can be identified. His PhD was an investigation of coastal wetlands in Sicily. He is the scientific coordinator for the AWG and HKW's collaborative project to seek a Global Boundary Stratotype Section and Point for the Anthropocene.

VIII Acknowledgments

The organizers as well as the artists Giulia Bruno and Armin Linke would like to thank their many project partners, who generously and in a variety of ways contributed to the realization of *Earth Indices*. The long-standing collaboration of the Anthropocene Working Group with the Max Planck Institute for the History of Science, Berlin, made *Earth Indices* possible. Our special thanks goes to the scientists, institutions and laboratories involved in the stratigraphic research on the Anthropocene, as well as the teams at Haus der Kulturen der Welt and Studio Giulia Bruno & Armin Linke.

Giulia Bruno and Armin Linke especially thank:
Hannah Baader, Massimo Bernardi, Estelle Blaschke, Costanza Caraffa, Thomas Fox, Giuseppe Ielasi, Doreen Mende, Daniela Persico, Will Steffen, Alessandro Stellino, Territorial Agency (John Palmesino and Ann-Sofi Rönnskog), Vanessa Vasic-Janekovic and Davor Vidas.

IX Team & Imprint

Earth Indices
Processing the Anthropocene

This booklet accompanies the exhibition *Earth Indices. Processing the Anthropocene*

May 19–October 17, 2022, Haus der Kulturen der Welt, Berlin

Earth Indices (2020–22) is an exhibition project by Giulia Bruno, Armin Linke and HKW, in cooperation with the AWG

The AWG is an interdisciplinary group of natural and social scientists who, under the umbrella of the International Commission on Stratigraphy (ICS), are working on a proposal for the geoscientific dating of the Anthropocene and its inclusion as a time unit within the geological timescale. http://quaternary.stratigraphy.org/working-groups/anthropocene/

Earth Indices was made possible through the collaboration between Haus der Kulturen der Welt (HKW) and the Anthropocene Working Group (AWG). *Earth Indices* was realized within the framework of *Evidence & Experiment* (2019–22), a project of HKW in cooperation with the Max Planck Institute for the History of Science (MPIWG, Berlin), supported by the Federal Foreign Office within the framework of *The Anthropocene and its Implications for Archives and Museums* and the Federal Government Commissioner for Culture and the Media in accordance with a ruling of the German Bundestag.

hkw.de/en/indices

HKW

MPIWG

Federal Foreign Office

Federal Government Commissioner for Culture and the Media

Anthropocene Working Group

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Haus der Kulturen der Welt is a business division of the Kulturveranstaltungen des Bundes in Berlin GmbH.

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Haus der Kulturen der Welt is supported by

Federal Foreign Office

Federal Government Commissioner for Culture and the Media

NEU START KULTUR

X Exhibition Map

1 Main entrance

2 Main lobby

Earth Indices. Processing the Anthropocene an exhibition by Giulia Bruno and Armin Linke with the Haus der Kulturen der Welt (2020–22).
Inkjet prints on paper, transparent foil, video and audio, including 135 prints (190.4 x 157.5 cm each) and 31 diptychs (240 x 182.8 cm each) displayed on a site-specific metal structure (dimensions variable). The prints relate to the twelve sites and the laboratories involved in the stratigraphic exploration of the Anthropocene. The prints are ordered by year of extraction and analysis of the geological cores and sediments.

3 Cloakroom lobby

The core representations on display will be explored by scientists and researchers in lecture-performances during the *Opening Days* program *Unearthing the Present* (May 19–22). The inventory will expand throughout the exhibition to include further materials from the various scientific working groups.

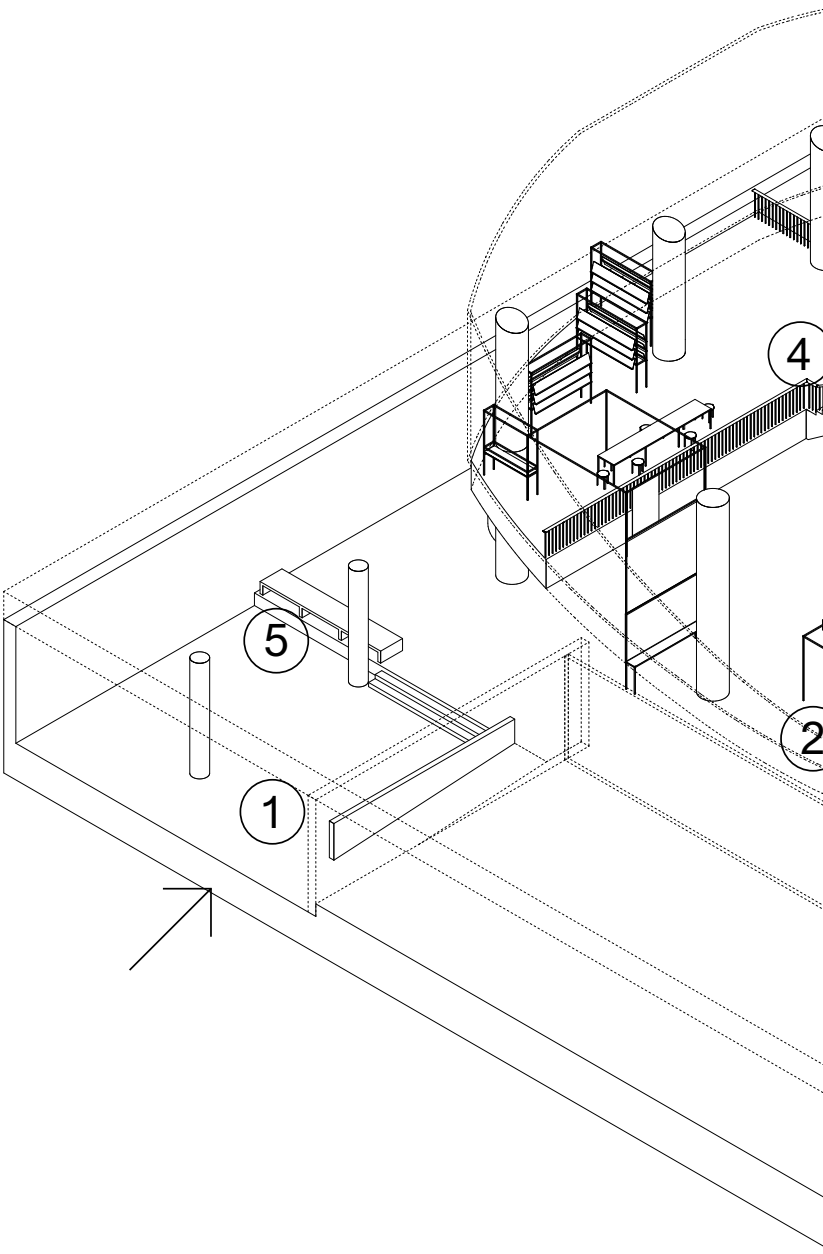
4 Auditorium lobby

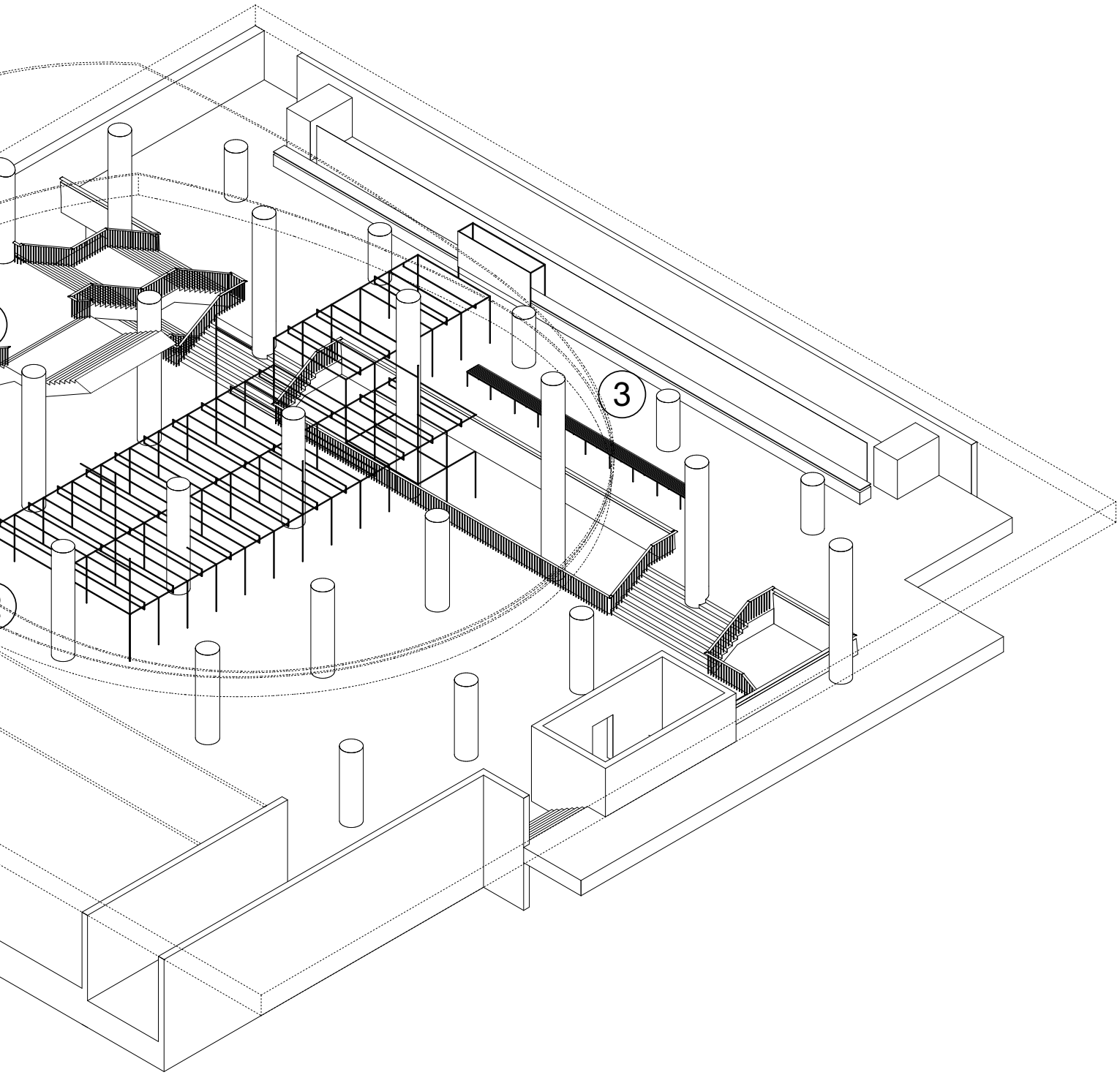
The archive of index cards presents all the materials collected in a series of dialogues between the artists Giulia Bruno and Armin Linke and the scientists of the Anthropocene Working Group. From these cards, commented on by the scientists, the artists selected images for inclusion in the sculptural installation. The archive currently consists of about 700 index cards printed in A3 format and will grow in number during and after the exhibition through new interactions with the scientists of the AWG.

A comprehensive library outlines the scientific background of the AWG research and documents the recent “geological turn” in cultural and political discourse.

The Anthropocene Curriculum research area provides further information on the AWG research project and on historical contexts, epistemic settings and conceptual interventions around the ongoing work of Anthropocene geology. Since 2013, the *Anthropocene Curriculum* has brought together scholars, artists, scientists and the public in a global network to collaboratively and experimentally explore questions of knowledge and its production in the Anthropocene.

5 Bookshop





Exhibition map design by Christine Andersen

How do we make sense of the transformations in the Earth system? Who is writing the chronicles of the planet? What are the tools and practices that allow us to read Earth’s changes?

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