Contents

A Geology of the Present

Traditionally, geology deals with events and matter from planetary deep time—with sediments and rocks whose age eludes the scales and concepts of human societies and their historiographies. For dating and describing the geological epochs, an understanding of political, economic, or technological processes and dynamics seemed inconsequential. The Anthropocene however, which—according to the Anthropocene Working Group (AWG) that has been studying this "geological epoch of humans" since 2009—began in the mid-twentieth century, is characterized by an interpenetration and acceleration of both Earth system and societal processes. Organic carbons, whose deposition took millennia and dates back millions of years, are rapidly being burned as fuel for the technosphere. In the Anthropocene, geological and historical time thus collide in a volatile present.

This present is characterized by accelerating feedback processes between societal decisions and the respective courses of action on the one hand, and planetary dynamics on the other. The processes of the Anthropocene destabilize the epistemological separation of culture and nature established in the early modern era, a separation that was integral not only for the modern order of knowledge but also for the forceful and oppressive structuring and division of the world and its societies. It was this separation that made the Anthropocene possible in the first place. The link between processes and dynamics once attributed to independent spheres is not only evident but also continuously becoming more entangled and complex in the Anthropocene.

The complexity of these feedback processes is demonstrated in an almost exemplary way in the geological sciences. It was the production of geological knowledge that made the massive extraction of fossil fuels possible, the basis of all further processes of the Great Acceleration that marks the beginning of the Anthropocene. To this day, geological knowledge is indispensable for the immense extraction of raw materials and energy sources. In the meantime, however, geologists are encountering the consequences of this development in the upper stratigraphic layers of the entire planet: from carbon and microplastic particles to the radioactive fallout from nuclear weapons testing and chemical evidence of increased carbon dioxide levels in the atmosphere.

To explain its subject matter, a geology of the present must therefore now resort to processes that go far beyond plate tectonics or karstification, extending into social, economic, and political developments. In this sense, geology stands as a model for the upheavals and challenges that disciplines, methods, and forms of knowledge production are subjected to in the Anthropocene. To make the complex convolutions of the Earth system and society in the present at all understandable and describable, it is therefore necessary not only to identify new objects of knowledge, but to develop new forms of knowledge, new practices of collaboration, and "new alphabets." Alphabets, that is, that also include the material signs and markers of planetary change and relate them to the symbolic signs of our (self-) understanding. A geology of the present knows not only about the evident connection between planet and society, but also about the deep entanglement of its own order of knowledge in specific economic, epistemological, and cosmological circumstances. It acknowledges that it participates in the production of its subject.

This publication represents a kind of map of the geological present in the early Anthropocene. From the periphery of the stratigraphic research project that seeks to formalize the new geological era, this volume assembles elements and fragments of an Anthropocene alphabet composed of terms and methods, datasets and landscapes, coordinates and photographs. The volume can be read as a handbook that records the emerging topographies and topologies of the new geological epoch.

The common reference and starting point for the contributions in this book are the stratigraphic analyses that have been carried out worldwide in recent years on behalf of the AWG. A prerequisite for the official ratification of a new geological epoch is the identification of a so-called Global Boundary Stratotype Section and Point (GSSP), also referred to as a "golden spike"—a specific location on Earth where the planetary transition from one geological era to the next can be clearly read stratigraphically. Since 2019, twelve possible locations of the Anthropocene GSSP have been investigated on behalf of the AWG. Among them are geological samples from the Antarctic ice sheet, sediments from a volcanic lake in northeastern China, tropical corals, and from a peatland on the Polish side of the Śnieżką Mountain.

These twelve "landscapes" of the Anthropocene are in no way causal for the new Earth epoch or marked particularly drastically by it. Rather, due to their geological contexts being as complex as they are contingent, these are places that are particularly well-suited to recording in detail the planetary changes of the past century. Moreover, these are sites that have been under scientific scrutiny due to institutional decisions that are equally complex and contingent. Yet perhaps because of this multiple contingency, these landscapes allow deep insights into the chronicle of the emerging new Earth epoch. The cores and material samples recovered in them, as much as the laboratories involved in their analysis act as nodes in the web of the relationships and feedbacks between the biosphere, geosphere, and technosphere that define the Anthropocene.

Simon Turner, the scientific director of the joint AWG-HKW project that aims to identify and describe a stratigraphic reference point for the Anthropocene, introduces the relevant scientific and institutional procedures underlying this process. Then, at the heart of this volume, come the descriptions of the twelve landscapes that are being examined as possible sites for a GSSP. Framing these, in fragmentary form for publication, is the preliminary mapping of this network by artists Giulia Bruno and Armin Linke in *Earth Indices*, exhibited at HKW in the summer of 2022. *Earth Indices* is a comprehensive archive of PDF files created in close collaboration between the artists and AWG scientists. These files register the actors, institutions, laboratories, and procedures involved in the stratigraphic analysis of the Anthropocene and reveal the extent of the network that was necessary to make these landscapes legible. The individual sheets of data look closely at the researches' manifold processes of exchange and coordination and shed light on the specific procedures used to produce geological evidence.

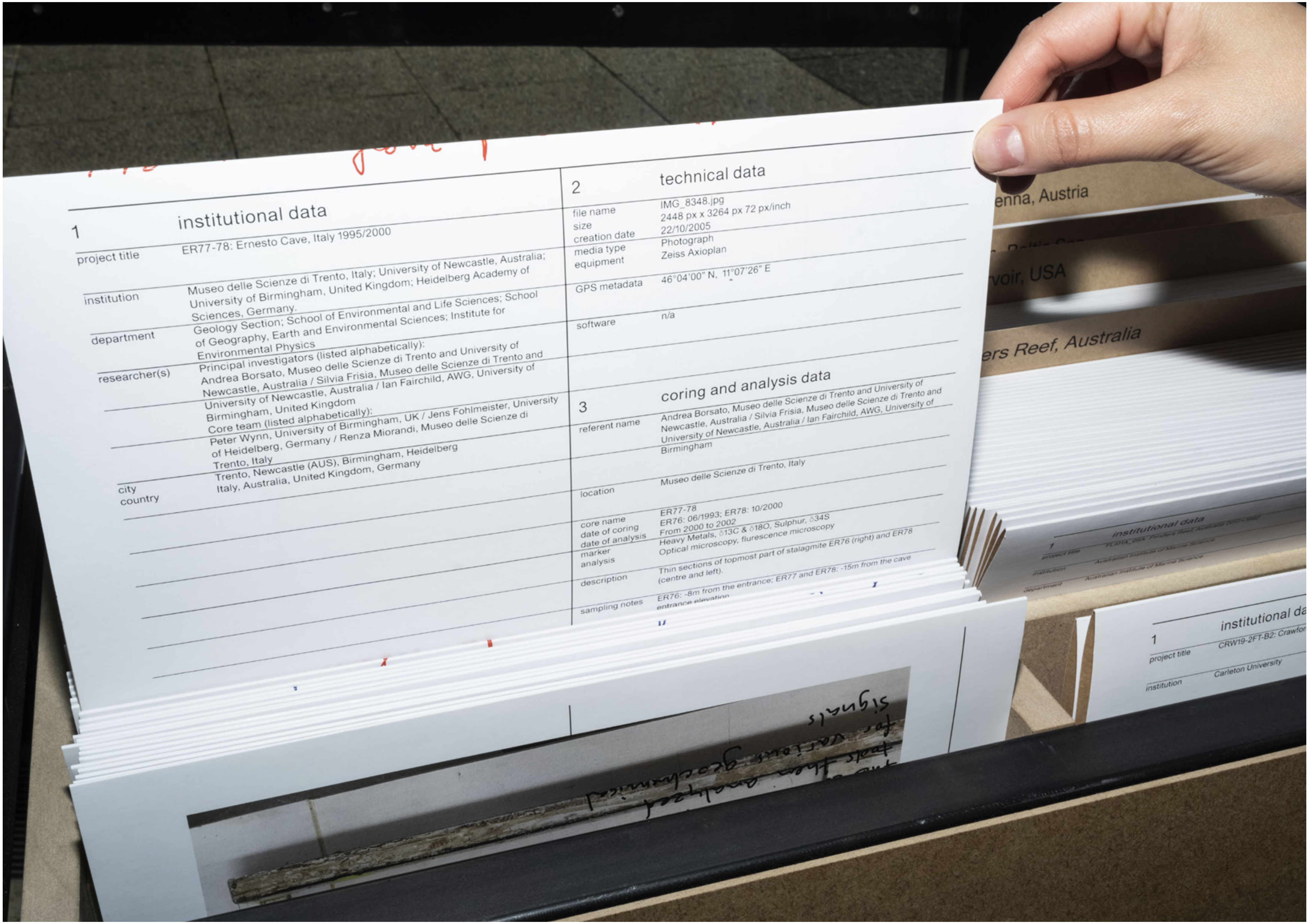
Through the juxtaposition and coexistence of landscape and laboratory, sediment and register, geology and society, this volume seeks to relate anthropogenic traces in the Earth system to the emerging body of knowledge for this new geological epoch.

For detailed information on the AWG research project please visit *anthropocene-curriculum.org*, a research platform that over the past ten years—based on an international network of scientists and artists—has explored the Anthropocene and responded to the need for new collective practices and contexts of knowledge production.

Katrin Klingan, Niklas Hoffmann-Walbeck, Georg Schäfer

Translated from the German by Faith Ann Gibson


increasing growth rate
Identified micro plastics using FTIR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project title ER77-78: Ernesto Cave, Italy 1995/2000
institution Museo delle Scienze di Trento, Italy; University of Newcastle, Australia; University of Birmingham, United Kingdom; Heidelberg Academy of Sciences, Germany.
department Geology Section; School of Environmental and Life Sciences; School of Geography, Earth and Environmental Sciences; Institute for Environmental Physics
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 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
city country Trento, Newcastle (AUS), Birmingham, Heidelberg Italy, Australia, United Kingdom, Germany
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file name IMG_8348.jpg
size 2448 px x 3264 px 72 px/inch
creation date 22/10/2005
media type Photograph
equipment Zeiss Axioplan
GPS metadata 46°04'00" N, 11°07'26" E
software n/a
3 coring and analysis data
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 Museo delle Scienze di Trento, Italy
core name ER77-78
date of coring ER76: 06/1993; ER78: 10/2000
date of analysis From 2000 to 2002
marker Heavy Metals, δ13C & δ18O, Sulphur, δ34S
analysis Optical microscopy, flurescence microscopy
description Thin sections of topmost part of stalagmite ER76 (right) and ER78 (centre and left).
sampling notes ER76: -8m from the entrance; ER77 and ER78: -15m from the cave entrance elevation
enna, Austria
voir, USA
ers Reef, Australia
institutional data
1 project title CRW19-2FT-B2: Crawfor
institution Carleton University
signals
for various
tools then analysed geochemical

Earth Indices. Processing the Anthropocene. An Archive and exhibition project by Giulia Bruno and Armin Linke

For more than ten years, Giulia Bruno and Armin Linke have been addressing the gradual formation of the Anthropocene from an artistic-ethnographic perspective. Following the first HKW-based meeting of the Anthropocene Working Group (AWG) in 2014, the two artists began to visually explore the geoscientific research process. Their work documents scientific procedures, thereby opening up the often inaccessible discourse spaces of such research and its institutions. When Haus der Kulturn der Welt embarked on a long-term project on the political and societal ramifications of the geologic Anthropocene, we invited Giulia Bruno and Armin Linke to document and explore the scientists' search for geological evidence of the new Earth epoch.

The resulting work portrays both the natural landscapes from which anthropogenic sediments are laboriously extracted and the complexities of laboratory processes and their inscription devices for transforming sediment into readable data. *Earth Indices* is a continuously growing archive that was first presented as an exhibition at HKW in the summer of 2022.

Earth Indices is both an archive and an experimental system in which it is not just the sediments of the new geological epoch that are made visible but also the instruments, procedures, and practices employed in the production of geological knowledge.

The artists have accompanied the AWG's investigations intensively, selected documents and materials from the research process, and invited the scientists to comment on them. *Earth Indices* shows photographs, sketches, scans, and datasets from all phases of the project, from views of the landscapes from which the stratigraphic samples were taken to recordings of the work processes of participating laboratories, through to microscopic photographs and jotted-down notes. Low-tech instruments and everyday utensils—shovels and plastic film—stand next to high-tech mass spectrometers and other analysis equipment:

> *Bruno, Linke:* 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 en-

> ters 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. 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.

In cooperation with the graphic 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 index cards, the works that make up *Earth Indices* register individual elements and moments in 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.

> *Bruno, Linke:* We now have about 500 images; all are composed into image PDFs containing metadata, the collected photographs, and comments. Metadata is treated as image. The 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.

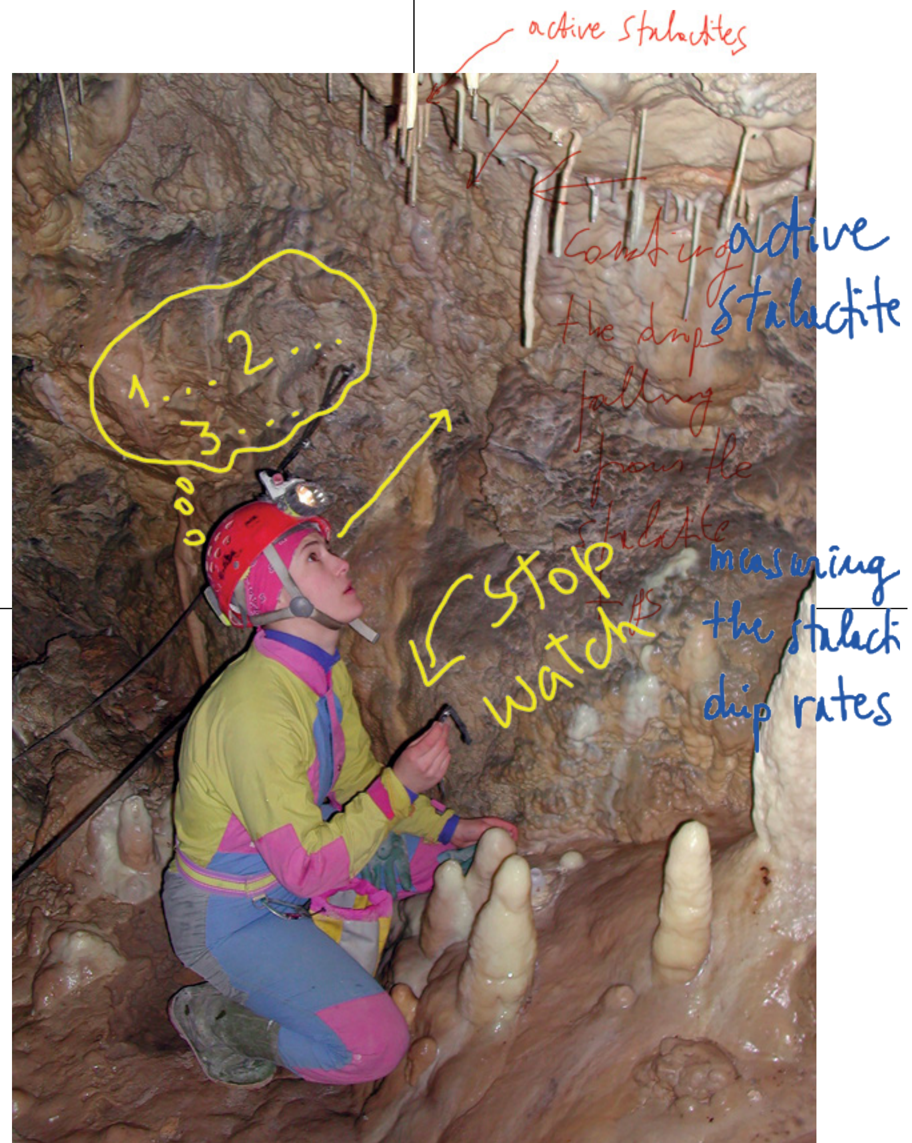
Overlaying the registry is a delicate, almost poetic, trace of the scientists' comments, instructions, and notes generated during discussions with the artists. These notes unlock the technical and anecdotal knowledge hidden in the documents, reflecting the praxis of the scientists' own work. The notes are echoes of an intense engagement with the stratigraphic material and an 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.

As disturbance, interruption, and uncertainty, the symptoms of the Anthropocene are already visible in different spheres of the Earth system and its societies. 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 proposes to fill this gap. In presenting an ensemble of Anthropocene knowledge production, *Earth Indices* attempts to make the production conditions for marking the new geological epoch visible and readable.

Earth Indices was presented at HKW from May to October 2022. Further detailed information and the complete *Earth Indices* archive can be found at anthropocene-curriculum.org.

Earth Indices: Sites of the Geological Anthropocene

What is the sensorium of the Anthropocene? From a small Canadian lake to coral reefs in the Gulf of Mexico, the Antarctic Peninsula to the peatlands of Sněžka Mountain in Poland, twelve landscapes filtering the global signals of planetary change have been selected by researchers of the Anthropocene Working Group (AWG). All sites produce sedimentary archives that store the material markers of the Anthropocene. Although the various sites are quite disparate ecosystems, they all chronicle the global signals of anthropogenic impact in their local environment. By localizing the Anthropocene in this way, these landscapes become regional witnesses of epochal Earth-system change.



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

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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

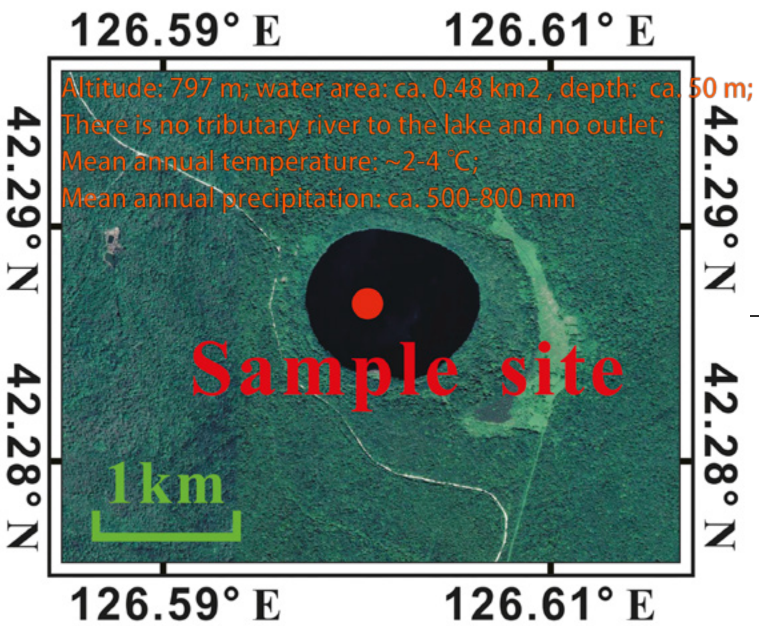
Oil rig near Flower Garden Banks in 2013. This rig has been removed down to below sea level so not to obstruct ship traffic. Lots of fish and corals have colonized the rigs.

Photo from diving Flower Garden Banks in 2012. Dr. DeLong went with the National Marine Sanctuary and a group of school teachers to teach them about coral reefs and past climate. These rocks are all live coral! Water depth is about 20 meters.

1	institutional data
project title	0FWFGB3-1: West Flower Garden Bank Reef, USA 2005
institution	Louisiana State University
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	IMG_0185.jpg 2736 px x 3648 px 72 px/inch 09/07/2012
media type equipment	Photograph Photo camera
GPS metadata	27.842485°N, 93.817084°W
software	n/a

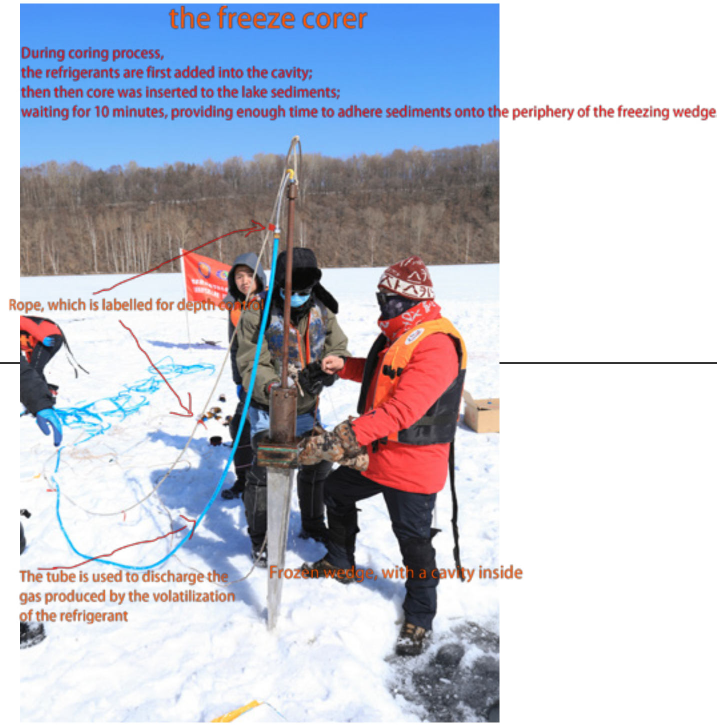
3	coring and analysis data
referent name	Kristine DeLong
location	E313 Howe Russell Geoscience Complex, Louisiana State University, Louisiana, USA
core name date of coring date of analysis	0FWFGB3-1 05/2005 n/a
marker analysis	Background info IRMS, ICP-OES, ICP-MS, AMS
description	Coral photo during diving trip to Flower Garden Banks
sampling notes	Canon Sure Shot camera
additional notes	This is a good example of the excellent coral coverage in Flower Garden Banks.
© original image	Kristine DeLong



1	institutional data
project title	SHLW-maar: Sihailongwan Lake, China 26-02-2021.
institution	Aerosol and Environmental Division State Key Laboratory of Loess & Quaternary Geology Chinese Academy of Sciences; National Natural Science Foundation of China (NSFC; Grant Number: 41991250)
department	Institute of Earth Environment
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 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, Institute of Earth Environment, Chinese Academy of Sciences (IEECAS) Jianghu Lan, Institute of Earth Environment, Chinese Academy of Sciences (IEECAS) Extended team (listed alphabetically): Tong Zhang, Institute of Earth Environment, Chinese Academy of Sciences (IEECAS) / Tianli Wang, Institute of Earth Environment, 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 (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 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 Sciences (IEECAS)
city country	Xi'an China

2	technical data
file name size creation date	The Sihailongwan Maar Lake.tif 2073 px x 2463 px 72 px/inch 20/09/2021
media type equipment	Sketch
GSP metadata	34°13'N,109°00'E
software	CorelDRAW

3	coring and analysis data
referent name	Yongming Han, Dewen Lei
location	Institute of Earth Environment, Chinese Academy of Sciences, 97 YanxiangRoad, Xi'an, Shanxi Province, China
core name date of coring date of analysis	n/a n/a n/a
marker analysis	Not specific analysis. n/a
description	四海龙湾玛珥湖 Sihailongwan Maar Lake
sampling notes	四海龙湾玛珥湖海拔797米，水域面积约 0.48 平方公里，湖底平坦,水深50米。 The lake has an attitude of 797m, with a water area of ca. 0.48km2, a flat bottom and a depth of ca. 50m.
additional notes	n/a
© original image	Yongming Han, Dewen Lei

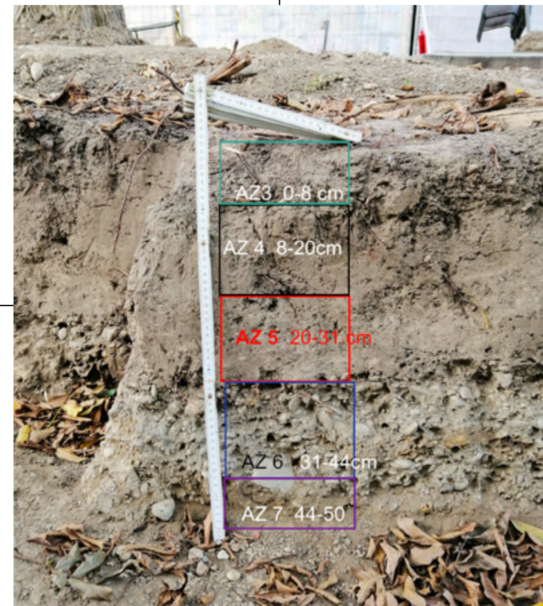


1	institutional data
project title	SHLW-maar: Sihailongwan Lake, China 26-02-2021.
institution	Aerosol and Environmental Division State Key Laboratory of Loess & Quaternary Geology Chinese Academy of Sciences; National Natural Science Foundation of China (NSFC; Grant Number: 41991250)
department	Institute of Earth Environment
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 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, Institute of Earth Environment, Chinese Academy of Sciences (IEECAS) Jianghu Lan, Institute of Earth Environment, Chinese Academy of Sciences (IEECAS) Extended team (listed alphabetically): Tong Zhang, Institute of Earth Environment, Chinese Academy of Sciences (IEECAS) / Tianli Wang, Institute of Earth Environment, 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 (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 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 Sciences (IEECAS)
city country	Xi'an China

2	technical data
file name size creation date	Freeze corer.jpg 4480 px x 6720 px 72 px/inch 26/02/2021
media type equipment	Photograph Camera (Canon EOS 5D Mark IV)
GPS metadata	42°17'N,126°36'E
software	n/a

3	coring and analysis data
referent name	Yongming Han, Dewen Lei
location	Sihailongwan Maar Lak, Jingyu Country, Baishan City, Jilin Province, China
core name date of coring date of analysis	n/a 26/02/2021 n/a
marker analysis	Not specific analysis. Freeze coring
description	用于冷冻取芯的装置。无水乙醇和干冰作为制冷剂。 Device for freezing coring. Dry ice and ethanol were added as refrigerantes.
sampling notes	该装置由三部分组成：中空的金属楔，内部用于放置制冷剂；盖子和重锤：用于密封冷冻腔室； 排气管：用于排除制冷剂挥发的气体. The device consists of three parts: a hollow metal wedge, which is used to place refrigerant inside; cover and hammer: used to seal the freezing chamber; exhaust pipe: used to remove the volatile gas of refrigerant.
additional notes	n/a
© original image	Bo Sun

Access road, excavation site Karlsplatz

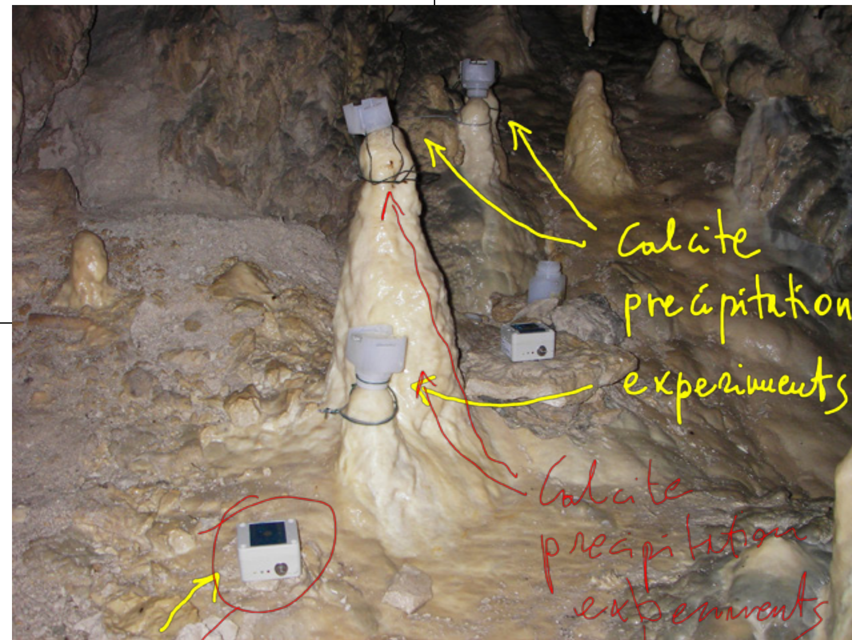


1	institutional data
project title	18/04/2019 2019_26: Karlsplatz, Wien Museum, Vienna, Austria
institution	University of Vienna & University of Applied Arts, Vienna
department	Department of Geology
researcher(s)	Michael Wagreich, Karin M. Hain, Katrin Hornek, Veronika Koukal, Kira Lappé, Constance Litschauer,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

2	technical data
file name size creation date	Karlsplatz_Profil.jpg 2100 px x 1868 px 96 px/inch 25/10/2019
media type equipment	PowerPoint Poster Camera/Computer
GSP 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 date of coring date of analysis	18-04-2019 2019_26 25/10/2019 n/a
marker analysis	n/a Accelerator mass spectrometry, VERA (Vienna Environmental Research Accelerator)
description	n/a
sampling notes	Sample with plutonium ca. 25 cm below park surface.
additional notes	n/a
© original image	Michael Wagreich, Maria Meszar

RV Elisabeth Mann Borgese



drip logger drip logger

1	institutional data
project title	ER77-78: Ernesto Cave, Italy 1995/2000
institution	Museo delle Scienze di Trento, Italy; University of Newcastle, Australia; University of Birmingham, United Kingdom; Heidelberg Academy of Sciences, Germany.
department	Geology Section; School of Environmental and Life Sciences; School of Geography, Earth and Environmental Sciences; Institute for Environmental Physics
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 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
city country	Trento, Newcastle (AUS), Birmingham, Heidelberg Italy, Australia, United Kingdom, Germany

2	technical data
file name size creation date	IMGP6218.jpg 1920 px x 2560 px 72 px/inch 17/08/2001
media type equipment	Photograph Nikon Coolpix P5000
GSP metadata	45°58’38” N, 11°39’25” E
software	n/a

3	coring and analysis data
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 n/a n/a
marker analysis	n/a n/a
description	Drip loggers and glass slides for calcite precipitation experiments.
sampling notes	n/a
additional notes	n/a
© original image	A. Borsato

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	5FF101FF-C91E-44CF-8A4D-0C6C7E0A5F49.jpg 3024 px x 4032 px 72 px/inch 13/04/2020
media type equipment	Photograph Digital camera (iPhone)
GSP 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 n/a 13/04/2020
marker analysis	n/a Display
description	Selection of photographs from the field and the ice core drill hanging in the BAS display area.
sampling notes	n/a
additional notes	n/a
© original image	Liz Thomas

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	DSC09486.jpg 4000 px x 6000 px 350 px/inch 18/02/2020
media type equipment	Photograph Camera
GPS metadata	37.41, -122.24
software	n/a

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 18/02/2020 n/a
marker analysis	Core collection Vibracoring
description	n/a
sampling notes	n/a
additional notes	To save space on the Hadai pontoon boat, a crew in the rowboat shutted core sections back to shore.
© original image	Anthony D. Barnosky

The Anthropocene as a Geological Time Unit

Pinpointing the onset of the Anthropocene in defined geological deposits is a small but significant step in understanding the evolution of our planet and our species. Recorded in layers of rock and ice, geologists can read the history of the Earth, its past conditions and environmental changes, using differences (and similarities) in rocks and sediment sequences. This breaking down of the story of a constantly changing planet into understandable, defined time periods has been a common feature in the development of human thought and has proved critical in the development of geological science.

There is no one location on Earth where the whole of geological history is recorded. 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 with time and space—is systematically recorded and ordered. Geological science, since its inception, has used stratigraphy to build a picture of our planet's formation and the search for the stratigraphic onset of the Anthropocene is a continuation of this process.

Measurements of time are critical to our understanding of the sequence of events and processes leading to the formation of rocks 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 were originally formed by plate tectonics.

As the science of stratigraphy developed, geologists used changes in rock types and the fossil record to define major units and gaps in geological time. For example, in a certain cliff, trilobite fossils (from the Cambrian period, approximately 500 million years ago) may appear

only at the base in vertically oriented deep-sea mudstones, while, abruptly above the trilobite-bearing rocks, dinosaur remains (say, from the Triassic period, around 250 million years ago) occur in terrestrial muds in a different tectonic orientation. This astonishingly abrupt change, its ability to be observed and named, would place this cliff among the sections of strata that become reference locations against which other strata with either abrupt or more gradual changes can be assessed. This was a continual process for geologists as they explored more of the planet and refined known and new stratigraphic details using increasingly advanced technological and analytical tools. The development of absolute dating methods during the twentieth century was also critical, as it greatly improved on the accuracy of former methods that relied on superposition and fossil occurrence.

These centuries of geological research are represented in the International Chronostratigraphic Chart, produced by the International Commission on Stratigraphy (ICS). This 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 eras, periods, and epochs—by identifying Global Stratotype Section and Points (GSSPs), informally known as "golden spikes." But it is not the locations of such GSSPs that is important: the Jurassic (starting within a 0.2-million-year margin of 201.3 million years ago) did not begin in Tyrol, Austria, and the Holocene (beginning 11,700 yr b2k) did not commence 1.5 kilometers below the Greenland ice cap. It is the timings and evidence recorded at these locations that provide reference sections of geological changes, changes that can be traced across the globe.

The Anthropocene Working Group (AWG) was established in 2009 and tasked by the Subcommission on Quaternary Stratigraphy (SQS), a constituent body of the ICS, with examining the Anthropocene as a chronostratigraphic unit, following the term's 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, following a long episode of human activity, a transition occurred in the mid-twentieth century, with unprecedented changes to planetary systems created by industrialization, technology advancement, and globalization—the so-called "Great Acceleration."

Since 2019, twelve sites across the planet have been intensively examined as possible locations for the Anthropocene GSSP. These dozen sites include deep lakes, marine basins, coral reefs, an estuary, a cave, an ice sheet, a human-made reservoir, a mountain peatland, and an urban archaeological site. The cores taken from them range in size from an enormous 133 meters long to a mere forty-five centimeters, and each site has unique environmental and geological characteristics. 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 weapons testing, fossil fuel combustion, industrialization, agriculture, and ecosystem change.

Locating geological sections that record a century or more in enough detail so that individual years can be identified requires a deep understanding of the conditions and characteristics of potential sites. Fortunately, scientists have been studying such sites and recent geological successions in order to track environmental and climatic conditions for a while, so, in 2016, members of the AWG began reviewing the existing literature to determine whether environmental archives containing proposed markers for the Great Acceleration existed with high enough resolution to see annual changes. A further constraint stemmed from the requirement for GSSP locations to allow for future research so, since most analytical work is destructive, groups needed to ascertain whether large enough samples existed for multiple analyses to occur whilst still leaving sufficient core intact for future study. 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 from around the world 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 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.

In 2022, we are at a critical moment in the process of defining the Anthropocene. In May 2022, AWG researchers presented the results of their analysis at Haus der Kulturen der Welt in Berlin. In early 2023, the AWG are voting to select the most suitable site 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.

Ending the Holocene epoch by placing the Anthropocene GSSP in the mid-twentieth century is a continuation of geological science in its attempt understand the formation of our planet. It is not a celebration of some predestined journey of human thought and activity; it is rather recognition that, resulting from the accelerated and unparalleled human activity of recent history, a near globally synchronous change in the Earth system has been imprinted into global stratigraphy.

IUGS

INTERNATIONAL CHRONOSTRATIGRAPHIC CHART

www.stratigraphy.org

International Commission on Stratigraphy

v 2022/10

Eonothem / Eon	Erathem / Era	System / Period	Series / Epoch	Stage / Age	numerical age (Ma)
					present
Phanerozoic	Cenozoic	Quaternary	Holocene	U/L Meghalayan	0.0042
				M Northgrippian	0.0082
				L/E Greenlandian	0.0117
			Pleistocene	U/L *Upper*	0.129
				M Chibanian	0.774
				L/E Calabrian	1.80
				Gelasian	2.58
		Neogene	Pliocene	U/L Piacenzian	3.600
				L/E Zanclean	5.333
			Miocene	U/L Messinian	7.246
				Tortonian	11.63
				M Serravallian	13.82
				Langhian	15.97
				L/E Burdigalian	20.44
				Aquitanian	23.03
		Paleogene	Oligocene	Chattian	27.82
				Rupelian	33.9
			Eocene	Priabonian	37.71
				Bartonian	41.2
				Lutetian	47.8
				Ypresian	56.0
			Paleocene	Thanetian	59.2
				Selandian	61.6
				Danian	66.0
	Mesozoic	Cretaceous	Upper	Maastrichtian	72.1 ±0.2
				Campanian	83.6 ±0.2
				Santonian	86.3 ±0.5
				Coniacian	89.8 ±0.3
				Turonian	93.9
				Cenomanian	100.5
			Lower	Albian	~ 113.0
				Aptian	~ 121.4
				Barremian	~ 129.4
				Hauterivian	~ 132.6
				Valanginian	~ 139.8
				Berriasian	~ 145.0

Eonothem / Eon	Erathem / Era	System / Period	Series / Epoch	Stage / Age	numerical age (Ma)
					~ 145.0
Phanerozoic	Mesozoic	Jurassic	Upper	Tithonian	149.2 ±0.7
				Kimmeridgian	154.8 ±0.8
				Oxfordian	161.5 ±1.0
			Middle	Callovian	165.3 ±1.1
				Bathonian	168.2 ±1.2
				Bajocian	170.9 ±0.8
				Aalenian	174.7 ±0.8
			Lower	Toarcian	184.2 ±0.3
				Pliensbachian	192.9 ±0.3
				Sinemurian	199.5 ±0.3
				Hettangian	201.4 ±0.2
		Triassic	Upper	Rhaetian	~ 208.5
				Norian	~ 227
				Carnian	~ 237
			Middle	Ladinian	~ 242
				Anisian	247.2
			Lower	Olenekian	251.2
				Induan	251.902 ±0.024
	Paleozoic	Permian	Lopingian	Changhsingian	254.14 ±0.07
				Wuchiapingian	259.51 ±0.21
			Guadalupian	Capitanian	264.28 ±0.16
				Wordian	266.9 ±0.4
				Roadian	273.01 ±0.14
			Cisuralian	Kungurian	283.5 ±0.6
				Artinskian	290.1 ±0.26
				Sakmarian	293.52 ±0.17
				Asselian	298.9 ±0.15
		Carboniferous – Pennsylvanian	Upper	Gzhelian	303.7 ±0.1
				Kasimovian	307.0 ±0.1
			Middle	Moscovian	315.2 ±0.2
			Lower	Bashkirian	323.2 ±0.4
		Carboniferous – Mississippian	Upper	Serpukhovian	330.9 ±0.2
			Middle	Visean	346.7 ±0.4
			Lower	Tournaisian	358.9 ±0.4

Eonothem / Eon	Erathem / Era	System / Period	Series / Epoch	Stage / Age	numerical age (Ma)
					358.9 ±0.4
Phanerozoic	Paleozoic	Devonian	Upper	Famennian	372.2 ±1.6
				Frasnian	382.7 ±1.6
			Middle	Givetian	387.7 ±0.8
				Eifelian	393.3 ±1.2
			Lower	Emsian	407.6 ±2.6
				Pragian	410.8 ±2.8
				Lochkovian	419.2 ±3.2
		Silurian	Pridoli		423.0 ±2.3
			Ludlow	Ludfordian	425.6 ±0.9
				Gorstian	427.4 ±0.5
			Wenlock	Homerian	430.5 ±0.7
				Sheinwoodian	433.4 ±0.8
			Llandovery	Telychian	438.5 ±1.1
				Aeronian	440.8 ±1.2
				Rhuddanian	443.8 ±1.5
		Ordovician	Upper	Hirnantian	445.2 ±1.4
				Katian	453.0 ±0.7
				Sandbian	458.4 ±0.9
			Middle	Darriwilian	467.3 ±1.1
				Dapingian	470.0 ±1.4
			Lower	Floian	477.7 ±1.4
				Tremadocian	485.4 ±1.9
		Cambrian	Furongian	*Stage 10*	~ 489.5
				Jiangshanian	~ 494
				Paibian	~ 497
			Miaolingian	Guzhangian	~ 500.5
				Drumian	~ 504.5
				Wuliuan	~ 509
			Series 2	*Stage 4*	~ 514
				Stage 3	~ 521
			Terreneuvian	*Stage 2*	~ 529
				Fortunian	538.8 ±0.2

Eonothem / Eon	Erathem / Era	System / Period	numerical age (Ma)
			538.8 ±0.2
Precambrian – Proterozoic	Neo-proterozoic	Ediacaran	~ 635
		Cryogenian	~ 720
		Tonian	1000
	Meso-proterozoic	Stenian	1200
		Ectasian	1400
		Calymmian	1600
	Paleo-proterozoic	Statherian	1800
		Orosirian	2050
		Rhyacian	2300
		Siderian	2500
Precambrian – Archean	Neo-archean		2800
	Meso-archean		3200
	Paleo-archean		3600
	Eo-archean		4000
Precambrian – Hadean			4567

Units of all ranks are in the process of being defined by Global Boundary Stratotype Section and Points (GSSP) for their lower boundaries, including those of the Archean and Proterozoic, long defined by Global Standard Stratigraphic Ages (GSSA). Italic fonts indicate informal units and placeholders for unnamed units. Versioned charts and detailed information on ratified GSSPs are available at the website http://www.stratigraphy.org. The URL to this chart is found below.

Numerical ages are subject to revision and do not define units in the Phanerozoic and the Ediacaran; only GSSPs do. For boundaries in the Phanerozoic without ratified GSSPs or without constrained numerical ages, an approximate numerical age (~) is provided.

Ratified Subseries/Subepochs are abbreviated as U/L (Upper/Late), M (Middle) and L/E (Lower/Early). Numerical ages for all systems except Quaternary, upper Paleogene, Cretaceous, Jurassic, Triassic, Permian, Cambrian and Precambrian are taken from 'A Geologic Time Scale 2012' by Gradstein et al. (2012), those for the Quaternary, upper Paleogene, Cretaceous, Triassic, Permian, Cambrian and Precambrian were provided by the relevant ICS subcommissions.

Colouring follows the Commission for the Geological Map of the World (www.ccgm.org)

CCGM CGMW

Chart drafted by K.M. Cohen, D.A.T. Harper, P.L. Gibbard, N. Car

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URL: http://www.stratigraphy.org/ICSchart/ChronostratChart2022-10.pdf

Twelve Views of the Anthropocene

Antarctic Peninsula, Antarctica

Core name:	PALMER
Geographical coordinates:	73°51′36″S, 065°27′36″W
Core Type:	ice core
Length:	133 meters

The Antarctic Peninsula—the northernmost arm of the planet's coldest, most remote continent—extends into the Southern Ocean toward the tip of South America. The peninsula is 522,000 square kilometers, and, alongside mountains, glaciers, and extremely high winds, it is home to penguins, seals, humpback whales, and scientists living at research stations established by eighteen different nations. The Antarctic Peninsula is one of the fastest-warming places on Earth, having already undergone an average annual temperature increase of between two and three degrees centigrade. It is also experiencing increased precipitation due to warming, with snowfall exceeding four meters per year in some areas. In recent decades, several of the peninsula's ice shelves have collapsed, ice flow velocities have increased, and glaciers are thinning. At present, the peninsula is losing ice mass at a rate of around 330 gigatons per year, and, if all the ice were to melt, global mean sea levels would rise by twenty-four centimeters.

Humans did not discover Antarctica until the early nineteenth century, and they did not explore it until the early twentieth, making it the last continent on Earth to be mapped and studied. However, its remoteness and lack of permanent habitation does not mean its delicate ecosystems have been immune to human influence. Heavy fishing in the waters surrounding the peninsula, research station infrastructure and pollution, oil spills, tourism, and invasive species (unintentionally brought by humans) have all impacted the native wildlife, while the climate crisis is disrupting the weather patterns, ocean currents, and ice sheets upon which the polar ecosystem depends.

In December 2012, Liz Thomas (head of the ice-core research group at the British Antarctic Survey – BAS) and her team collected an ice core from the Antarctic Peninsula ice sheet that measures 133 meters in length and constitutes a record that extends back to 1621. This is currently the longest ice-core record from the peninsula, with almost 400 years of pre-Anthropocene data with which to compare the mid-twentieth-century changes. The temperature at the core site (1,897 meters above sea level) ranges from minus thirty degrees centigrade during the winter to minus fifteen in the summer—cold enough that the area remains free from surface melt, which might otherwise damage the paleoclimate record.

Ice sheets form when snow accumulates and becomes compacted into dense glacial ice. The layers of ice—and the air bubbles trapped within them—preserve particles of dust, ash, pollen, and trace elements, as well as atmospheric gases such as carbon dioxide and methane from the time the snow was deposited. The air trapped in ice cores is the only direct record we have of atmospheric compositions that predate modern measurements, and ice cores thus form valuable archives that allow scientists to reconstruct past conditions, including surface temperature, amount of snowfall, ocean and atmospheric circulation, sea ice extent, and marine productivity. Long-range records are also kept in the trace elements found in the ice that include, for example, pollution or volcanic eruptions. In the Palmer core, huge peaks in sulfur correlate with known volcanic eruptions, while the polar seasons—twenty-four-hour sunlight in high summer and twenty-four-hour darkness in deep winter—are also legible through various markers: levels of hydrogen peroxide (which is degraded by sunlight), sulfur compounds and biological traces (which vary according to seasonal marine productivity), and stable water isotopes (which vary according to surface temperature). These volcanic and seasonal signals allow scientists to produce a very high resolution and accurate age-scale (with a margin of error of just three months) by counting the annual layers.

The ice archive contains a variety of anthropogenic signals, such as the effects of global warming and industrial pollution. A clear ongoing rise in average surface temperature (recorded by stable water isotopes) is visible from the 1950s, with increases in the 1990s corresponding to the breakup of the Larsen Ice Shelf (this shelf extends along the east coast of the Antarctic Peninsula and has reduced in size from 85,000 square kilometers to 67,000 square kilometers in the last thirty years). While comparable high surface temperatures are visible throughout the core (that is, going back to the seventeenth century), it is only after 1950 that the warmer temperatures are consistent

enough to lead to the disintegration of the ice shelf. Similarly, the core also records a big rise in both extreme precipitation events and annual snowfall (calculated by measuring the varying thickness of annual layers) from the mid-twentieth century onward, with the latter increasing to almost four times the preindustrial average. The increase in snowfall is driven by changes in atmospheric circulation caused by global warming.

Levels of methane—a greenhouse gas with eighty times the warming effect of carbon dioxide—increase from 700 parts per billion (ppb) in the preindustrial era to 1,800 ppb in the 1990s, with an acceleration in the rate of increase observable around the 1950s caused by human agriculture and industry. Spheroidal carbonaceous particles (SCPs)—a by-product of high-temperature fossil fuel combustion—have also been identified in the Palmer ice core, with the earliest particle deposited in 1936. Although SCPs appear in the core only in small numbers, this is the first ice-core evidence that fly ash has reached the Antarctic continent. The first evidence of plutonium (239+240 Pu) in the Palmer ice core occurs in the ice layer corresponding to the years 1945–46. This is coincident with the earliest atomic weapon tests in July 1945. The concentrations of 239+240 Pu increased after 1945, reaching a maximum in the ice layer corresponding to 1960–61.

While atmospheric aerosols and pollutants reach mainland Antarctica only in very small concentrations, the meteorology of the peninsula means that the ice there captures anthropogenic changes in climate, land use, and heavy industry in the southern hemisphere landmasses and beyond. The peninsula acts as a barrier to the southern westerly wind (SWW)—a belt of strong winds that nearly constantly encircles Antarctica and carries atmospheric aerosols and pollutants from distant landmasses—while a prominent low-pressure system ensures constant snow deposits that create a continuous record in the ice sheet.

The 133-meter-long core was cut into eighty-centimeter-long sections on site and then transported to the BAS ice-core laboratories at the University of Cambridge, UK, for analysis. Various chemical, isotopic, and gas measurements were made using a bespoke continuous-flow analysis (CFA) method. This method involves melting the core from one end with a hot plate, discarding the outer material (which might be contaminated through contact during sampling or transportation), and then directing the inner material through various instruments for analysis. The core was subjected to the following analyses: stable water isotopes (oxygen and deuterium), conductivity, dust, major ions and chemical species (including sulfate, nitrate, ammonium, chloride, methane sulfonic acid, sodium, calcium, magnesium, and potassium), and methane.

Paleoclimatologist Liz Thomas is head of the ice-core research group at the BAS, an active research team comprising senior and postdoctoral researchers (Daniel Emanuelsson, Diana Vladimirova, Jack Humby, and Dieter Tetzner), analytical chemists, technicians, ice-core drilling engineers, and PhD students. Thomas has led several expeditions to Antarctica and the Arctic (Greenland and Svalbard) and recently led an expedition to drill the first ever ice cores from the subantarctic islands. Her research has improved our understanding of Antarctic surface mass balance, highlighted the significance of the Antarctic Peninsula, and quantified the contribution of twentieth-century changes to global sea levels.

Beppu Bay, Japan

Core name:	BMC21 S1-5
Geographical coordinates:	33°16′66″N, 131°32′24″E
Core Type:	marine basin sediment core
Length:	94.2 cm

Beppu Bay is on the northeast coast of Kyushu, one of Japan's five main islands. It opens onto the Seto Inland Sea, which sits between Kyushu and two other Japanese islands, Honshū and Shikoku, and is connected to the Pacific Ocean via two channels. The bay was formed in a tectonic depression between two faults around seven million years ago, currently covering 475 square kilometers with an average water depth of thirty-six meters. It is bordered by two cities: Beppu with a population of around 120,000, and Ōita, with around 470,000. Several rivers run through the cities before draining into the bay, bringing runoff from urban areas and industrial zones that include several steel, petrochemical, and electronics plants. Kyushu is home to Japan's most active volcano, Mount Aso, and the geothermal and tectonic activity manifests in numerous hot springs in Beppu, which make the city a popular tourist attraction.

Connected to mainland Asia until around 12,000 years ago, what is now the Japanese archipelago has been inhabited by hominids since the Pleistocene. Kyushu is the site of the oldest known Jômon pottery fragments, dating from 12,700 years ago, and the first rice paddy farming by the Yayoi people around 10,000 years ago. After the rapid economic growth in Japan in the mid-twentieth century, the population and urban area of Ōita increased abruptly, while Beppu saw growth owing to the rapid development of spa facilities. Along with a substantial increase in fruit orchards around Beppu Bay, this industrialization and urbanization led to a rise in the quantity of pollutants and fertilizers entering the bay, which caused unprecedented eutrophication of the water from the 1960s.

In June 2021, the research team (headed by Michinobu Kuwae and Yoshiki Saito) collected the 94.2-centimeter-long GSSP-candidate core from the deepest point of the Beppu Bay basin, at a depth of seventy meters. Sedimentation rates are relatively high (around eight millimeters per year), which provides a substantial amount of material for analysis and creates a long-running, high-resolution record for study. There is a sill at the mouth of the bay (at fifty meters deep) that constrains tidal mixing and results in anoxic water below this depth from spring to late fall. The undisturbed, anoxic water enables subannual sediment layers, or varves, to form. A calendar-year chronology for the cores is established by counting these layers and checking them against lead-210 dating. The slopes around the deepest part of the basin are very steep and collapse during earthquakes and floods, producing turbidites in the sediment layers, which—owing to records of historical flood events in the Ōita and Ōno rivers—can be used as an additional time control. Fortunately, the Holocene–Anthropocene transition period has not been disturbed by such events.

The core holds records that extend back 130 years and includes local and global signals of anthropogenic impacts. There is a sharp increase in spheroidal carbonaceous particles (SCPs) starting in 1965, which corresponds to industrial developments in Ōita—including the establishment of a petroleum plant in 1964 and a smelting factory in 1972. The 1960s also sees peaks in dichlorodiphenyltrichloroethane (DDT) and hexachlorocyclohexane (HCH) derivatives as a result of increased pesticide use; a rise in polychlorinated biphenyls (PCBs) due to industrial use; and a sharp increase in microplastics. Furthermore, the late 1960s sees various biotic changes as a result of eutrophication in the area: an increased concentration of diatom frustules, an increase in phytoplankton productivity, a notable change in phytoplankton communities, and a change in pollen diversity. These variations correspond to an increase in the local human population and land-use changes that led to higher levels of nutrients, pollutants, and fertilizers ending up in the bay. By the late 1960s, eutrophication also led to high sulfur concentrations due to hypoxia in the deepest layer of water. Evidence of industrialization is also recorded in the Japanese anchovy scales found in the core: increased atmospheric carbon dioxide from fossil fuel combustion is evident through a decrease in carbon-13 in the scales after 1952, while local inputs of sewage, chemical waste, and nitrogen fertilizers are visible as an increase in nitrogen isotopes in the scales after 1952. Both values are unprecedented in the 300 years before 1950.

Mid-twentieth-century nuclear weapons testing is evidenced with a slight rise in plutonium-239 and plutonium-240 in 1952, a sharp increase in 1958, and a peak in 1962–66. The uranium isotope signatures show a similar trend, with an initial rise around 1951, a sharp increase in 1957, and a peak in 1961–66. There is also a regional signature from the Marshall Islands weapons tests, with a peak in the plutonium isotope ratio around 1958 that can be correlated with signals in coral cores from close to the islands. The cesium-137 fallout maximum is visible in 1955, with a second peak in 2011 that corresponds to the Fukushima nuclear disaster. Meanwhile, carbon-14 in fish scales increases rapidly in 1963, which shows that radioactive contamination from nuclear weapons testing had reached the higher levels of the marine ecosystem food chain by this point.

The cores were also subjected to the following analyses: biotic markers (chlorophyll a, diatoms, algal pigments, biogeochemical indices, total sulfur, and palynomorphs); sediment geochemistry; lead isotopes; organic compounds (PCBs, DDTs, and brominated flame retardants (BFRs)); microplastics; stable carbon and nitrogen isotopes; and varve chronology via diatoms in seasonal laminae.

The research team formed following the annual meeting of the Japan Association for Quaternary Research on August 24, 2019, during which Michinobu Kuwae presented the Beppu Bay sediments as a potential GSSP of the Anthropocene. Yoshiki Saito, a member of the AWG, encouraged him to establish a Beppu Bay GSSP research team.

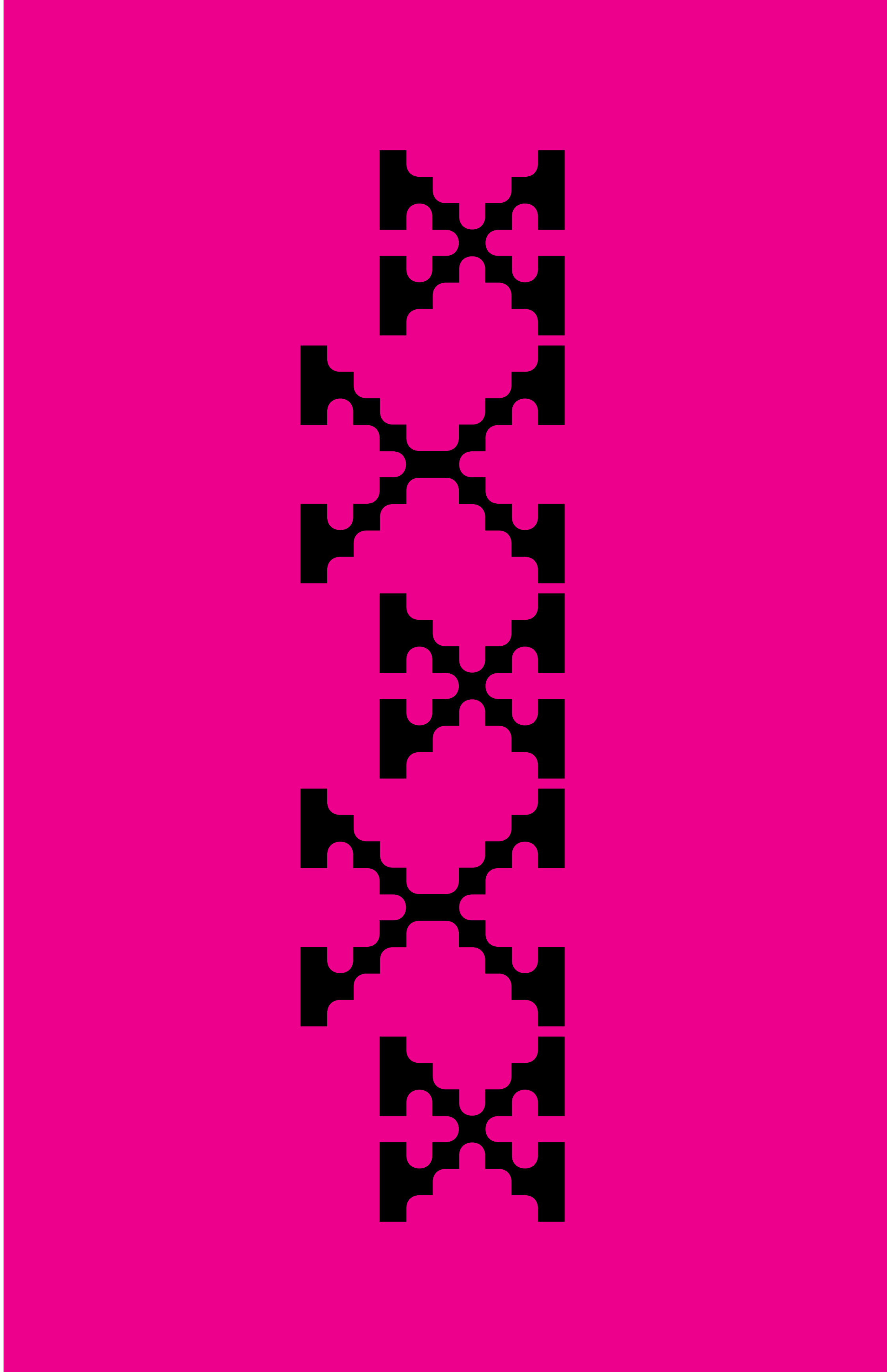
Crawford Lake, Canada

Core name:	CRW19-2FT-B2
Geographical coordinates:	43°28′10″N, 79°57′12″W
Core Type:	lake sediment core
Length:	69 cm

Crawford Lake is a small, deep lake within a protected conservation area in Southern Ontario, Canada. It is surrounded by young cedar-dominated woodland (the old-growth forest was cleared by colonizers in the mid-nineteenth century) and numerous recreational hiking trails. In the 1960s, corn pollen and other cultigens was discovered in 600-year-old sediments, and archaeologists began excavating the site in 1972 for evidence of settlement. Since then, remains of Indigenous longhouses (and more than 10,000 artifacts) have been found approximately 200 meters from the lake; these were occupied by several hundred people during at least two distinct phases between the late thirteenth and late fifteenth centuries. Three longhouses have now been reconstructed at the site and serve as education and exhibition spaces.

The lake is four kilometers from the small community of Campbellville, and thirty kilometers from the industrial city of Hamilton, which has been a major steel manufacturing center since the mid-twentieth century. The Crawford Lake Conservation Area has been administered by Conservation Halton since 1969, giving it protected status. The organization has applied for funding to build a new educational area and visitor center and to otherwise improve this important site. Crawford Lake may also be renamed in the Wyandot language to reflect its past as an Indigenous settlement.

The lake is situated in a karstic limestone landscape and fills a sinkhole created by the dissolution of underground rock. Because of the lake's great depth (twenty-four meters) relative to its surface area (2.4 hectares), it is what is known as a meromictic lake: the dense bottom layer of water (called the monimolimnion) does not mix with—and has different water chemistry to—the less dense upper layers (the mixolimnion). The isolated bottom layer of water remains undisturbed, enabling the accumulation of clearly laminated varves (layers of sediment), which can provide precise information about the time in which they were deposited. Usually, the bottom layer of a meromictic lake is anoxic, since oxygenated water does not circulate from the



upper waters. The discovery of oxygen-demanding benthic organisms proved that Crawford Lake is exceptional: the monimolimnion is fed by oxygenated groundwater. This phenomenon is important for geologists, as such conditions should ensure that any plutonium from mid-century nuclear weapons testing will remain in the sediment layer in which it was deposited (whereas, in anoxic water, the plutonium could remobilize and thus disrupt the chronology of the record).

The Crawford Lake core—which was collected by Francine McCarthy and her team in February 2019—tells a story of anthropogenic impacts from ancient Indigenous settlements (in the thirteenth to fifteenth centuries), through settler-colonial communities (from the mid-nineteenth century), to postindustrial global events (beginning in the mid-twentieth century). The sediments show how local, historic anthropogenic impacts can be differentiated from those that mark the proposed geological time interval of the Anthropocene, which is concerned with a globally synchronous, broad-scale transformation in the Earth's history.

The core is characterized by alternating layers of dark organic matter (deposited in winter) and light calcite (deposited in summer), which record a high-resolution record of changes in the lake ecosystem. In 1268 CE, the first appearance of corn pollen provides evidence of Indigenous agricultural activity, coinciding with the first distinct varves. Farming in the area continues for more than 200 years, evidenced by agricultural pollen (maize and sunflower) and fungal spores from crop pathogens (such as corn smut). The agricultural activity also results in thicker varves (as more sediment was deposited), while increased algae production from a higher nutrient load resulted in lake eutrophication. In 1486, the Indigenous village was abandoned, and, without the agricultural input, the varves again become thinner for the next 400 years, until the early nineteenth century when European colonizers arrived. As a result of agriculture and logging (a lumber mill operated by the lake from 1883 to the 1920s), thick varves (of between one and three millimeters) containing dark-gray charcoal were deposited, and there is evidence of a second phase of increased nutrient input, erosion, and eutrophication.

The "bomb pulse"—the sudden increase of carbon-14 in the Earth's atmosphere from around 1955 to 1963, caused by hundreds of nuclear weapons tests—is also evident in the sediments of Crawford Lake. Broad-scale global changes are thus preserved alongside local anthropogenic impacts. Varve-scale analysis of radionuclides in the core is ongoing, but owing to the oxygenated monimolimnion of Crawford Lake, any traces of plutonium-239 should be sharply preserved.

An eighty-nine-centimeter-long sediment core was one of several collected from the deepest point of Crawford Lake in February 2019, using the freeze-coring method, which allows the varved succession to be recovered intact. Because the varves deform slightly during slicing, the core cannot simply be cut straight through; rather, precise scalpel work is required that follows the curved lines of the varves. The freeze cores were subsampled by hand at Carleton University in Ottawa and sent to laboratories where analyses targeted indicators of environmental change, including diatom and scaled chrysophyte assemblages, fossil pigments, non-pollen palynomorphs, plutonium, radiocarbon, sediment chemistry, spheroidal carbonaceous particles (SCPs), and stable isotopes. Other sampling was performed to characterize present lake conditions, including seasonal water chemistry, hydrological measurements, and biological activity. Unfortunately, only very thin rinds of sediment are retrieved by freeze cores (especially in the upper portion of the core), which provided relatively small volumes of material for multiple laboratory analyses. Because of this, several more cores were extracted in February 2022.

Team Crawford consists of over forty researchers from nine Canadian institutions under the coordination of Francine McCarthy at Brock University, St. Catharines, Ontario. In 2018, Martin Head realized the potential of the undisturbed annual laminations in this lake as a potential Anthropocene GSSP, and two additional freeze-coring expeditions were planned to collect further material for analysis to support its candidacy. In 2019, freeze coring and subsequent curation, high-resolution imagery, and subsampling of freeze cores was coordinated by Tim Patterson.

Colleagues at Conservation Halton and the Royal Ontario Museum have been involved with research at Crawford Lake since the late 1960s. Among the many scientists who have worked on the lake is Eugene Stoermer, the biologist who helped popularize the Anthropocene hypothesis together with Paul Crutzen. The Canadian Museum of Nature in Ottawa became involved in 2019 and has agreed to archive a freeze-core face from the deep basin of Crawford Lake at its cryogenic facility, irrespective of the decision of the AWG.

East Gotland Basin, Baltic Sea

Core name:	EMB201/7-4
Geographical coordinates:	57°10′11″N, 020°04′20″E
Core Type:	deep marine basin sediment core
Length:	45 cm

The Baltic Sea is a landlocked arm of the Atlantic Ocean, enclosed between Scandinavia and the rest of Europe. The basin that today's brackish sea occupies was formed by the retreat of the Fennoscandian ice sheet (between 9,000 and 13,500 years ago). The surrounding land has been inhabited ever since, with around eighty-five million people living there today. The region has a long and rich human history: people have used the area for fishing and trade routes that have facilitated centuries of social and cultural exchange, while surrounding national boundaries have shifted as a result of political and economic forces. All this human activity has also had a significant impact on the sea's ecology. High levels of nutrient runoff from the surrounding land has resulted in the Baltic being one of the most eutrophic seas on the planet, with adverse effects on marine ecosystems. In response to the damaging effects of human activity, the Baltic Marine Environment Protection Commission (HELCOM) was founded in 1974 and has continued to make recommendations for sustainable maritime activities since then—although the health of the Baltic Sea has continued to decline.

Traces of the region's cultural, environmental, and climate history are well-preserved in the seafloor sediments—some of which lay at depths of 249 meters (in the Gotland Deep) or 459 meters (in the Landsort Deep), although the average depth of the Baltic Sea is just fifty-four meters. Scientific research on this body of water began in the 1800s, making the Baltic one of the most well-studied seas in the world. Since then, scientists have investigated many aspects of its geology and ecology, including the formation of the basin, the stratigraphic record, coastal processes, sediment dynamics, and the interaction between anthropogenic and natural processes.

The sediment core EMB201/7-4 was collected at a depth of 241 meters in December 2018 from the seafloor of the Eastern Gotland Basin in the central region of the Baltic Sea. At this depth, it is pitch black, cold (around five degrees centigrade), and the water pressure is around twenty-five times that of the surface. The seabed 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 deep water of the Baltic Sea (below the halocline between sixty and eighty meters) is very low in oxygen, making it inhospitable for most aquatic life forms. This means that the fine silt and clay of the seafloor remains largely undisturbed, preserving the organic and chemical markers deposited in the sediments.

The forty-five-centimeter-long core records a story that begins in around 1840 and continues until 2018, showing, at a depth of twenty-seven centimeters, a remarkably stark change in the visible sediments: the light-beige and gray colors toward the bottom of the core are suddenly replaced with much darker matter, which indicates a rapid change in the conditions under which the mud was deposited. This transition corresponds to an increase in organic carbon, reflecting the deoxygenation of deep waters in the Baltic Sea in the 1950s—a consequence of algal growth at the surface (related to the new-found use of industrial nitrate and phosphate fertilizers in the postwar period) and oxygen-consuming bacterial activity at depth. Analyses reveal that this change occurs in parallel to increases in geochemical markers that record the mid-twentieth-century acceleration of industrial processes, fossil fuel combustion, and pollution in the Baltic Sea and its catchment area.

The light-colored lower section of the core records from around 1840 to 1950, and these layers were laid down at a rate of 0.2 centimeters per year. From around 1950, the layers roughly double in thickness to 0.4 centimeters per year. The clear, horizontal layers tell us that the sediments were not disturbed after deposition. The research team used event stratigraphy to define various time markers, including the date of core sampling (2018); increased cesium-137 from the Chernobyl nuclear power plant accident (1986); the appearance of dichlorodiphenyltrichloroethane (DDT) pesticides (1950); and the extrapolated age of the bottom of the core (1840). These markers could then be used to date the traces appearing at other positions in the core. Around 1956 (the stark color change at twenty-seven centimeters), there is a sharp increase in various anthropogenic markers, including lead and other metals, organic carbon, biomarkers, DDT derivatives, radionuclide fallout signals, microplastics, and spheroidal carbonaceous particles (SCPs)—some of which peak in the 1970s and 1980s.

The plastic microparticles include a range of polymer types (mostly thermoplastics) that reflect the widespread and various use of plastics since the mid-twentieth century.

The forty-five-centimeter-long sediment core EMB201/7-4 was retrieved by Research Vessel *Elisabeth Mann Borgese* using a multi-corer that was lowered to the seafloor by a shipboard winch. When it reached the seafloor, multiple sixty-centimeter-long PVC tubes were pushed into the soft sediment, and the top and bottom of each tube was sealed. The water-sediment interface and approximately the first fifty centimeters of the sediments are extracted intact within the tube. The core was subjected to various analyses, including chemical composition, radionuclides, mercury, total nitrogen, total organic carbon, nitrogen and carbon stable isotopes, polycyclic aromatic hydrocarbons (PAHs), DDT derivatives, trace metals, microplastics, radiocarbon, SCPs, and plutonium stable isotopes.

The Leibniz Institute for Baltic Sea Research (IOW) in Warnemünde, Germany, is dedicated to the study of the oceanography and ecology of the Baltic Sea and is leading the Baltic Sea candidature in the context of the Anthropocene GSSP project. The research team, composed of thirteen scientists, is headed by Jérôme Kaiser, an experienced Baltic Sea sedimentologist and organic geochemist, and Juliana Ivar do Sul, a member of the AWG and an experienced microplastics researcher.

Ernesto Cave, Italy

Core name:	ER76–78
Geographical coordinates:	45°58′37″N, 011°39′28″E
Core Type:	cave speleothem
Length:	45 cm

Ernesto Cave (Grotta di Ernesto) is a small cave in Northern Italy's mountainous Trentino province, located at 1,167 meters above sea level. It consists of a seventy-meter-long descending gallery that opens into three successive chambers: Sala del Focolare, Sala Grande, and Sala Terminale. Active stalagmites and stalactites decorate the passages, courtesy of the porous overlying Jurassic limestone. The cave was discovered in the autumn of 1983 during excavations for road construction, and it takes its name from the boy who was the first person to enter the cave since its entrance was blocked by debris around 8,000 years ago. Inside was evidence of human activity dating to the Mesolithic period (around 9,000 years ago), including a hearth and some animal bones bearing tool marks. The cave was reclosed with an iron door to prevent disturbance by humans or animals and to preserve the natural ventilation patterns.

The steep, north-facing slope of the Asiago Plateau on which the cave is situated overlooks the deep Sugana Valley and is covered with a young forest of beech, spruce, and silver fir. The forest is only around eighty years old, as the area was cleared to facilitate military operations prior to the First World War.

Speleothems (including stalagmites, which grow up from the floor, and stalactites, which hang down like stone icicles) are formed when water filters through limestone and drips into a cave. When the water loses excess carbon dioxide, it deposits calcium carbonate—a process that, over thousands of years, forms the spikes and spires that adorn underground chambers. The annual layers of stalagmites and stalactites thus constitute extremely long-running archives. Because Ernesto Cave is relatively small, largely undisturbed (it is closed to the public), and has been well-studied since the early 1990s, the records held in its speleothems can be used to form accurate pictures of past environmental and climatic conditions.

The average rate of stalagmite growth in Ernesto Cave is around 0.1 millimeters per year, made up of two distinct alternating layers:

most of the growth is pale colored, being made up of translucent, non-fluorescent calcite (up to approximately 200 micrometers thick), but a thin brown layer of fluorescent calcite (0.5–four micrometers thick) forms in autumn. The fluorescence and dark color of the autumn layers originates from soil-derived organic matter, which is flushed into the cave during autumn rainfall. Another imprint of the seasons is the sulfate content in the stalagmite: lower levels of carbon dioxide increase the pH of the drip water, which in turn increases the sulfate. Over centuries, sulfate levels also change depending on pollution inputs. Whereas some signals (such as the seasonal flushing of soil-derived organic matter) are transmitted practically instantaneously, others are delayed due to storage in the soil and vegetation. Thus, signals such as sulfate concentration or carbon-14 have a variable lag (of up to fifteen years) between the date of environmental input and the date of incorporation into the stalagmite layer.

In around 1840, there are various changes which document the end of the Little Ice Age. There is a decrease in organic content as the warmer temperatures enabled more efficient degradation of organic matter in the soil above, as well as an increase in carbon-13 and stalagmite growth rate (caused by increased dissolution of calcium carbonate as a result of higher carbon dioxide production in the soil). At the beginning of the twentieth century, there are increased trace elements and organic matter that document the deforestation that occurred to facilitate military operations before the First World War. Then, in 1960, there is another increase in stalagmite growth rate following a rise in surface temperature as well as increased sulfur from industrial pollution. There is also evidence of the mid-century "bomb pulse," when nuclear weapons testing increased levels of carbon-14 in the atmosphere.

Three active stalagmites were removed from the cave: ER76 in June 1993, ER77 in November 1995 (the forty-five-centimeter-long GSSP candidate), and ER78 in October 2000. The stalagmites were removed at their base by chisel and hammer and transported to the Museo delle Scienze in Trento. Each stalagmite was cut along its growth axis, and the two halves were sliced into ten- to twelve-millimeter-long slabs, which were polished and scanned with a flatbed scanner before being cut into thin sections for geochemical analyses. Most of the pieces are now held in the geological sample collection at the Museo delle Scienze in Trento. The stalagmite samples were subjected to various analyses, including petrography and microstratigraphy, optical fluorescence imaging, annual laminae counting, uranium-thorium dating, stable isotope analyses, radiocarbon analyses, synchrotron radiation-based and ion microprobe sulfur and trace-element concentration analyses, and sulfur isotope analyses.

Because of the small number of comparable stalagmites at the site, it is not possible to obtain further samples containing the same material (as is possible with sediment cores), although other similar stalagmites in the cave demonstrate the reproducibility of the material. Given the extremely slow rate of growth, the total material that constitutes the Anthropocene archive in the Ernesto Cave stalagmites is only around five millimeters thick—therefore providing much less material in total for analysis.

The Ernesto Cave research team formed in 1994 when the cave was selected as a study site in the framework of the paleoclimate EU Project EV5V-CT94-0509. The initial group consisted of Silvia Frisia, who led the project, and Andrea Borsato, based at the Museo Tridentino di Scienze Naturali (MTSN; renamed in 2013 as Museo delle Scienze in Trento) alongside Ian Fairchild from the University of Birmingham in the UK. Following the initial European project, the research team was supported by two grants from the Autonomous Province of Trento (1998–2005) and continued to collaborate with Fairchild in a wide range of successor projects, including an innovative soil-to-cave study of carbon dioxide levels and carbon isotopes and their potential relationship to the Anthropocene.

Flinders Reef, Australia

Core name:	FLI01A_5A
Geographical coordinates:	17°43′48.0″S, 148°25′48.0″E
Core Type:	coral core
Length:	300 cm

Flinders Reef is an oceanic reef in the Coral Sea, 250 kilometers off the northeast coast of Australia—120 kilometers farther out than the Great Barrier Reef. Protected since 1975, the 2,000 kilometers of the Great Barrier Reef encompasses around 3,000 coral reefs that are home to myriad fish, anemones, crustaceans, sponges, jellyfish, turtles, mollusks, worms, sea snakes, sharks, and rays. Flinders Reef, at forty kilometers long, is one of the largest separate reef systems in the Coral Sea.

Many coral reefs worldwide are threatened by a variety of local and global anthropogenic pressures. Locally, increased on-land development and agriculture has resulted in more polluted water around the reefs, alongside the pressure from fishing and tourism. Because Flinders is an offshore oceanic reef, however, it is less vulnerable to local human influences than those closer to the coast. This means that the records stored in Flinders corals are more indicative of global and regional changes than local ones. Globally, the carbon dioxide released into the atmosphere by the burning of fossil fuels has caused both rising sea temperatures (via global warming) and ocean acidification (the oceans absorb some of the extra carbon dioxide from the atmosphere, which forms carbonic acid and thereby increases the pH of the water), both of which threaten corals. Warmer ocean temperatures are one cause of coral bleaching, and although corals can recover from bleaching events given enough time, global warming means that the frequency and intensity of bleaching events are increasing, making it harder for corals to recover. Meanwhile, ocean acidification decreases the amount of carbonate ions in seawater, which may cause coral skeletons to grow more slowly and become weak and brittle.

Two *Porites sp.* coral cores were collected from Flinders Reef in 1992 and 2017. *Porites sp.* is a massive stony coral that grows to around four meters in height and six meters across. As corals grow, they preserve a record of the water chemistry in their exoskeletons, by incorporating stable isotopes (which contain information about past temperature) and trace elements. This information allows scientists to reconstruct past environmental and climatic conditions. *Porites sp.* are particularly useful for analysis since they grow continuously over a life span of potentially hundreds of years. The Flinders cores exhibit a growth rate of between 0.8 and 1.6 centimeters per year. The varying density of the skeleton during the year produces annual growth bands, which provide a high temporal resolution that can be accurately dated.

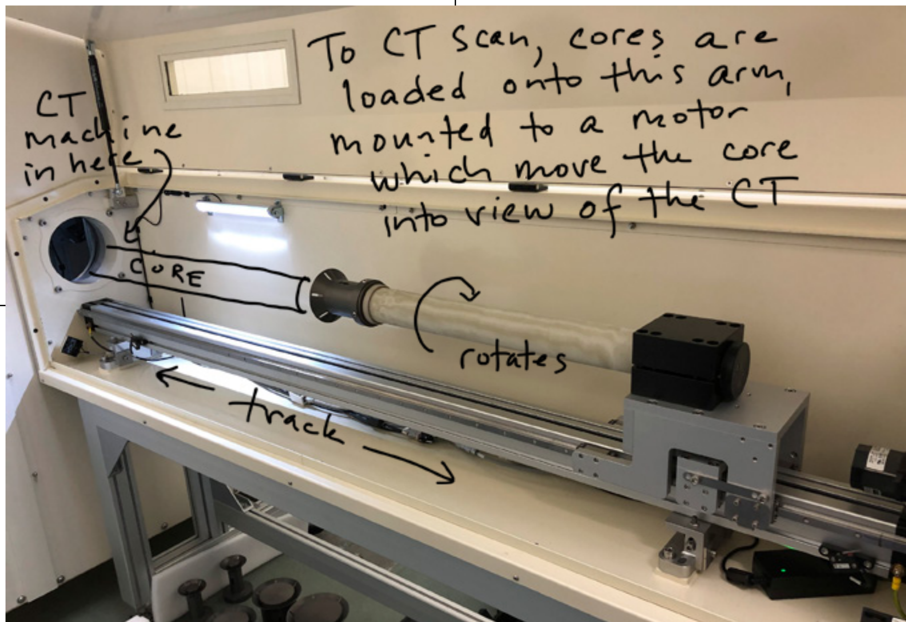
The two Flinders Reef cores preserve archives from 1708 to 1992 (FLI01A) and 1835 to 2017 (FLI05A). There is a clear “bomb pulse” recorded in carbon-14 levels that rise dramatically around the 1950s and peak in 1975, before slowly decreasing—a result that is correlated in coral samples from across the Great Barrier Reef. Meanwhile, changes in the abundance of other carbon isotopes (carbon-13 and carbon-12) reflect the addition of anthropogenic carbon dioxide into the atmosphere and oceans from the burning of fossil fuels. The cores also record changes in ocean temperature (likely caused by the climate crisis) through oxygen isotopes and strontium/calcium ratios, with a distinct rise in temperature starting in the 1950s and accelerating in the 1970s. Over the 300 years recorded in the coral core, levels of boron isotopes reflect ocean pH and have a lot of variability, showing a slight downturn in the second half of the twentieth century. The lowest—and therefore most acidic—pH level recorded in the coral is found around the year 2000.

Using a hydraulic drill system, a three-meter-long core (FLI01A) was collected in May 1992 from a depth of five to ten meters by divers from the Australian Institute of Marine Science (AIMS); and a 0.5-meter-long core (FLI05A) was collected in December 2017 from a depth of five meters by divers from James Cook University (Australia) and the University of Western Australia using a pneumatic air-drilling system. Cored samples were sliced into slabs (seven to eight millimeters thick and nine centimeters wide) along the main growth axis, using a diamond-blade precision saw. Slabs were X-rayed to assess the optimal sampling path closest to the main growth axis. Both cores were sampled at bimonthly resolution (six samples per annual growth band) from 1940 to the end of the core, and FLI01A was sampled at annual resolution pre-1940. The samples were subjected to various analyses, including radiocarbon (carbon-14), isotopes (nitrogen-15, oxygen-18, carbon-13), trace elements (ratios of strontium/calcium, magnesium/calcium, uranium/calcium, and barium/calcium), pollution metals, radiogenic isotopes (plutonium, cesium, and americium), and spheroidal carbonaceous particles (SCPs). The Flinders Reef team is headed by Paleobiologist Jens Zinke of the University of Leicester.

Earth Indices: Cores

Stratigraphic samples from pacific corals, lake deposits in northeastern China, speleothems found in an Italian cave, and the drill cores taken from the twelve candidate sites of the Anthropocene have become the corpora delicti of the geological formalization process. As memory sticks of the Anthropocene's sensoria, they store rich raw data of a converging human and natural history. Imprinted onto these sediments is a stratigraphic record that provides a detailed archive of human impact and a central piece of evidence of the anthropogenic–geological transformation, with some cores dating back a millennium, writing an Earth-bound logbook that merges the history of mankind and the history of the planet. It must be possible to clearly date the succession of layers annually, so that the mid-twentieth century period can be identified against pre-Anthropocene sediments.

Real Antarctic ice core on display at the British Antarctic Survey (BAS)



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	IMG_1886.HEIC 3024 px x 4032 px 72 px/inch 22/04/2019
media type equipment	Photograph Camera
GSP metadata	36.96, -122.06
software	n/a

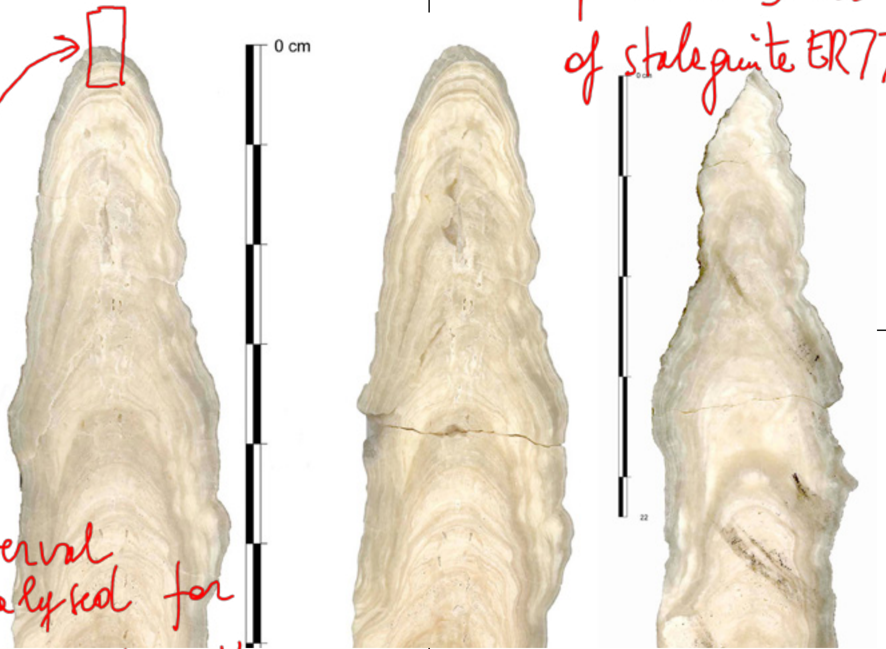
3	coring and analysis data
referent name	M. Allison Stegner, Elizabeth A. Hadly, Anthony D. Barnosky
location	USGS Pacific Coastal and Marine Science Center, 2885 Mission St., Santa Cruz, CA 95060
core name date of coring date of analysis	JRBP2018-VC01 B n/a 22/04/2020
marker analysis	Sediment density CT scanning
description	CT scanner before a core section is in place.
sampling notes	GeoTek CT scanner
additional notes	n/a
© original image	Anthony D. Barnosky

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	IMG_3921.jpg 3024 px x 4032 px 72 px/inch 24/09/2020
media type equipment	Photograph Camera
GSP metadata	36.96, -122.06
software	n/a

3	coring and analysis data
referent name	M. Allison Stegner, Elizabeth A. Hadly, Anthony D. Barnosky
location	USGS Pacific Coastal and Marine Science Center, 2885 Mission St., Santa Cruz, CA 95060
core name date of coring date of analysis	JRBP2018-VC01 B n/a 24/09/2020
marker analysis	core preservation n/a
description	n/a
sampling notes	n/a
additional notes	n/a
© original image	M. Allison Stegner

parallel "slices" of stalagmite ER77



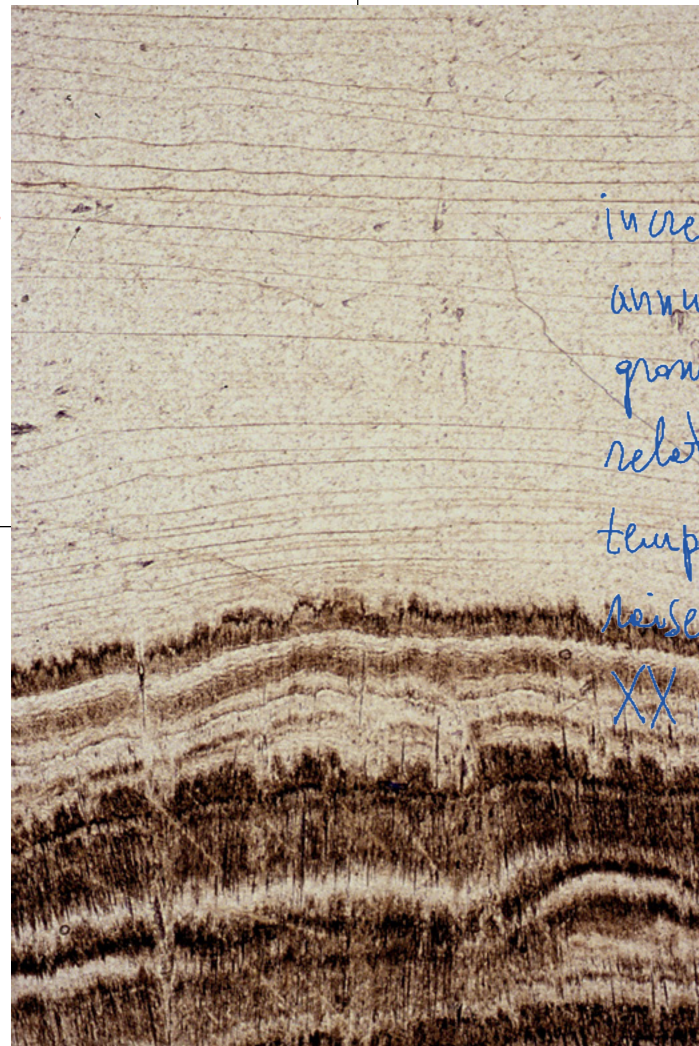
interval analysed for ^{14}C bomb peak

1	institutional data
project title	ER77-78: Ernesto Cave, Italy 1995/2000
institution	Museo delle Scienze di Trento, Italy; University of Newcastle, Australia; University of Birmingham, United Kingdom; Heidelberg Academy of Sciences, Germany.
department	Geology Section; School of Environmental and Life Sciences; School of Geography, Earth and Environmental Sciences; Institute for Environmental Physics
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 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
city country	Trento, Newcastle (AUS), Birmingham, Heidelberg Italy, Australia, United Kingdom, Germany

2	technical data
file name size creation date	ER77-insieme.jpg 2498 px x 3515 px 300 px/inch 17/08/2001
media type equipment	Photograph Epson Perfection scanner
GSP metadata	46°04'00" N, 11°07'26" E
software	Adobe Photoshop 7.0

3	coring and analysis data
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	Museo delle Scienze di Trento, Italy
core name date of coring date of analysis	ER77-78 ER77: 11/1995 2006 and 2007
marker analysis	$\delta^{13}C$ & $\delta^{18}O$, Radiocarbon/bomb spike MS ($\delta^{13}C$ & $\delta^{18}O$), AMS (C14)
description	Stalagmite ER77, complete set slab scans.
sampling notes	ER77 and ER78: -15m from the cave entrance elevation.
additional notes	n/a
© original image	A. Borsato, R. Miorandi

increasing growth rate



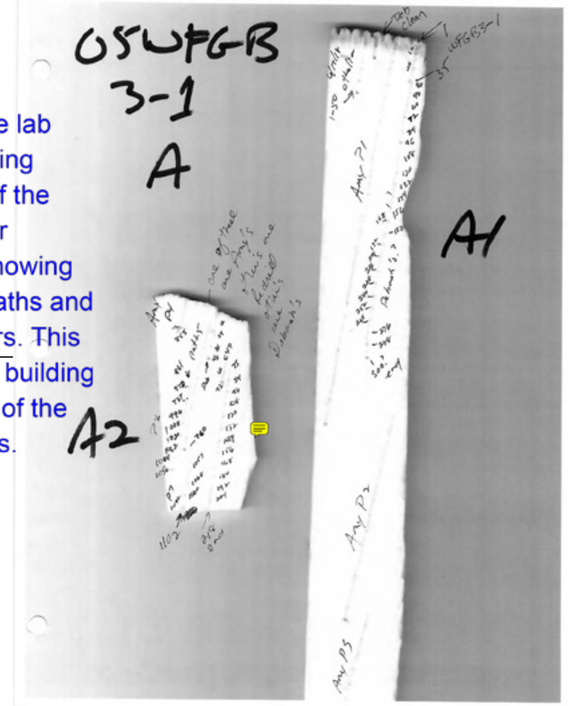
increasing annual growth related to temperature raise in the XX century

Close-up of the coral top with millimeter-scale structures.

1	institutional data
project title	0FWFGB3-1: West Flower Garden Bank Reef, USA 2005
institution	Louisiana State University
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	A004 - 20130607_185049.bmp 1024 px x 1280 px 96 px/inch n/a
media type equipment	Photograph Microscope
GPS metadata	30.411607°N, 91.178627°W
software	n/a

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
marker analysis	Trace Elements and isotopic analysis IRMS, ICP-OES, ICP-MS, AMS
description	Microscope image of the coral calyx on the core slab before micromilling.
sampling notes	Dino-lite digital microscope image.
additional notes	Micro sampling targets particular parts of the coral skeleton to get a good signal.
© original image	Kristine DeLong

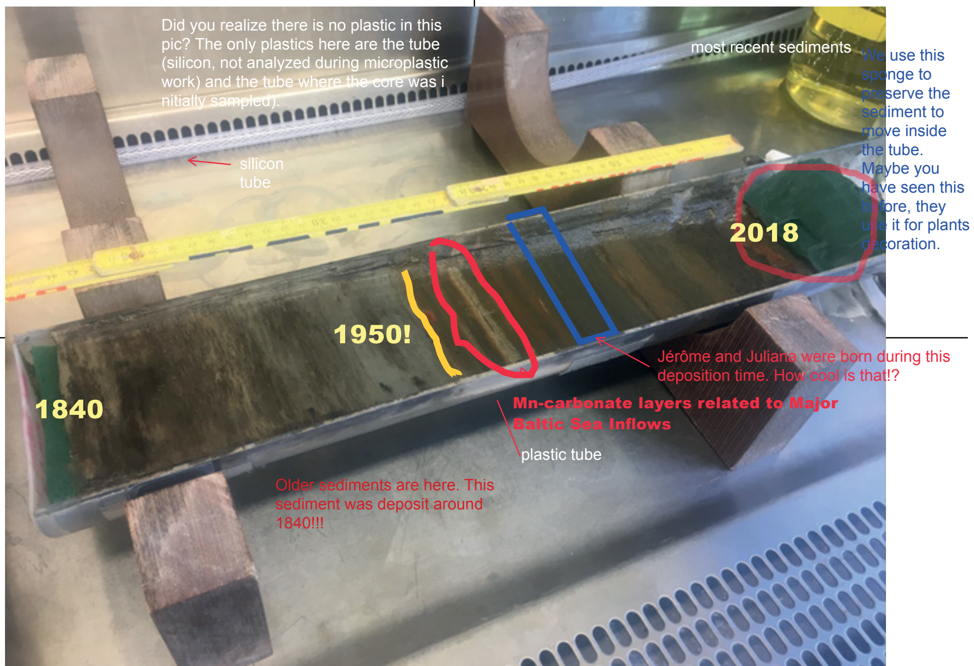


A page from the lab notebook showing that is a copy of the coral slabs after micro-milling showing the sampling paths and sample numbers. This will be used for building the chronology of the chemical results.

1	institutional data
project title	0FWFGB3-1: West Flower Garden Bank Reef, USA 2005
institution	Louisiana State University
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	05WFGB3-1 all_Page_26.pdf 1650 px x 1275 px 150 px/inch 2019
media type equipment	Logbook Scanner
GPS metadata	30.411607°N, 91.178627°W
software	n/a

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	0FWFGB3-1-A1 and A2 coral slab scan with 2015 drill paths: West Flower Garden Bank Reef, USA.
sampling notes	Black and white copy.
additional notes	Coral copy show sampling paths and divots that are used to assign a year to the geochemical data.
© original image	Kristine DeLong



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
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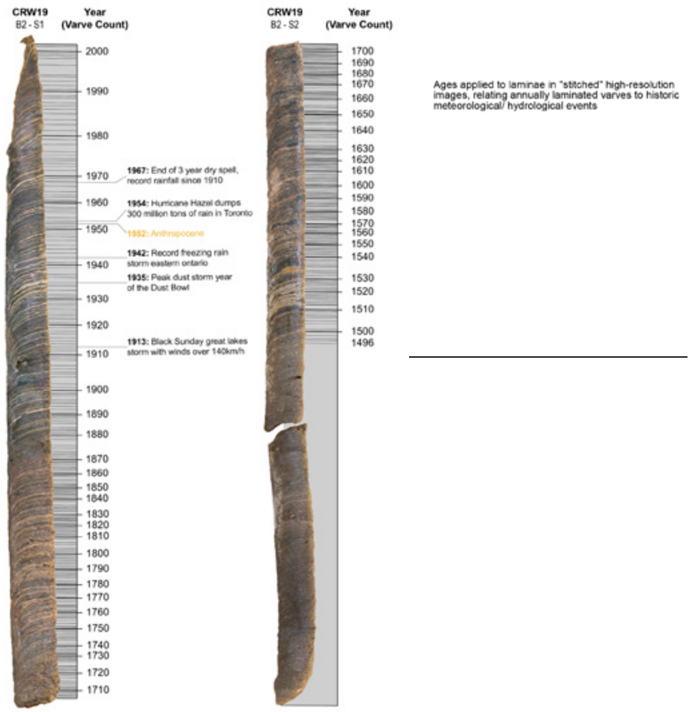
	Agnieszka Bondyra, Adam Mickiewicz University / Katarzyna Marcisz, Adam Mickiewicz University / Marcin Siepak, Adam Mickiewicz University / Gael Le Roux, Université de Toulouse
city country	Poznań Poland

2	technical data
file name size creation date	20200923_111019.jpg 1907 px x 4093 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

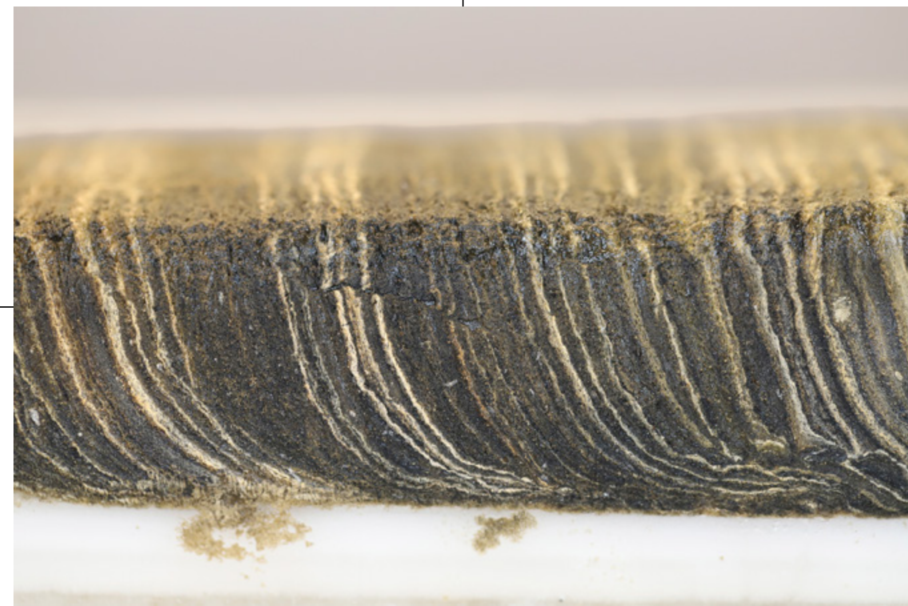
3	coring and analysis data
referent name	Barbara Fiałkiewicz-Kozieł
location	Lab., Krygowskiego 10, 61-618 Poznań
core name date of coring date of analysis	SN0 29/08/2020 23/09/2020
marker analysis	This is a photo of core, where all markers were measured. Subsampling of core
description	This is a photo 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	Subsampling using carbon steel knives and bags.
© original image	Adrian Sitarz



1	institutional data
project title	CRW19-2FT-B2: Crawford Lake, Canada 2019
institution	Carleton University
department	Earth Sciences
researcher(s)	Ms. Krysten Serack (Lafond), Dr. Nawaf Nasser, Dr. R. Timothy Patterson
city country	Ottawa Canada

2	technical data
file name size creation date	Figure 4 - Dated Core.jpg 3509 px x 2083 px 300 px/inch 20/10/2019
media type equipment	Photograph Canon EOS 6D Mark II with a Canon EF 100mm f/2.8L Macro IS USM lens and Canon Macro Ring Lite MR-14EXII
GSP metadata	45.38N/ 75.70W
software	Adobe Photoshop 2020

3	coring and analysis data
referent name	n/a
location	1125 Colonel by Drive, Ottawa, ON K1S 5B6
core name date of coring date of analysis	CRW19-2FT-B2 n/a n/a
marker analysis	Varve-scale analysis Varve-scale analysis
description	Stitched compilation of high-resolution images of core CRA-19-2Ft-B2 with varve ages assigned by visual counting.
sampling notes	n/a
additional notes	n/a
© original image	n/a



1	institutional data
project title	CRW19-2FT-B2: Crawford Lake, Canada 2019
institution	Carleton University
department	Earth Sciences
researcher(s)	Ms. Krysten Serack (Lafond), Dr. Nawaf Nasser, Dr. R. Timothy Patterson
city country	Ottawa Canada

2	technical data
file name size creation date	IMG_0483.jpg 4160 px x 6240 px 72 px/inch 20/10/2019
media type equipment	Photograph Canon EOS 6D Mark II with a Canon EF 100mm f/2.8L Macro IS USM lens and Canon Macro Ring Lite MR-14EXII
GSP metadata	45.38N/ 75.70W
software	n/a

3	coring and analysis data
referent name	n/a
location	1125 Colonel by Drive, Ottawa, ON K1S 5B6
core name date of coring date of analysis	CRW19-2FT-B2 n/a n/a
marker analysis	Varve-scale analysis Varve-scale analysis
description	n/a
sampling notes	n/a
additional notes	n/a
© original image	n/a

Karlsplatz, Wien Museum, Vienna, Austria

Core name:	2019_26
Geographical coordinates:	48°11'57.0"N, 016°22'21.4"E
Core Type:	urban sediments
Length:	n/a

Karlsplatz is a square in Vienna, Austria's capital city. Today, it is home to the Resselpark, the Karlskirche (a baroque church completed in 1737), the main building of the Technische Universität Wien, and the Wien Museum—adjacent to which is the research site. Historically, the River Wien (a tributary of the Danube) flowed here, but a two-kilometer-long stretch of the river through the city center—including the area that is now Karlsplatz—was covered over in the late nineteenth century. An enclosed market hall occupied Karlsplatz from 1921 to 1936, after which the site, along with much of the city, suffered bombing and destruction during the Second World War. Groundwork for the Wien Museum began in the 1950s, with its curated historical and art exhibitions opening from 1959. In 2019, it was closed for renovations that exposed the urban sediments now being studied as an auxiliary stratotype for the Anthropocene.

The city sits in the Vienna Basin, a sedimentary basin between the Alps and the Carpathian Mountains, and the area has a long human history, with traces of occupation extending back to the Paleolithic period. A Celtic settlement was established by the River Danube around 500 BCE, which, in the first century CE, became Vindobona, a Roman garrison town of 15,000 inhabitants that would sow the seeds of the capital as it is now. The city went through various phases of historical import, being the seat of the Holy Roman Empire (1558–1806), the Habsburg Empire (1806–67), and the Austro-Hungarian Empire (1867–1918). With industrialization, the population peaked at two million in the early twentieth century, before falling to 1.5 million after the Second World War. Today, around 1.9 million people live there.

The research at the Karlsplatz site is part of a larger project that looks at more than 60,000 borehole sites (from old wells) and archaeological data across the city. These reveal a variety of anthropogenic materials, including glass, metals, brick, ceramics, and residential waste, with concrete and plastic making up the majority since 1900. Unlike the other sites being studied for markers of the Anthropocene, the material from the Karlsplatz site is not a GSSP candidate, 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 (ICS). Importantly, because the samples being tested are urban deposits, the necessary continuous record required for a GSSP is absent. Anthropogenic sediments do not contain annual layers, since deposition rates are highly variable, and the layers can get mixed and reworked during different construction phases. Further, because the site will be covered over once the renovations of the Wien Museum are complete, future sampling (another criterion for GSSP candidates) will be hindered. However, the site could be used to define an auxiliary stratotype for the Anthropocene, as the stratigraphic markers and technofossils in the urban rubble contain signals that have potential correlations with findings from the candidate GSSP sites.

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 (such as helmets, revolvers, and insignia). Remains, descriptions, and photographs of different historical stages of the site—riverbed infill, river pavement, market hall, war zone, museum—allow the various layers of the excavation 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 the market hall (built 1921–22) form the base for the Anthropocene stratigraphic section. The Second World War rubble, which fills the remains of these constructions, contains significantly high concentrations of lead, zinc, and copper (from various industrial sources) and some traces of plutonium, which may reflect contamination from the formerly exposed rubble surface or later sediments. The rubble and overlying finer-grained artificial ground and soil build an unconformity that is historically dated as post-Second World War, representing a few years of ongoing renovations after 1945. In the overlying soil layers (up to 1959, the year of the museum's opening when the park area was leveled and recultivated), high concentrations of radionuclides appear (including plutonium, uranium, and americium) together with characteristic radionuclide ratios (plutonium-240/plutonium-239), reflecting the fallout from atmospheric nuclear weapons testing. The appearance of these markers in the coarse, urban anthropogenic sediments of big cities demonstrates the globally synchronous appearance of the radionuclides, which makes them exemplary for defining the Anthropocene.

Samples were taken from the Karlsplatz excavation site between October 2019 and January 2020 and classified according to grain size of larger particles and the proportion of other fine-grained, clayey material. The samples were then sieved to separate grains smaller than two millimeters, which were dried and pulverized. These sediment samples were then analyzed by accelerator mass spectrometry (AMS) using the setup at the Vienna Environmental Research Accelerator (VERA). The samples were analyzed for concentrations (atoms per gram) of uranium-233, uranium-236, uranium-238, neptunium-237, plutonium-239, plutonium-240, plutonium-241, and americium-241. Isotope ratios (plutonium-240/plutonium-239, plutonium-241/plutonium-239, and uranium-233/uranium-236) were calculated to trace atomic weapons fallout material from the 1950s and 1960s.

A research team was formed in order to propose an interdisciplinary project on Vienna's urban anthropogenic sediment by the artist Katrin Hornek and geologist Michael Wagreich. Discussions with members of the AWG, especially Matt Edgeworth and Colin Waters, helped with further formulation of the project. The proposal was granted funding by the Vienna Science and Technology Fund, and the project started in January 2018.

San Francisco Estuary, USA

Core name:	SFB-20A
Geographical coordinates:	37°32′58.3″N, 122°10′59.3″W
Core Type:	estuary sediment core
Length:	230 cm

San Francisco Bay is a shallow estuary on the coast of California. The iconic Golden Gate Bridge crosses the strait that connects the bay to the Pacific Ocean. The Bay sits in a tectonic depression between two major faults—the San Andreas and the Hayward—and has fluctuated between a terrestrial and marine landscape over the last million years. Today's brackish, muddy estuary is the latest manifestation of a landscape produced by a continual interplay of sea-level change, tectonic motions (as stresses and compression between multiple faults have uplifted and lowered a mosaic of crustal blocks), and the accumulation of river-borne sediments comprising clays, silts, and organic matter.

The area has long been important for humans. Indigenous populations (predominantly Muwekma Ohlone) have utilized the marine, estuarine, and freshwater habitats in the Bay Area since the mid-Holocene (around 4,000 years ago). The remains of shell mounds and village sites record prehistoric foraging habits and the extent of occupation in the region. But Indigenous culture was decimated by the European colonizers who arrived in the mid-eighteenth century: California's Indigenous population plummeted from around 310,000 in 1769 to 16,277 in 1880 as a result of disease, dislocation, starvation, and genocide at the hands of Europeans. The California Gold Rush (1848–55) sparked an immigration boom and turned San Francisco Bay into an important global seaport and continental rail terminus. A 1940s initiative to fill in parts of the bay for industrial use (the Reber Plan) was halted in the 1960s by the establishment of the nonprofit organization Save the Bay, which has since worked to protect and restore the area.

The subtidal mudflat ecosystem of San Francisco Bay is home to many species of bacteria, algae, various other microorganisms (including foraminifera and ostracods), mollusks, and crustaceans. However, it bears the uneasy distinction of being one of the most reconfigured aquatic ecosystems on the planet, with more than 200 invasive species having taken up residence since the mid-nineteenth century—some of which were deliberately introduced, while others hitched a ride on ships from across the globe. In some places, ninety-nine per cent of the bay's biomass is comprised of introduced, non-native species. While many of these neobiota are soft-bodied and do not preserve well, some have hard shells that remain in the bay's shallow subtidal sediments, waiting to become the fossils of the future. Decades of scientific study have established a chronology of species invasion in the area over the last two centuries (with a distinct acceleration in observable increase around 1950). Organism remains can therefore be used to develop a biostratigraphic record that is temporally precise enough to define the Anthropocene.

The GSSP research team collected a 230-centimeter-long core from the South Bay in April 2019. While there are depositional gaps in the sedimentary record of San Pablo Bay (at the northern end of San Francisco Bay), possibly due to sediment mixing and resuspension, the South Bay preserves a record of continuous deposition. To ensure a complete archive, the core collection site was also selected to avoid the many areas of the bay disturbed by dredging and shipping lanes. The core holds about seventy years of sediments. Its dense, grayish mud is visibly flecked with coarse sand and shells and contains geochemical and mineral traces of past environmental conditions. Remains of five hard-shelled invasive species were found, all first appearing in the bay within a narrow stratigraphic interval of twenty-one centimeters. This represents a temporal range spanning the late 1970s to the late 1980s, marking a distinct signature of ecosystem change. First to appear—in the same one-centimeter interval around the late 1970s, which suggests they may have arrived together—are two Japanese ostracods: *Bicornucythere bisanensis* and *Spinileberis quadriaculeata*. Above the first occurrence of these ostracods, the Japanese foraminifera *Trochammina hadai* occurs at 119 centimeters depth. It is known to have arrived in San Francisco Bay in 1983. At a slightly higher level in the core, 115 centimeters depth, is the first occurrence of the East Asian bivalve mollusk, *Potamocorbula amurensis*, which is colloquially known as the Amur River Clam. It invaded San Francisco Bay in 1986. Finally, the ostracod *Eusarsiella zostericola*, an arrival from the US Atlantic Coast, appears a little way above the clam. This evidence of significant anthropogenic ecosystem reconfiguration corresponds to a larger global trend of species redistribution that

will be legible in the far future, just as ancient changes to the biosphere can be read in the rock record.

The core also records various traces of human industry. Between 190 centimeters and 130 centimeters, there is a significant rise in mercury levels—perhaps evidence of mining. The elevated concentrations may represent the increased demand for mercury in the 1960s and 1970s, as well as mercury emitted into the atmosphere by fossil fuel combustion. Spheroidal carbonaceous particles (SCPs) occur at relatively low concentrations throughout the core, likely first appearing in the 1960s.The sediment core SFB-20A was collected using a vibracorer, a system comprising a thin metal cylinder that is lowered to the seafloor (in this case from a boat) and then vibrated into the loosely compacted sediment. The sealed tube is then taken back to the laboratory and cut in half lengthwise to reveal the intact sediment. The core was subjected to the following analyses: microfossils (foraminifera, ostracods, and mollusks), SCPs, mercury, radionuclides, carbon isotopes, nitrogen isotopes, pollen, microplastics, and X-Ray Fluorescence (XRF) scanning.

The research is led by Stephen Himson and Mark Williams. Himson is a PhD student whose research focuses on understanding biological change in San Francisco Bay and its geological signature. He is supervised by Mark Williams, Jan Zalasiewicz, and Colin Waters, who have extensive research experience studying paleontological and sedimentological records both in deep time and in recent sedimentary successions. The research has been supported by Mary McGann, who was instrumental in organizing the logistics of the coring expedition. McGann has conducted groundbreaking work examining the biostratigraphic and ecological implications of the introduction of *Trochammina hadai* to San Francisco Bay.

Searsville Lake, USA

Core name:	JRBP2018-VC01B
Geographical coordinates:	37°24′24.8″N, 122°14′16.5″W
Core Type:	reservoir sediment core
Length:	944.5 cm

Searsville Lake sits in the eastern foothills of the Southern Coast Range in San Mateo County, California, on the Traditional Territories of the Muwekma Ohlone people. The landscape is a product of compression and tension related to movements of the Earth along multiple faults (the San Andreas, Pilarcitos, and Searsville). Lakes and ponds are a common feature along fault zones, as depressions fill with water, or stream flows are blocked. Searsville Lake is, however, a human-made body of water, created by the construction of Searsville Dam in 1892. The dam was built to establish a water source for the city of San Francisco (which is around forty-five kilometers north of the site), but the water turned out to be unsuitable for drinking. However, the reservoir remains to this day. In 1919, it was acquired by Stanford University and subsequently served multiple purposes—as a popular recreation area as well as an education and research site for the university community. In 1975, recreational activities were terminated after the designation of the area as Stanford's Jasper Ridge Biological Preserve, which now encompasses 1,183 acres set aside for education, research, and conservation. Situated just seven kilometers from Stanford and the surrounding suburbs, the preserve provides important habitats for extraordinarily diverse communities of wildlife and vegetation. The concrete dam (which is about twenty meters high and eighty-four meters wide) that created Searsville Lake was built across the narrow, steep-sided ravine of San Francisquito Creek. The catchment area of the San Francisquito encompasses approximately 123 square kilometers and twenty smaller creeks that carry a vast amount of sediment down from the Santa Cruz Mountains. Much of this sediment settles out behind the dam, so that over the past 130 years it has filled more than 90 percent of the reservoir basin (without intervention, the lake would eventually fill completely, so that no water would be stored by the dam). The accumulated sediments provide a geological record of historical conditions in the catchment area, including changes in climate, tectonics, vegetation, and human activity.

Searsville Lake's proximity to the Pacific Ocean coast (sixteen kilometers away) means that the sediment holds global signals carried by winds coming across the Pacific, as well as local and regional signals of environmental, biological, geological, and climatic conditions. On average, lakes in the northern hemisphere accumulate 0.1–0.2 centimeters of sediment per year, but Searsville Lake accumulates a vast ~12 centimeters per year—sometimes with several centimeters accumulating in days or even hours during storms. The large amount of material that represents relatively small spans of time provides a very high-resolution archive for study, allowing scientists to observe changes at annual and even seasonal scales.

Core JRBP2018-VC01B was extracted from a water depth of 2.68 meters (the deepest part of the reservoir near the dam) in 2018 using a vibracorer from a raft. The timeframe that the 944.5-centimeter-long core documents—from about 1900 to 2018—spans the proposed Holocene to Anthropocene transition and records local, regional, and global signals of the Anthropocene. The uneven thickness of the lighter- and darker-brown fine-grained silt layers show that the rate of accumulation has not been steady, and CT scans of the core reveal that these differences in color represent changing densities of material—a result of the huge variance in seasonal conditions at the site. In summer, since many of the contributing streams run dry and there is more fine organic matter in the water, the water level drops, which causes the density of the deposited sediment to decrease. In winter, heavy rains from intense storms carry more coarse material down from the mountains, and the density of the deposits increases. These seasonal differences can be cross-referenced with dendrochronological data (the archives of tree rings), radiometric data, and the dam construction date (that is, the age of the lowest sediments) to produce a very accurate timeline of the core samples.

At around 600 centimeters core depth, which corresponds to around 1940, levels of carbon, nitrogen, and spheroidal carbonaceous particles (SCPs) all indicate the global increase in fossil fuel combustion. At around 450 centimeters, there are also increased levels of lead and mercury, as well as radioactive material (cesium-137, plutonium-239, and plutonium-240) from nuclear weapons testing. Mercury levels go from averaging around 50 parts per million before the 1900s to 90 parts per billion (ppb) after—as a result of its increased use in industrial processes—with a huge, anomalous increase to 240 ppb at a depth of 425 centimeters, coincident with elevated cesium and lead (in the mid- to late 1960s).

The core records other local and regional signals including pollen, which documents logging, agriculture, and introduced species. While these markers specifically reflect local events, they are manifestations of global trends that mark the profound ways in which human actions have reconfigured the biosphere.

After extraction, the core was divided into one-meter-long (or less) sections (to fit into core scanning machines and refrigerated storage) and split lengthwise for sampling. Material from the core was subjected to the following analyses: X-Ray Fluorescence (XRS) scanning (geochemical), CT scan (density changes), lead-210 dating, cesium-137, cesium-134, americium-241, plutonium concentrations and isotopes, carbon-14, stable carbon and nitrogen isotopes, lead concentrations and isotopes, SCPs, mercury and other heavy metals, diatoms, ostracods, pollen, and environmental DNA. Around 700 meters to the southwest of Searsville Lake is a smaller, naturally formed body of water called Upper Lake Marsh (it is what is known as a "sag pond," having been formed by tectonic forces of the underlying San Andreas Fault). A core taken from this older lake holds a record that goes back 1,500 years, which provides longer context to the approximately 126 years of data of the GSSP-candidate core.

The research team consists of M. Allison Stegner, Elizabeth A. Hadly, SeanPaul La Selle, Brian Sherrod, R. Scott Anderson, Bryan Black, Anthony D. Barnosky, Sergio Redondo, and Maria Viteri. The team's formation began in 2016, when discussions within the AWG began to focus on finding suitable sites to examine as potential Anthropocene GSSPs. At the time, Hadly, Barnosky, and Sherrod had been discussing the potential of sediments in Searsville Lake to provide a detailed earthquake history, since the site lies very near the San Andreas Fault and it was known from previous work to contain a long and detailed sedimentary record. These discussions morphed into the realization that the rapid sediment-accumulation rate could also archive exactly the kinds of geological signals needed to recognize the onset of the Anthropocene epoch and series.

Sihailongwan Lake, China

Core name:	SHLW-maar
Geographical coordinates:	42°17′19″N, 126°36′21″E
Core Type:	lake sediment core
Length:	80 cm

Sihailongwan Lake is a low-rimmed volcanic crater lake (or maar lake) in Jilin province in northeastern China. A round lake with a diameter of 750 meters, it is relatively deep for its size (with a maximum depth of fifty meters) and is located 797 meters above sea level in the Longgang volcanic field—a plateau-like landscape of Quaternary alkali basalt, a fine-grained, dark-colored, volcanic rock. Longgang, which covers 1,700 square kilometers, is a result of tectonic plates colliding, whereby the Pacific Plate is being thrust beneath the Eurasian Plate, an action that results in volcanic activity. This activity has produced 164 volcanic centers in the area (crater lakes, maars, and cones), with the most recent eruption—from the Jinlongdingzi volcano, fifteen kilometers south of Sihailongwan Lake—occurring in 460 CE. Today, the area is covered in a dense conifer and broadleaf forest (the previous Korean-pine-dominated forest was destroyed by long-term human activities). Sihailongwan Lake is accessible via a paved road from the nearest town of Jingyu (population around 100,000), which is located thirty kilometers northeast of the site.

There are traces of human agricultural practices in the region that is today Jilin province dating back 8,000 years, with evidence that it was one of the places of origin for dry farming. Because of the province's substantial shale and mineral reserves, its modern economy has been characterized by heavy industry. However, the Longgang area is protected; since 1991, it has been a designated as an 8,102-hectare forest park: the Jilin Longwan National Natural Reserve.

Since Sihailongwan Lake was formed in a volcanic crater, it has no tributary or outlet rivers. It is fed by rainwater—mainly during the East Asian monsoon season from June to September when 500–800 millimeters fall—and some groundwater. These characteristics produce favorable conditions for the accumulation of seasonally distinct layers of sediment called varves. Because Sihailongwan Lake is relatively deep for its surface area, and because it does not have any inflows or outflows, anoxic conditions occur in the bottom layer of water. This means that the matter that falls and settles on the lake bed remains undisturbed, enabling the preservation of a continuous record of environmental and climatic conditions. The varves are composed of a dark-colored, diatom-rich layer formed during summer and fall and a light-colored siliciclastic layer, which is likely deposited after the spring ice thaw. Wind conditions mean that the area receives windborne material from northern and northwestern China, which composes the majority of the sediment deposited in the lake, making it sensitive to long-range signals. The Longgang volcanic field has several maars and crater lakes of varying age—including geologically young, deep lakes such as Sihailongwan Lake, and older lakes that are infilled in and dried-up—which provide a range of sediment records for analysis, allowing results to be cross-checked across the well-studied region.

In February 2021, twenty-four cores were collected from Sihailongwan Lake. The cores show clear laminated varves, with a very dark layer in the top five centimeters (perhaps a result of decreasing dissolved oxygen concentrations over time). Mixed yellowish and dark layers occur at between five and nine centimeters, which become gradually lighter with depth. In addition, there are three distinct light layers at around 5, 7.5, and 30.5 centimeters, which are composed of siliclastic minerals. These distinct layers allow scientists to apply a high-resolution age scale to the cores, cross-referenced with dates of nuclear weapons testing.

The cores record an overall increasing trend of soot, mercury, and spheroidal carbonaceous particles (SCPs)—all from fossil fuel combustion—since 1950. Concentrations of these pollutants decreased from the late 1990s and early 2000s. This likely relates to air pollution control activities in China; for example, the implementation of a desulfurization subsidy from 2004, which incentivized coal plants to reduce their sulfur emissions, and the Air Pollution Prevention and Control Law from 2012, which held local governments accountable for improving air quality.

Cesium-137 and plutonium-239/240 begin to increase at 8.8 centimeters (around 1953) and peak at 7.7 centimeters (around 1963) and 7.9 centimeters (around 1964), respectively, recording the global nuclear fallout maximum from the "bomb pulse" in 1963–64. The earlier plutonium peak may be related to the fact that plutonium is less stable than cesium in water. Iodine-129 has a different profile, beginning to increase at around 8.8 centimeters (1950 ± 3 CE) and continuously increasing with large fluctuations until 4.4 centimeters. From 4.4 centimeters depth upwards (early 1990s–2021), it decreases and then rapidly increases. The variation is related to the global fallout of atmospheric nuclear weapons testing and long-term emissions from European nuclear-fuel reprocessing plants via long-distance atmospheric transit to East Asia by the westerly winds. No signal from the Chernobyl disaster is found in the cores.

The Sihailongwan cores have similar profiles to those taken from Huguangyan Maar Lake in Guangdong province in southeastern China, which supports the idea that both lakes record atmospheric deposition of long-range pollutants.

The cores from Sihailongwan Lake with lengths of fifty to eighty centimeters were collected using a freeze corer. The cores were collected during winter so that scientists could work directly on the frozen lake without the need for a platform. They drilled a hole through the seventy-centimeter-thick surface ice and lowered the coring wedge to the lake floor. The cores were packaged and transported back to the Institute of Earth Environment, Chinese Academy of Sciences in Xi'an. The cores were subjected to the following analyses: X-Ray-Fluorescence (XRF) scanning; magnetic susceptibility; chronological dating with varve counting and lead-210; cesium-137 analyses; mass accumulation rates; nuclides of plutonium and iodine isotopes; organic carbon and total nitrogen concentrations and their stable isotopes; black carbon, char, and soot concentrations; carbon-14; SCP concentrations; polycyclic aromatic hydrocarbons (PAHs) and oxygenated PAHs; heavy metals (lead, copper, zinc, and cadmium); and mercury concentrations and isotopes.

The Sihailongwan Lake research team is led by principal investigator Yongming Han, from the State Key Lab of Loess and Quaternary Geology, Institute of Earth Environment, Chinese Academy of Sciences. The Anthropocene GSSP research of this team was initiated by Zhisheng An, who is a member of the Chinese Academy of Sciences and a foreign associate of the US National Academy of Sciences, USA. Both Han and An are members of the AWG. Throughout the late 1980s to the late 1990s, their research focus had been on the study of natural changes of the Quaternary climate and environment. They reconstructed historical Quaternary climate changes at different time scales using geological and biological records (such as loess, lake, and marine sediments and stalagmite, coral, and tree rings). As gradually they began to recognize the importance of human impacts on global climate and Earth systems, An proposed a shift of research focus in 2006 from natural processes to the interactions between human beings and natural processes. Since then, they have focused on human impacts on climate, environment, and Earth systems, as well as predicting future climate. In 2019, the team gained major project funding from the National Natural Science Foundation of China to research the characteristics, impacts, and dynamics of the Anthropocene in China. Various geological and biological indicators are used to reflect the history of human impact in the country. In January 2022, the group formally established an Anthropocene division of the Geological Society of China, which includes over sixty members from various universities and scientific research institutes in China.

Śnieżką Peatland, the Sudetes, Poland

Core name:	SN0
Geographical coordinates:	50°44′20,90″N, 005°42′28,03″E
Core Type:	peat monolith
Length:	50 cm

The Sudetes are a Central European mountain range that extend 300 kilometers along much of the border between Poland and the Czech Republic, and partly into eastern Germany. The region is geologically diverse—with lower, rolling hills in the western end of the range, and higher peaks in the east—and has been subject to various volcanic, metamorphic, and erosive processes through its phases of mountain building. Today, continuous forest is restricted to the higher regions, while the foothills have been exposed to deforestation for settlements and agriculture over many centuries. Many of the beech, sycamore, and ash trees that were once dominant here—as well as some of the region's peatlands—were replaced in the nineteenth and twentieth centuries by monocultures of Norway spruce. In the western portion of the Sudetes is Poland's Karkonosze National Park (established in 1959), a fifty-six square kilometer area of forest-covered, steep, rocky mountainous terrain with numerous glacial landforms that were carved out in the Pleistocene. The park includes Śnieżką Mountain—the highest peak of the Sudetes at 1,603 meters—on the top of which stands a Roman Catholic chapel that was completed in 1681 and an observatory from 1974.

The human history of the Sudetes extends back millennia: there is evidence of Paleolithic settlements and Neolithic agriculture, as well as the exploitation of river-deposited gold by Celts in the third century BCE. The region's rich metal ore and lignite (or brown coal) stores encouraged a history of extraction and industry that started in the eleventh century. By the twentieth century, mines, factories, and power plants operated by all three neighboring countries had contributed to making the region one of the most polluted in Europe. In the 1980s, it was dubbed the "Black Triangle" on account of its extremely high levels of industrial pollution and the concomitant effects on human health—a fact that prompted the signing of a 1991 agreement between the three nations to attempt to improve and protect the area.

In August 2020, Barbara Fiałkiewicz-Kozieł and her team collected a peat monolith core from Równia pod Śnieżką, a rain-fed, sphagnum-moss peatland on a high plateau (1,350–1,450 meters above sea level) around 300 meters to the west of Śnieżką peak. Peat forms when acidic, cold, nutrient-poor, water-saturated, and anoxic conditions prevent full decomposition of plant remains, which therefore accumulate and preserve a continuous archive of atmospheric and environmental conditions. The Śnieżką peat archive provides a particularly useful geological record since it is exclusively rainfed (so does not get local signals from groundwater); is on a flat plateau (so that deposited water stays in place); has a relatively fast accumulation rate (which provides a lot of material for analysis); and is in a mountainous environment (which is good for observing background levels of atmospheric pollution, since higher altitudes are less vulnerable to local sources). Despite the Śnieżką peatland's position in the Black Triangle, atmospheric pollutant levels bear more similarity to locations in northern Poland, Switzerland, and Belgium than to local areas. This long-range sensitivity is owing to the fact that, since the site is close to the highest peak of the Sudetes, the long-range signals are not blocked by any mountainous barriers. The fact that the peatland is extensive and protected within a national park ensures the possibility of future sampling.

The fifty-centimeter-long peat core (SN0) contains a record that extends from 1931 to 2020. SN0 corroborates analyses done on two previous cores—SN1 and SN2—that were collected from the same area in 2012 (fifteen meters away from the SN0 location). Radioactive material from both mid-century nuclear weapons testing and the Chernobyl disaster in 1986 enables accurate dating of the peat layers. The cores record traces of global industrial activities, with spheroidal carbonaceous particles (SCPs) and spheroidal aluminosilicates (SAPs) from fossil fuel combustion appearing around 1950 and peaking in the 1970s. Pre-1950s SAPs (from the heating of mountain cottages) are irregular in shape and measure up to fifty micrometers, while post-1950s SAPs become much smaller (less than 1–9.5 micrometers) and rounder—a result of high-temperature coal combustion, which indicates long-range atmospheric transit from the tall chimneys of power plants. Meanwhile, the appearance of various trace elements—lead, zinc, copper, nickel, and chromium—are indicative of regional industry in the Black Triangle area. Analyses of lead isotopes, combined with the history of coal production and prevailing wind patterns, enabled the source of these signals to be identified. Chromium

and nickel deposits—starting in the 1880s and peaking in 1920—are likely a result of nickel ore smelting and stainless-steel production by the Krupp company in Germany. A second peak in 1970 is attributed to general Black Triangle activity.

Some distinct biological changes are also visible in the SN1 core. At 37.5 centimeters (around 1950), pollen of the invasive species *Ambrosia artemisiifolia* (or common ragweed, native to the Americas) begins to appear, while various humidity-sensitive testate amoebae species decrease and disappear as a result of rising temperatures and a drop in the peat water table.

Three peat monolith cores, SN0, SN1, and SN2, were extracted from the Śnieżką peatland using a Wardenaar corer: SN0 was collected in August 2020; SN1 and SN2 were collected in June 2012. The Wardenaar corer—specifically designed for sampling peatland—is a rectangular stainless-steel box with sharp cutting edges at the base. SN1 and SN2 were sliced into one-centimeter-thick samples for analysis, while SN0 was sampled intact. All cores were analyzed for bulk density, ash content, macrofossils, and SAPs. SN0 was analyzed for carbon and nitrogen content, carbon and nitrogen isotopes, radionuclides, SCPs, and mercury, and was dated using lead-210. SN1 was dated using carbon-14 and lead-210 and was also analyzed for stable lead isotopes, radionuclides, pollen, testate amoebae, SCPs, trace elements, and rare earth elements. Work on SN2 was less detailed; aside from physical description, it was analyzed for trace elements, stable lead isotopes, carbon, nitrogen, and sulfur. Age control was provided using carbon-14.

The Śnieżką team consists of scientists from Poland, France, Argentina, and the UK, with the majority working from Adam Mickiewicz University in Poznań, Poland. Barbara Fiałkiewicz-Kozieł is the main principal investigator and is responsible for all project logistics, conceptualization, interpretation, and geochemical analysis. The co-principal investigators are Edyta Łokas, from the Institute of Nuclear Physics in Kraków, who is responsible for radionuclides measurements and interpretation, and Beata Smieja-Król from the University of Silesia in Katowice, responsible for SAP analysis and interpretation.

West Flower Garden Bank Reef, USA

Core name:	05WFGB3-1
Geographical coordinates:	27°52′00″N, 093°49′00″W
Core Type:	coral core
Length:	174 cm

The West Flower Garden Bank is a coral reef in the northern Gulf of Mexico, around 190 kilometers from the US coast. At approximately twenty meters below the surface, and extending over ninety-six square kilometers, it is the largest and shallowest of a chain of seventeen banks that are home to an abundance of marine life. Crabs, lobsters, sea stars, urchins, and sea cucumbers roam a landscape of corals, sponges, anemones, and seaweeds, while more than 250 species of fish inhabit the area alongside rays, sharks, sea turtles, jellies, octopuses, and squids. The Flower Garden Banks National Marine Sanctuary is protected, actively managed, and well-studied: regular monitoring of the reefs has occurred since 1972.

The reefs in this area are unusually far from the coast, due to their unique formation process. In the Jurassic period—about 190 million years ago—the Gulf of Mexico was a very shallow sea that, thanks to the hot, dry climate, was subject to a lot of evaporation. This resulted in a thick layer of salt being deposited on the seafloor, which was later buried by layers of sand and mud. Because rock salt is less dense than the overlying sediments, it causes the seafloor to bulge upward, especially in places disturbed by deeper tectonic movements (the site lays over the edge of a continental shelf), forming "salt domes" that rise toward the ocean surface. It is on these salt domes that the reefs have formed during the last 10,000 years, after the Last Glacial Maximum. The salt domes also create spaces under the seabed in which oil and gas deposits form—making them attractive sites for petroleum exploration. More than 9,000 offshore oil platforms have operated in the northern Gulf of Mexico since 1982, including several within thirty kilometers of the reefs. Partially due to these oil company interests, the geology of the region is well documented and understood.

The remote location of these reefs means that they are less vulnerable than coastal reefs to anthropogenic pollution from the land, and—since it takes ten to twelve hours to reach the reefs by boat—they are also less disturbed by fishing and diving. Because of the unusual

latitude (near the northernmost limits of coral-supporting conditions) and depth (17–40 meters) of these reefs, they have so far been minimally affected by coral bleaching—a condition caused by rising sea temperatures that is threatening coral reef ecosystems worldwide. They are not immune to anthropogenic influence, however. The Gulf of Mexico serves as a watershed to a vast area that includes eastern Mexico and two-thirds of the continental US, with the Mississippi River Basin accounting for the single largest portion of this catchment area.

In May 2005, the research team collected a 174-centimeter-long core from a *Siderastrea siderea* coral colony in the West Flower Garden Bank reef. *Siderastrea siderea*—also known as the massive starlet coral or round starlet coral—is a stony coral that grows in large boulder-like structures with a mustard-brown color, sometimes reaching more than two meters across. As corals grow, they preserve a record of the water chemistry in their exoskeletons that allows scientists to reconstruct past environmental and climatic conditions. *Siderastrea siderea* is a particularly good species to use for paleoclimate reconstructions, since its relatively slow growth rate means that an average-sized colony is older—and therefore has longer-running records—than similarly sized colonies of other species. Coral exoskeletons are made of aragonite (a mineral form of calcium carbonate), the density of which varies throughout the year as they grow. The resultant annual growth bands (visible in X-ray images) allow scientists to observe individual years of growth in coral cores, with dates verified by thorium-230 radiometric dating.

The 174-centimeter-long core constitutes an archive that extends from 1755 to 2005. The core 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. This is evident in the core in a decrease in carbon isotope ratios (or the Suess effect). It also records an indirect effect of the oil industry starting in the 1950s and peaking in the 1980s: an increase in barium in seawater, which may come from the discarded drilling mud (barite) used in ocean oil drilling.

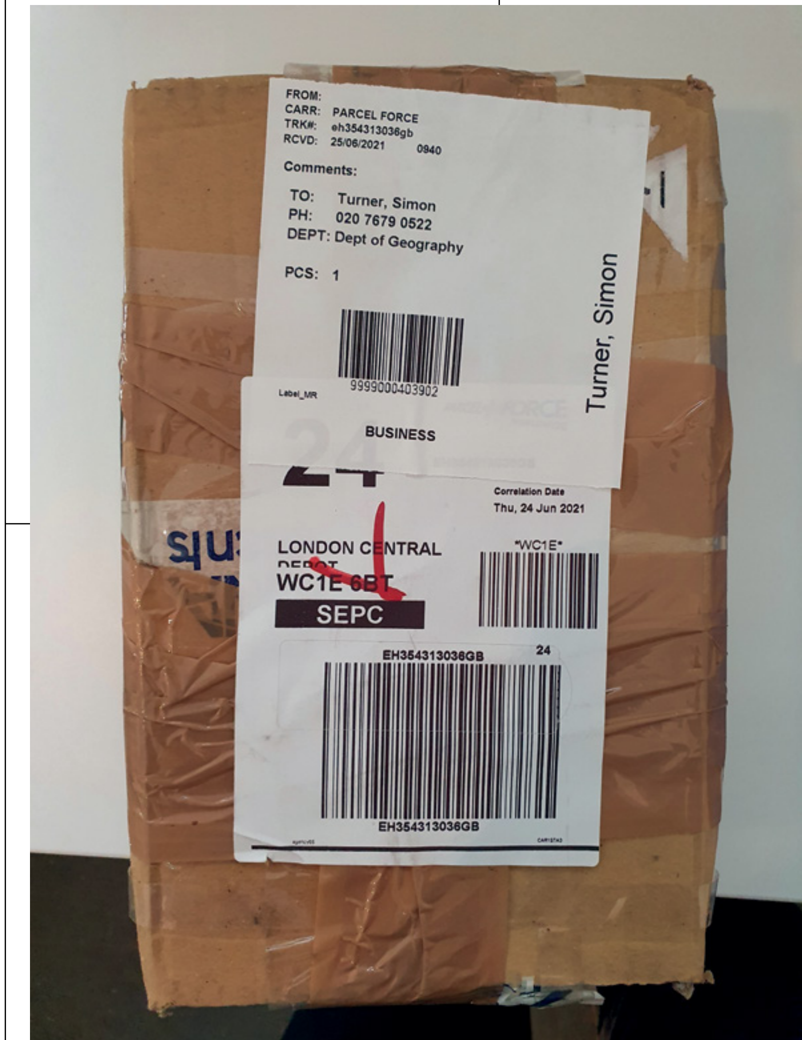
Coral skeletons can also record changes in ocean chemistry caused by the use of fertilizers on land. Fertilizers contain large amounts of nitrogen and phosphorus, and when runoff from agricultural fields flows into the ocean, the concentrations of these elements in the water increase. Starting in the 1960s, there is an increase of nitrogen in the West Flower Garden Bank core that correlates with an increase in nitrogen in the Mississippi River (which empties into the Gulf of Mexico). The northern Gulf of Mexico, off the Louisiana coast, is one of the world's largest "dead zones," where the increase in nitrogen and phosphorus leads to plankton blooms that deplete oxygen in the bottom waters as the organic matter decays.

Core 05WFGB3-1 was collected in May 2005 at a depth of 23.8 meters by a team of scuba divers using an underwater hydraulic drill, with a 10.2-centimeter-diameter diamond-tipped drill bit. They drilled vertically down from the top of the coral colony. The coral core extraction at this site was challenging, since divers can only work underwater at this depth for thirty to forty-five minutes, but the coring process takes several hours. Communication underwater is nonverbal and limited, and coral dust produced by drilling causes the normally clear waters to turn murky. Underwater currents and visits from curious marine life can complicate things further. Once retrieved, the core was subjected to various analyses, including carbon and oxygen isotopes, barium, magnesium, strontium, calcium, radionuclides, radiocarbon, nitrogen isotopes, spheroidal carbonaceous particles (SCPs), and annual growth and coral density.

The research team is led by Kristine DeLong (Louisiana State University) and Jens Zinke (University of Leicester).

Earth Indices: Labs

Which tools and instruments and what kind of infrastructures make the global fingerprint of humankind in the Earth's sediments readable? Whether microplastics, neobiota, fly ash particles, or the accumulation of radionuclides from nuclear weapons testing, every material demarcation of the new geological epoch has to go through a chain of forensic evidence of the Anthropocene in order for the geological epoch to take shape. The data-analysis methods and dating techniques—from CT scanners and synchrotrons to gamma spectrometry—are employed to separate the anthropogenic signals from the noise of the Earth system. The microscopic traces of anthropogenic markers left in the Earth's archives not only point to the disruptions of ecosystems and material flows, but also to the political, technological, and ecological history behind them.



I tipped this box on its end to replicate the monolith like nature of the original core of peat collected by our colleagues in Poland.

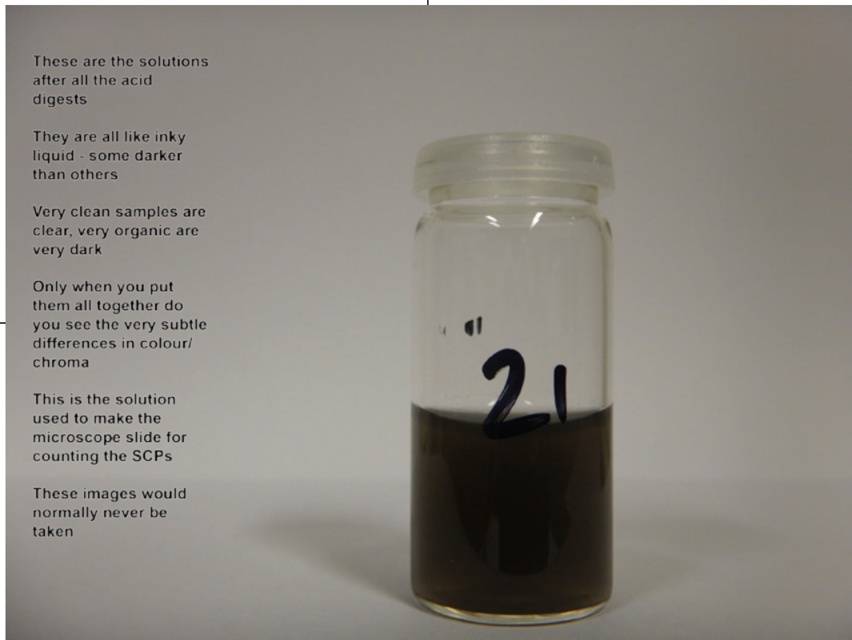
Inside the freeze-dried samples are all in sealed, air-tight bags.

A potential geological epoch contained in a non-descript cardboard box.

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
GSP metadata	50°44.20.90 N, 15°42.28.03 E
software	n/a

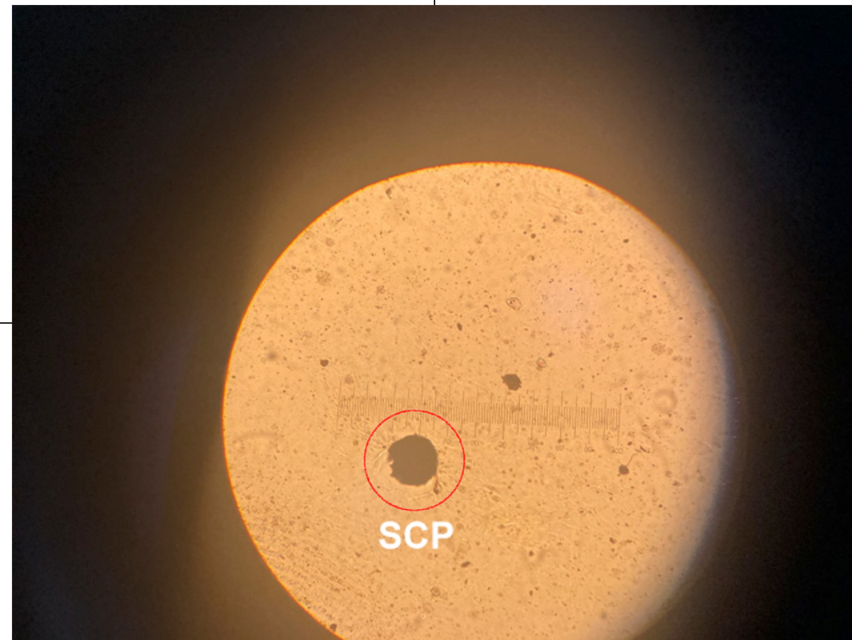
3	coring and analysis data
referent name	Barbara Fiałkiewicz-Kozieł
location	Lab., Krygowskiego 10, 61-618 Poznań
core name date of coring date of analysis	SN0 29/08/2020 23/09/2020
marker analysis	This is a photo of core, where all markers were measured. Bags of peat for posting. Subsampling of core.
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



1	institutional data
project title	UCL Environmental Radiometric Facility and Department of Geography
institution	University College London
department	UCL Geography
researcher(s)	Neil Rose, Simon Turner, Sarah Roberts, Handong Yang
city country	London United Kingdom

2	technical data
file name size creation date	DSCN3938.jpg n/a 16/12/2020
media type equipment	Photograph Nikon Coolpix AW 130
GPS metadata	51.5246095, -0.134486282 (WGS84, decimal lat lon)
software	n/a

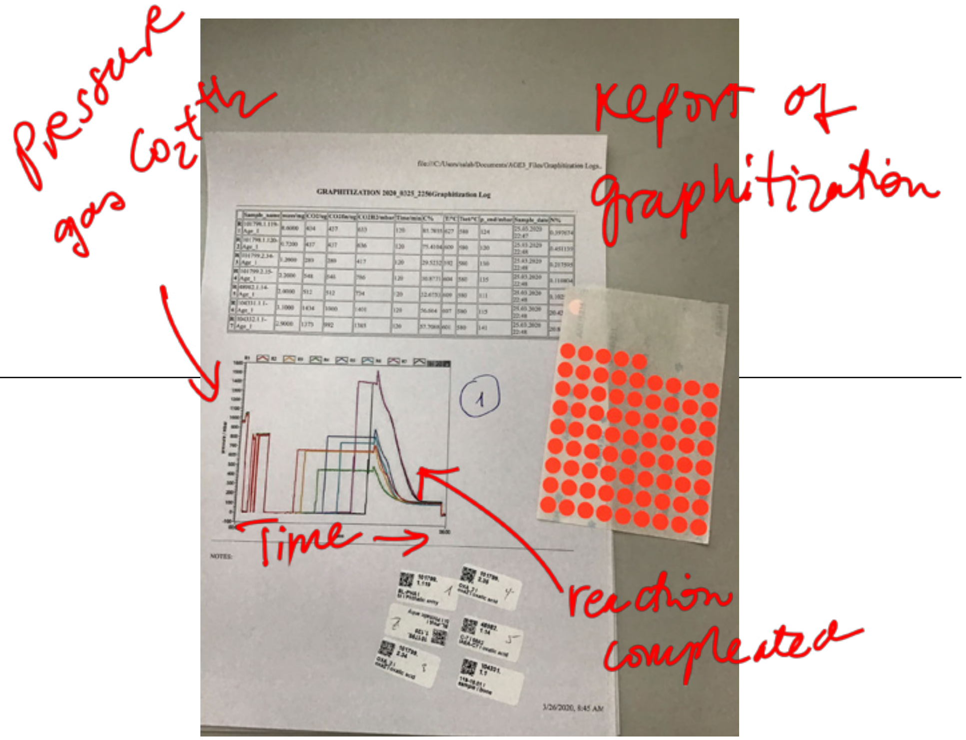
3	coring and analysis data
referent name	SImon Turner
location	UCL Geography Laboratory, Gower Street, London, WC1E 6BT, United Kingdom
core name date of coring date of analysis	EMB201/7-4 MUC1 n/a n/a
marker analysis	SCPs Acid digestion
description	The final solution from each tube is transferred to a glass vial with deionised water. This solution is what is transferred to the glass slide for mounting and counting.
sampling notes	n/a
additional notes	n/a
© original image	Simon Turner



1	institutional data
project title	UCL Environmental Radiometric Facility and Department of Geography
institution	University College London
department	UCL Geography
researcher(s)	UCL Environmental Radiometric Facility Principal investigators (listed alphabetically): Handong Yang, University College London / Neil Rose, University College London
	UCL Geography: Spheroidal Carbonaceous Particle (SCP) analysis Principal investigators (listed alphabetically): Sarah Roberts, University College London / Neil Rose, University College London / Simon Turner, University College London Extended team (listed alphabetically): Lucy Roberts, University College London / Aarhus University (from 1st Sept 2021)
	UCL Geography: Mercury Analysis Principal investigators (listed alphabetically): Sarah Roberts, University College London / Handong Yang, University College London
city country	London United Kingdom

2	technical data
file name size creation date	Peat_1.tiff 3024 px x 4032 px 72 px/inch 21/06/2021
media type equipment	Photograph iPhone SE & Leica Microscope
GPS metadata	51.5246095, -0.134486282 (WGS84, decimal lat lon)
software	Raw image

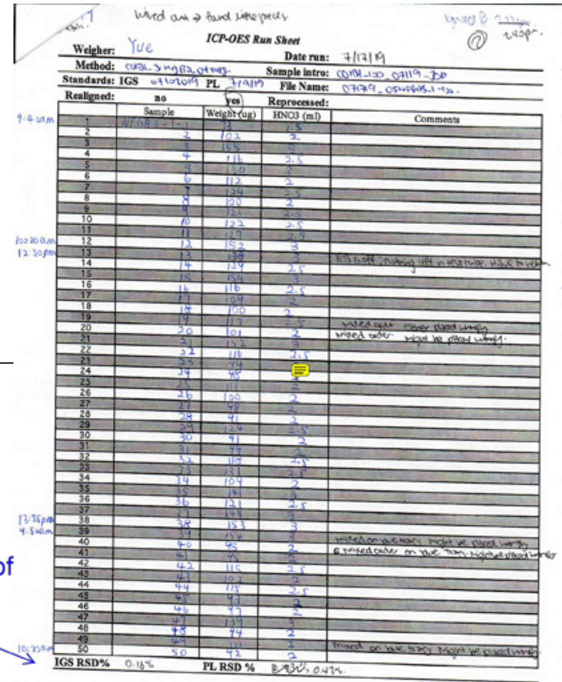
3	coring and analysis data
referent name	Simon Turner, Sarah Roberts, Neil Rose
location	UCL Geography, North West Wing, University College London, Gower Street, London, WC1E 6BT
core name date of coring date of analysis	SN0: Śnieżka peatland, The Sudetes, Poland 2020 21/06/2021
marker analysis	SCPs Optical microscopy
description	View down microscope eyepiece using iphone showing common features of slide prepared for SCP counting. Red rectangles created in mark up to highlight possible SCPs.
sampling notes	Visual checking of SCPs, on-line sharing during counting.
additional notes	n/a
© original image	Sarah Roberts



1	institutional data
project title	ETH Zurich, Laboratory of Ion Beam Physics
institution	ETH Zurich
department	Laboratory of Ion Beam Physics
researcher(s)	Principal investigators (listed alphabetically): Irka Hajdas, Laboratory of Ion Beam Physics, ETH Zurich Core team (listed alphabetically): Karin Wyss, Laboratory of Ion Beam Physics, ETH Zurich / Negar Haghipour, Geological Institute, ETH Zurich / Lukas Wacker, Laboratory of Ion Beam Physics, ETH Zurich
city country	Zurich Switzerland

2	technical data
file name size creation date	IMG_0680.jpg 3264 px x 2448 px 72 px/inch n/a
media type equipment	Photograph Photo camera
GSP metadata	N 47.40952774, E 8.50934081
software	None used

3	coring and analysis data
referent name	Irka Hajdas
location	ETH Zurich, Laboratory of Ion Beam Physics (LIP), HPK, Otto-Stern-Weg 5, 8093 Zurich, Switzerland.
core name date of coring date of analysis	n/a n/a n/a
marker analysis	Radiocarbon AMS sample preparation
description	n/a
sampling notes	n/a
additional notes	n/a
© original image	Irka Hajdas



The analyst adds details of the ICP-OES methods and standards used for each run. Notes are added from weighing or from the analysis.

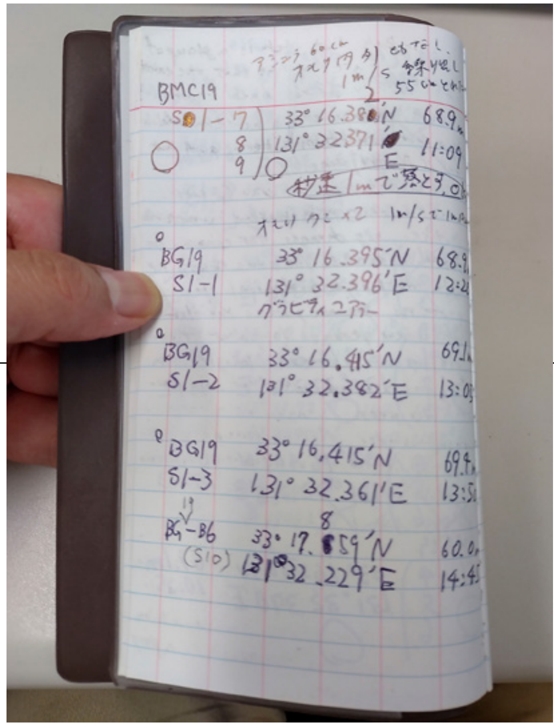
The run precision is noted at the bottom of the sheet.

The lab run sheet for ICP-OES analysis. Students weigh out the coral powder using a high precision micro-balance to between 100 and 200 micrograms. They then determine how much nitric acid to add to dissolve the coral powder before analysis.

1	institutional data
project title	0FWFGB3-1: West Flower Garden Bank Reef, USA 2005
institution	Louisiana State University
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	071719_05WFGB3-1_A1_1-100_Page_1.pdf 1650 px x 1275 px 150 px/inch 2019
media type equipment	Logbook Scanner
GPS metadata	30.411607°N, 91.178627°W
software	n/a

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 17/07/2019
marker analysis	Sr/Ca, Mg/Ca, and Ba/Ca ICP-OES
description	PAST Laboratory sample weighing notes for 05WFGB3-1 from 2019.
sampling notes	Standard lab form for weighing samples for geochemical analysis.
additional notes	Notes are used for quality control of the data before building the master chronologies.
© original image	Kristine DeLong



1 institutional data

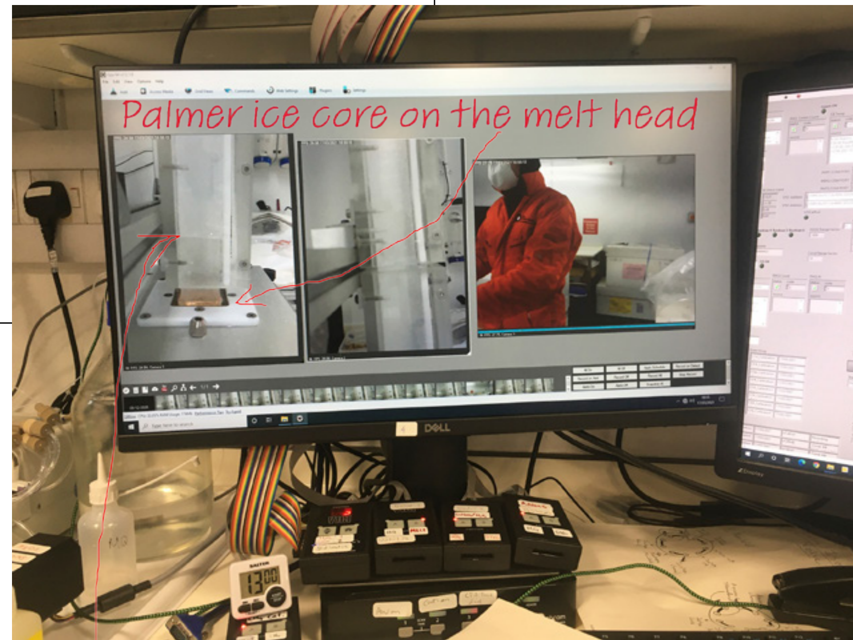
project title	2019 BMC19 S1-4: Beppu Bay, Japan 10-09-2019
institution	Ehime University
department	Center for Marine Environmental Studies
researcher(s)	Michinobu Kuwae
city country	Matsuyama Japan

2 technical data

file name size creation date	三千宣 加 - Core site description BMC19 3410 px x 2589 px 72 px/inch 19/09/2021
media type equipment	Logbook Photo camera
GSP metadata	33°51’3”N;132°46’30”E
software	n/a

3 coring and analysis data

referent name	Michinobu Kuwae
location	Beppu Bay, Oita Prefecture
core name date of coring date of analysis	BMC19 S1-7, BG19 S1-1,S1-2 10/09/2019 n/a
marker analysis	n/a C-14, δ15N , δ13C, dinoflagerates, foraminifer, palynomorphs
description	はMultiple core samplelerのMC。BGのBもBeppu Bay、Gはgravity corerのG。 MC – Multiple core sampler. BG – B from Beppu bay, G from gravity corer.
sampling notes	コア試料が海底に着底した後、すぐに緯度経度と水深を記載。BMCのBは、Beppu BayのB、MC。 As soon as the core sample reaches the sea bottom, we immediately record latitude, longitude and water depth. The B of BMC refers to Beppu Bay.
additional notes	別府湾の表層の泥は非常に柔らかい。そのため、マルチプルコアラーのオモリはすべて取り外した。ワイヤーを繰り出す速度は1m/sec The surface mud of Beppu bay is very soft. We therefore removed all weights from the multiple corers. The lowering speed of the wire was 1m/sec.
© original image	Michinobu Kuwae



break coming up

1 institutional data

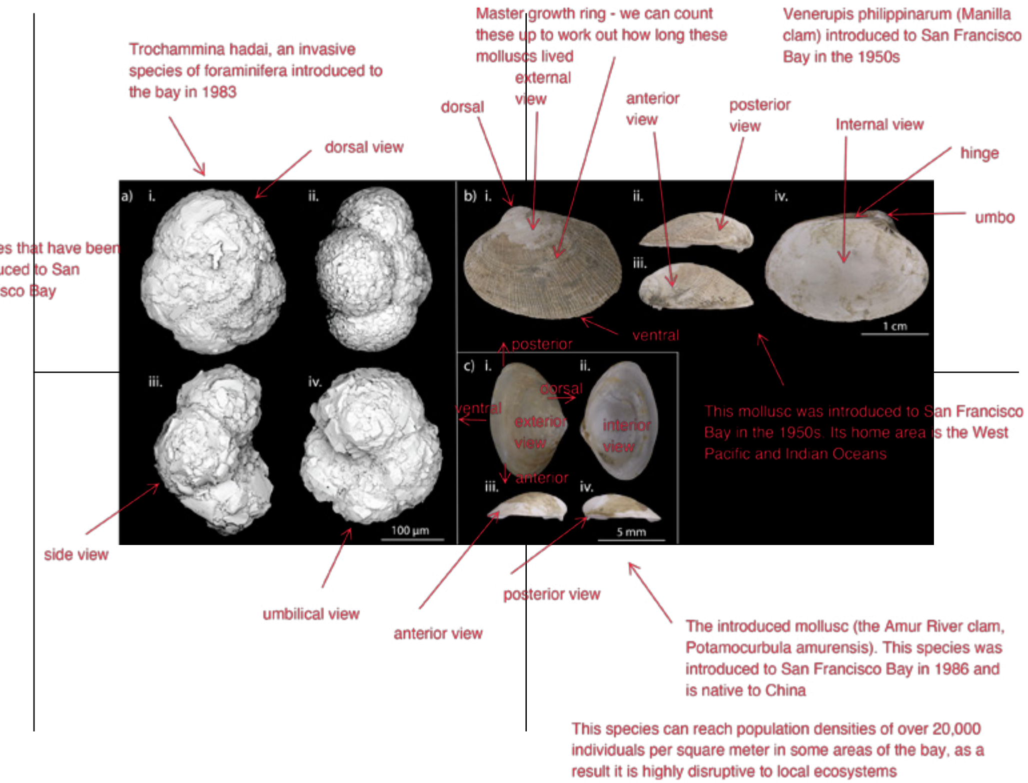
project title	PALMER: Antarctic Peninsula, Antarctica 24-29/12/2012
institution	British Antarctic Survey, Natural Environment Research Council, UK Research and Innovation
department	Ice core research group
researcher(s)	Principal investigators (listed alphabetically): Elizabeth Thomas, British Antarctic 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	IMG_5175.jpg 3024 px x 4032 px 72 px/inch 12/03/2021
media type equipment	Photograph Digital camera (iPhone)
GSP 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 12/03/2021
marker analysis	Chemistry. Stable water isotopes, methane Melt head
description	Display screen showing ice on the melt head and team working in the freezer.
sampling notes	n/a
additional notes	The metal melt head is heated to ~20°C to slowly melt the ice core in the freezer.
© original image	Daniel Emanuelsson, Jack Humby, Diana Vladimirova



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

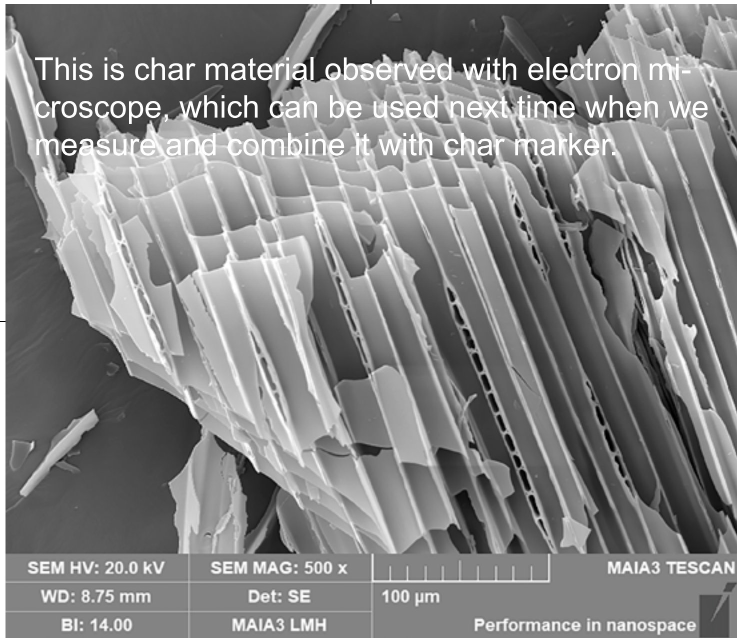
2	technical data
file name size creation date	agu poster plate.png 10357 px x 17777 px 150 px/inch 15/08/2019
media type equipment	Photograph Scanning electron microscope and photo camera
GSP metadata	52.623214,-1.122661
software	Photoshop

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	Three species (Trochammina hadai, Potamocorbula amurensis and Venerupis philippinarum) introduced to San Francisco Bay in the 20th century.
sampling notes	Compilation of samples across several cores, samples came from the top 1 m of sediment.
additional notes	n/a
© original image	Stephen Himson, Mark Williams, Ian Wilkinson, Mary McGann

1	institutional data
project title	SHLW-maar: Sihailongwan Lake, China 26-02-2021.
institution	Aerosol and Environmental Division State Key Laboratory of Loess & Quaternary Geology Chinese Academy of Sciences; National Natural Science Foundation of China (NSFC; Grant Number: 41991250)
department	Institute of Earth Environment
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 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, Institute of Earth Environment, Chinese Academy of Sciences (IEECAS) Jianghu Lan, Institute of Earth Environment, Chinese Academy of Sciences (IEECAS) Extended team (listed alphabetically): Tong Zhang, Institute of Earth Environment, Chinese Academy of Sciences (IEECAS) / Tianli Wang, Institute of Earth Environment, 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 (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 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 Sciences (IEECAS)
city country	Xi’an China

2	technical data
file name size creation date	XRF core scanner.jpg 2269 px x 4608 px 72 px/inch 01/07/2021
media type equipment	Photograph Phone (HUAWEI YAL-AL00)
GPS metadata	34°13’N,109°00’E
software	n/a

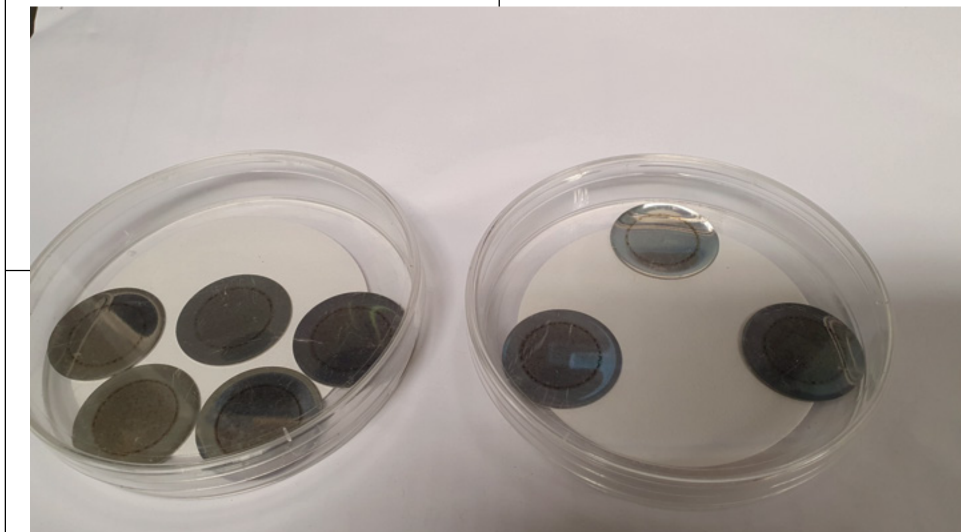
3	coring and analysis data
referent name	n/a
location	Institute of Earth Environment, Chinese Academy of Sciences, 97 YanxiangRoad, Xi’an, Shanxi Province, China
core name date of coring date of analysis	SHLW21-Fr-3 n/a n/a
marker analysis	Not specific analysis. Making thin secctions
description	XRF扫描 The XRF Core scanner.
sampling notes	扫描电压为50 kV 、 10 kV. Electronic volt is 50 kV and 10 kV.
additional notes	n/a
© original image	Yalan Tang



1	institutional data
project title	SHLW-maar: Sihailongwan Lake, China 26-02-2021.
institution	Aerosol and Environmental Division State Key Laboratory of Loess & Quaternary Geology Chinese Academy of Sciences; National Natural Science Foundation of China (NSFC; Grant Number: 41991250)
department	Institute of Earth Environment
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 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, Institute of Earth Environment, Chinese Academy of Sciences (IEECAS) Jianghu Lan, Institute of Earth Environment, Chinese Academy of Sciences (IEECAS) Extended team (listed alphabetically): Tong Zhang, Institute of Earth Environment, Chinese Academy of Sciences (IEECAS) / Tianli Wang, Institute of Earth Environment, 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 (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 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 Sciences (IEECAS)
city country	Xi'an China

2	technical data
file name size creation date	3.tiff 666 px x 768 px 109 px/inch n/a
media type equipment	Photograph SEM Microscope
GSP metadata	n/a
software	n/a

3	coring and analysis data
referent name	n/a
location	Institute of Earth Environment,CAS, No. 97 Yanxiang Road, Xi'an 710061, Shaanxi, China
core name date of coring date of analysis	SHLW21-Fr-1 n n/a/a
marker analysis	Black carbon Scanning electron microscopy
description	黑碳是燃料不完全燃烧的产物，分为焦炭和烟炱。图中是焦炭，仍保留有燃料的原始结构,不能远距离传播。Black carbon is the production of incomplete combustion, which consists of char and soot. The picture shows char, which still retains the original structure of fuel and cannot spread over a long distance.
sampling notes	n/a
additional notes	n/a
© original image	n/a



The results of the plutonium separation, starting from the bottom of the sea and now a counting-ready sample–prepared and washed stainless steel discs, with a thin electrodeposited plutonium-enriched layer on each for alpha spectrometric counting.

Anoxic. An environment with low or no oxygen.

Atmospheric aerosols. Very small airborne drops of liquid or solid particles (generally smaller than one micron), including soot aerosols (from fossil fuel combustion), volcanic aerosols, and soil-dust aerosols.

Auxiliary stratotype. A stratotype, or definitive location of geological evidence, that provides further information in support of a boundary marked by a GSSP.

Benthic organisms. Organisms that live on or in the bottom sediments of a body of water, such as a seabed or lakebed.

Bomb pulse. The sudden increase in carbon-14 in the Earth's atmosphere resulting from hundreds of nuclear weapons tests, beginning in 1945 and intensifying after 1950. It lasted until 1963, when the Limited Test Ban Treaty was signed by the United States, the Soviet Union, and the United Kingdom.

Chrysophyte. Golden or golden-brown, predominantly freshwater algae. Their color comes from carotenoid pigments alongside chlorophylls.

Continental shelf. The area of the seafloor that extends from a continent's shore at a depth of around 150–200 meters.

Coral bleaching. The expulsion of the algae that usually gives coral its color. Revealing its white calcium carbonate skeleton, coral bleaching occurs when corals are stressed by changes in environmental conditions, like changes in temperature and pollution levels. Coral can regain their algae if conditions improve, but increasing incidence of environmental stressors leave less time for corals to recover in between bleaching events.

Diatom. A microscopic, single-celled algae with a shell-like cell wall (called a frustule) made of silica. They live in nearly all bodies of salt and freshwater.

Eutrophication. An excessive growth of algae and other plants due to an increased input of nutrients, which in turn causes a depletion of oxygen and a reduction in animal life.

Event stratigraphy. The study of geological traces of relatively short-lived events (from instantaneous to millions of years). Events may be represented by depositional, erosional, fossil, or geochemical features, and they could be local, regional, or global in scale.

Exoskeleton. An external skeleton.

Fluorescence. The emission of light and other radiation by a substance that has absorbed electrons or radiation of a different wavelength, especially ultraviolet light and X-rays.

Foraminifera. A diverse group of single-celled marine organisms with a shell made of calcium carbonate. They live in a variety of habitats in a range of forms, and their fossils can be used to reconstruct past environments.

Frustule. The shell-like cell walls of diatoms, made of silica.

Global Boundary Stratotype Section and Point (GSSP). An internationally agreed location and geological section with a clear ability to define the lower boundary of a chronostratigraphic unit on the geologic time scale. The GSSPs are used as reference points for other locations and sections and in further stratigraphic research.

Golden spike. A golden spike is the informal term for a Global Boundary Stratotype Section and Point (GSSP), referring to the spike that may be driven into rock to mark the lower boundary of a geological time unit.

Halocline. A layer in a body of water where salinity and density change sharply.

Hexachlorocyclohexane (HCH). Any one of a group of organic compounds with a six-carbon ring containing one chlorine and one hydrogen attached to each carbon. HCH compounds have poisonous, pesticidal, and persistent organic pollutant properties.

Holocene. The current geological epoch, beginning around 11,700 years ago, and characterized by the relatively stable climate that allowed major human civilizations and the modern world to develop.

Hypoxia. Depletion of dissolved oxygen in water and sediments.

Ice flow. A region of fast-moving ice within an ice shelf.

Karst. A region which is underlain by porous limestone and has landforms produced by dissolution and underground drainage systems (such as karst towers, caves, and sinkholes).

Last Glacial Maximum. The point when the most recent ice age reached its greatest intensity, approximately 21,000 years ago. The average global temperature was approximately 5 degrees Celsius lower than it is today.

Little Ice Age. A phase between 1550 and 1850 with globally lower temperatures and increased glaciation compared to the present.

Maar. A volcanic crater caused by an eruption. A maar characteristically fills with water to form a crater lake, which may also be called a maar lake.

Meromictic. permanently stratified body of water in which the bottom layer of water (the monimolimnion) does not mix with the upper layers, usually because of differences in chemical composition, such as salinity, and physical differences in temperature.

Monimolimnion. The bottom layer of a meromictic lake, which is usually anoxic or hypoxic (low in oxygen) and does not mix with the layers of water above.

Neobiota. Organisms that are non-native to the environment in which they now reside.

Neolithic. A time period that saw the first fixed human settlements and the domestication of animals and cereals, beginning around 12,000 years ago.

Ostracod. Tiny crustaceans that live inside a bivalve shell.

Paleolithic. A time period extending from the first use of stone tools by hominins around 3.3 million years ago to the end of the Pleistocene. It is subdivided into the Lower, Middle, and Upper Paleolithic.

Palynomorph. Microfossils (between five and 500 micrometers in size) of pollen, fungal spores, or other microscopic organic matter. Their presence in sediments can be used to determine past environmental conditions.

pH. A measure of acidity or alkalinity on a logarithmic scale of 0–14. pH 7 is neutral; lower values are acidic, and higher values are alkaline. The term derives from the German *Potenz* (power) and the former chemical symbol for the hydrogen ion, H (now H^+).

Pleistocene. The geological epoch preceding the Holocene, extending from 1.806 million years ago until around 11,000 years ago.

Polychlorinated biphenyls (PCBs). Organic chlorine compounds that are highly toxic to humans and other animals. They have been banned in the US since 1978 and globally since the Stockholm Convention on Persistent Organic Pollutants of 2001. Because PCBs are non-flammable, chemically stable, and have electrical insulating properties, they were used in many products including electrical equipment, paints, plastics, pigments, and dyes.

Polycyclic aromatic hydrocarbons (PAHs). Toxic compounds commonly produced by the combustion of hydrocarbon fuels. They can be found in the air, soil, and water.

Quaternary. The most recent geo-chronological period of time (the last two million years), which includes the Pleistocene and Holocene epochs.

Radiometric dating. A precise method of dating geological specimens by determining relative proportions of radioactive element isotopes with known radioactive decay rates (half-lives). Different methods are used depending on the age of Earth materials being measured. Uranium–Lead radiometric dating can provide ages for rocks going back to the formation of the Earth; radiocarbon dating is used to date organic remains from the last ~60,000 years.

Radionuclide. A radioactive atom of an element, identified by the number of nuclear neutrons and protons and energy state.

Siliciclastic. Inorganic sediments comprised of silicate minerals and rock fragments.

Spheroidal aluminosilicates (SAPs). Forms of spheroid-shaped fly ash composed of aluminum, silicon, and oxygen, produced during high-temperature oil and coal combustion.

Spheroidal carbonaceous particles (SCPs). Spheroid-shaped black carbon particles produced during high-temperature oil and coal combustion. SCPs are a distinct marker of human influence on the planet and can now be found in environmental archives on every continent, including very remote areas such as the Arctic and Antarctica.

Stable water isotopes. Naturally-occurring, non-radiogenic isotopes of an element. Many elements have several stable isotopes. Stable water isotopes include deuterium (^{2}H), oxygen-16, and oxygen-18, which can be used for paleoclimate reconstructions.

Suess effect. A change in the ratio of atmospheric concentrations of carbon isotopes (^{13}C and ^{14}C) caused by fossil-fuel combustion emissions, named after Austrian chemist Hans Suess.

Technofossils. Material remains of human civilizations and industries that may be preserved in the geological record, including everything from stone tools to cell phones, roads, and building materials.

Testate amoebae. A single-celled eukaryote with a shell-like cell wall.

Turbidites. Sedimentary deposits caused by the disturbance of sediments on a slope by strong wave action or earthquake shock.

Unconformity. A temporary break in an otherwise continuous rock record caused by a period of erosion or a pause in sediment accumulation.

Varves. Annual or sub-annual layers of sediment that reflect seasonal deposition of lake sediments and record changes in chemistry, biology, and sediment inputs, thereby providing a chronology of past environments.

X-ray fluorescence (XRF). The emission of “secondary” (or fluorescent) X-rays from a material that has been bombarded with high-energy X-rays or gamma rays. It is used to identify component elements and their concentrations.

The Anthropocene Working Group (AWG) is an interdisciplinary research group dedicated to the investigation of the Anthropocene. It was established in 2009 by the Subcommission on Quaternary Stratigraphy (SQS), a component body of the International Commission on Stratigraphy (ICS), and since then has worked to assess the Anthropocene as a geological time unit.

\+ Niklas Hoffmann-Walbeck was program assistant in the Literature and Humanities department at Haus der Kulturen der Welt (HKW) from 2017 to 2022, focusing on Anthropocene-related research projects, publications, and events. Most recently, he has served as scientific coordinator for HKW’s “Evidence & Experiment” project. He works as a curator, author, and translator: together with Janek Müller he was artistic director of the “Heat Cold Devices” (2018–19) project, and his German translation of Robert Byron’s *The Station* was published by Die Andere Bibliothek in 2020.

\+ Katrin Klingan is a literary scholar, curator, and producer of art and cultural projects. As Curator at HKW between 2011 and 2022, she has organized research projects exploring the entanglement between human culture, natural environments, and global technologies as well as structures of inequality and asymmetrical power relations. Since 2013, together with Christoph Rosol, she has headed the *Anthropocene Curriculum*, an international network and research project that experimentally and collaboratively explores pathways towards a new interdisciplinary culture of knowledge and education. Her most recent projects at HKW include *Mississippi. An Anthropocene River* (2018–19), *Life Forms* (2019), *Unearthing the Present*, and *Where is the Planetary?* (2022).

\+ Georg N. Schäfer is a researcher and scientific coordinator of the “Evidence & Experiment” project at Haus der Kulturen der Welt (HKW). Outside of HKW, Georg is pursuing a PhD project at the Max Planck Institute for the History of Science and Friedrich Schiller University in Jena, examining the role of modern economics in the emergence of the Anthropocene and combining his research interests in the history of ideas and knowledge, the history of economic thought, environmental history, and the human geological epoch. Together with co-author Sören E. Schuster he has recently published *Mapping Mainstream Economics: Genealogical Foundations of Alternativity* (Routledge, 2022).

+ Giulia Bruno studied biology, photography, and filmmaking. Her work as a photographer and filmmaker focuses on issues of identity, technology, language, and architecture. The boundary between the artificial and the natural are other strands she pursues in her research and artistic work. Her short film *Capital* was awarded first prize at Visioni Italiane 2015. In 2018, her video work *Artificial Act* was selected by Mark Rappolt in the Future Greats of *ArtReview*. Giulia Bruno is currently teaching at the Design Academy Eindhoven.

+ Armin Linke is a photographer and filmmaker. His work is dedicated to documenting how humanity uses technologies and knowledge to transform the surface of the Earth. His work has been exhibited internationally including at the Centre Pompidou in Paris, ZKM: Center for Art and Media in Karlsruhe, Istanbul Biennial, and many more. Currently, he is a visiting professor at the Higher Institute for Artistic Industries (ISIA) in Urbino, Italy. His project *Image Capital* was awarded the Kubus. Sparda Art Prize in 2019.

+ Simon Turner is 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 presented an investigation of coastal wetlands in Sicily. He is the scientific coordinator for the Anthropocene Working Group (AWG) and Haus der Kulturen der Welt's collaborative project to seek a GSSP for the Anthropocene.

+ J. Rowan Deer is a writer and editor based in Berlin. Her PhD and postdoctoral research experience are in the Environmental Humanities, and her book *Radical Animism: Reading for the End of the World* was published by Bloomsbury in 2020. She was on the editorial team of Haus der Kulturen der Welt's website anthropocene-curriculum.org for 2022.

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