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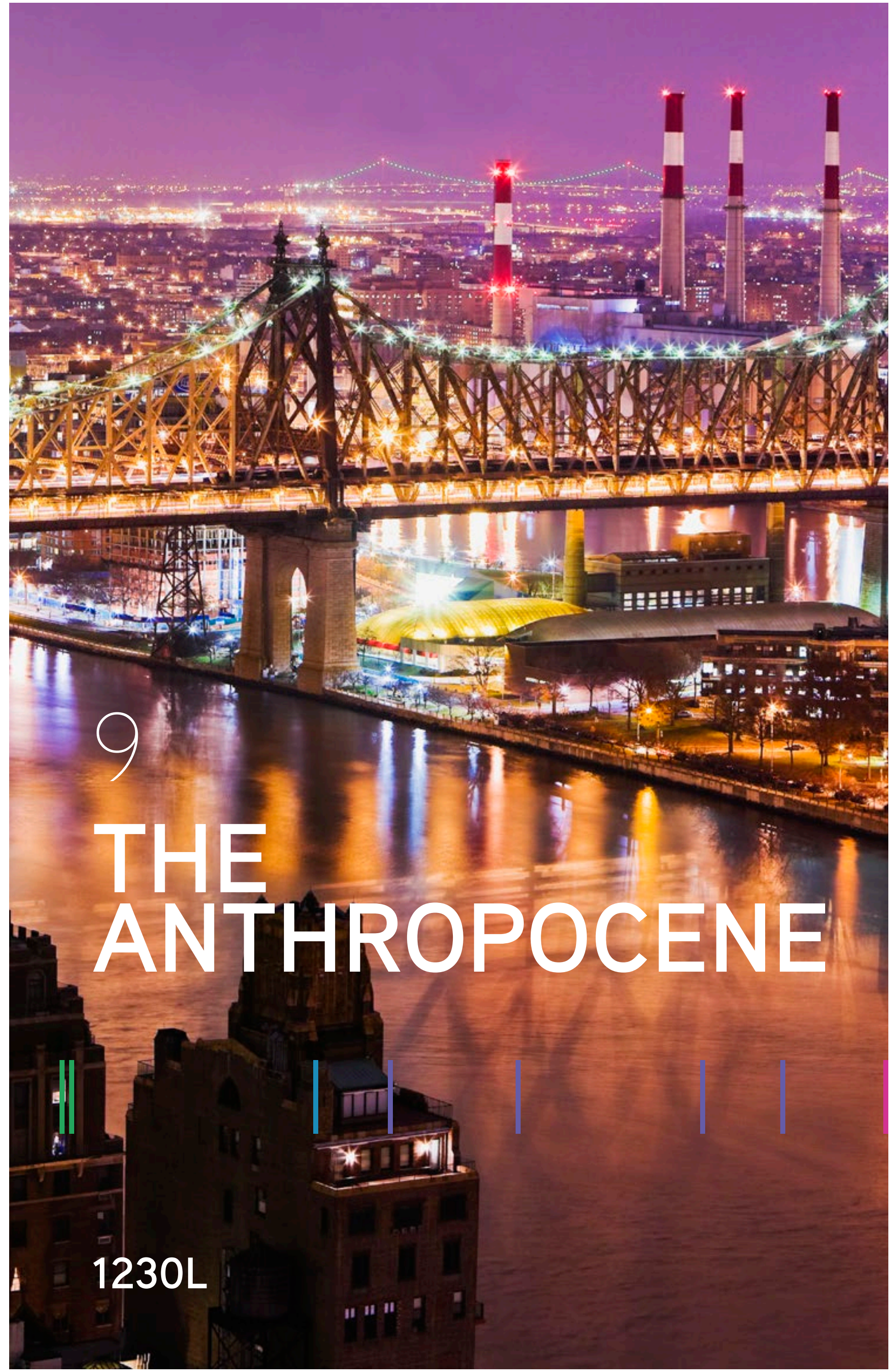

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THE ANTHROPOCENE

A NEW GEOLOGIC EPOCH?

By Cynthia Stokes Brown

For the first time in the 3.5-billion-year history of life on Earth, a single species, humans, has gained the capacity to effect major change in the entire biosphere.

The case for the Anthropocene

Geologists have worked out a system of naming large segments of Earth's time. They call short periods of thousands of years "epochs," longer ones that last tens of millions of years "periods," and really long ones lasting hundreds of millions of years "eras." The longest measurements of time are called "eons." Geologists refer to our current epoch as the Holocene, which started about 10,000 years ago, when the temperature stabilized at a new level of warmth after the last ice age. The word Holocene comes from Greek roots: *holo* meaning "whole" and *cene* meaning "new." Hence, Holocene means "wholly new."

In 2000, a Nobel Prize–winning Dutch chemist, Paul Crutzen (1933 —), suggested that we are in a new geologic epoch, which he proposed calling the Anthropocene. He believed that the state of human domination over the planet, which has drastically altered the Earth from its pre-industrial condition, warranted the name change. *Anthropo* is the Greek root for "human."

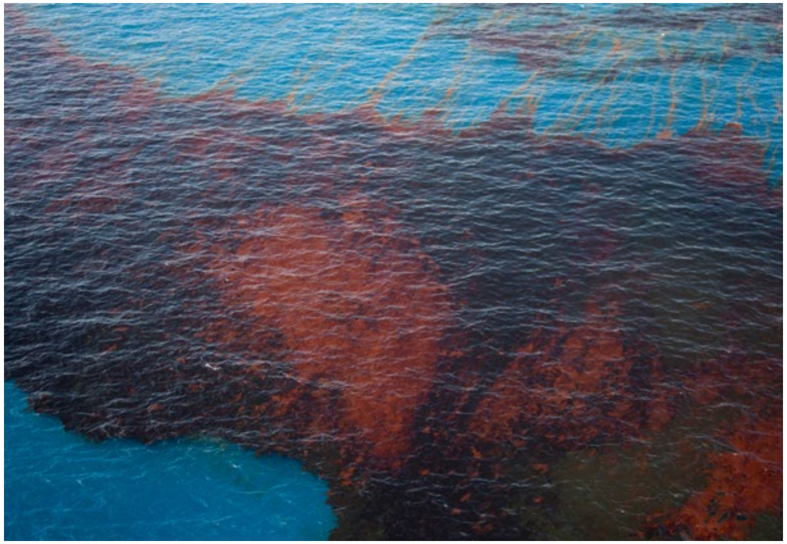
Geologists have an authority, the International Commission on Stratigraphy (ICS), that is the official keeper of the geologic time scale, the scale for expressing the history of Earth. Stratigraphy is the study of the order of strata, which are the layers of sedimentary rock and soil — each with characteristics that distinguish them from other layers.

In 2008, some geologists proposed to the ICS that it designate the Anthropocene as a formal geologic unit of time. An informal poll taken in 2010 showed that about half the members of the ICS thought the case was strong enough to adopt this new epoch. No official vote has been taken, but an Anthropocene Working Group continues to study the issue, and many geologists have begun to use the term; indeed, in 2011, the Geological Society of America called its annual meeting "Archean to Anthropocene: The Past Is Key to the Future."

Evidence of change

What kind of evidence could demonstrate that humans have begun to dominate and alter the life systems of Earth? The most prominent answer is by now a familiar one: climate change.

Plants and animals are moving northward; glaciers are melting; storms and droughts are increasing in severity; and weather patterns are changing. Behind these weather patterns are changes in the Earth's atmosphere that scientists can track over geologic time. A tiny part of Earth's atmosphere is so-called greenhouse gases, which hold in heat reflected from Earth and do not let it escape into space. One of these greenhouse gases is carbon dioxide (CO_2). During the glacial/interglacial cycles of the past million years, the CO_2 varied approximately 100 parts per million (ppm) — from 180 ppm to 280 ppm — due to processes not affected by humans. Since the Holocene and the beginning of human agriculture, the atmospheric concentration of CO_2 has risen from 280 ppm to about 390 ppm, much faster than ever before. This has happened mostly due to humans burning fossil fuels in the last 250 years. Leading scientists are now saying that we must reduce this



Oil from a spill in the Gulf of Mexico

concentration of CO_2 to 350 ppm and that global emissions must be cut by 4.8 percent every year until 2050 in order to keep our climate from a devastating warming. Instead, in 2011, emissions of CO2 increased almost 6 percent; the two biggest producers are China, with 24.6 percent of the total, and the United States, with 16.4 percent.

One might think that natural changes in climate would proceed slowly and gradually, but it doesn't always happen that way. Sometimes, like at the end of the last ice age, change speeds up because positive feedback cycles accelerate the process. For example, when glaciers at the poles melt, there is less area of whiteness to reflect some of the Sun's heat back into space. Instead, the heat is absorbed into the land and water, warming it and causing more melting of the glaciers, which then reflect even less heat; the feedback cycle continues.

Not only has the atmosphere been changed by CO_2 emissions, so too has the chemistry of the oceans. The oceans are absorbing extra CO_2 from the atmosphere. The extra CO2 makes the water more acidic, endangering the life of creatures that form calcium shells, which disintegrate under too much acid. Runoff from fertilizers and pesticides contributes as well, causing strange blooms of harmful algae, while widespread overfishing threatens marine species worldwide.

More than just sea life is under threat; the biodiversity of all sectors of the planet is declining faster than the usual background rate (the normal rate of change). Reports peg the present rate of decline as somewhere between a hundred to a thousand times the background rate. Up to half of all species face extinction in the twenty-first century, and many biologists believe the current extinction will rank as one of Earth's six major ones before it is over.

Another way that humans are changing Earth's systems lies in our ability to synthesize artificial chemicals, like drugs, pesticides, plastics, and synthetic fabrics. Earth is absorbing these chemicals, with unknown side effects.

For example, humans now "fix" more nitrogen artificially than all the world's plants do. (Fixing nitrogen means converting nitrogen from the atmosphere (N2) into ammonia (NH3), so that it is usable in biologic processes.) Most plants cannot convert nitrogen from the air and need to have it added to the soil. But a few kinds of plants, such as legumes, can fix nitrogen with the help of common bacteria that use plants to help it extract nitrogen from the air, which is then stored in the plants' roots. People fix nitrogen by burning oil or gas to synthesize ammonia from atmospheric nitrogen and hydrogen. For example, synthetic ammonia fertilizers made by burning fossil fuels contribute to increased food production. Human synthesis of nitrogen is altering Earth's whole nitrogen cycle.

Another power that humans have gained control over is that of nuclear energy. The United States dropped two atomic bombs on Japanese cities (Hiroshima and Nagasaki) in 1945 to end World War II. Since then, a handful of nations have tested bombs and several major peacetime accidents at nuclear plants have occurred. But, so far, nuclear power has not been used destructively on a massive scale. Large numbers of bombs exist, and some are on alert to be launched within 15 minutes. Multiple deployments could annihilate millions of people and send large-scale debris up into the atmosphere, blocking the Sun's rays long enough to produce a "nuclear winter" that would be as destructive to life as the asteroid of 65 million years ago that wiped out the dinosaurs.

The foregoing evidence may convince biologists and climate scientists, but geologists have a very specific method of periodization. They look for evidence in the rocks, or at least in layers of mud that will become rock. They are finding that proof. Worldwide sediments contain the radioactive signature of atomic bomb testing in the 1960s. Similar evidence of chlorine from bomb testing and of mercury associated with the burning of coal also exists in ice-core samples.

Environmental historians support the claims of geologists. For example, scholar John McNeill, in his environmental history of the twentieth-century world, *Something New Under the Sun*, asserts that "the human race, without intending anything of the sort, has undertaken a gigantic uncontrolled experiment on the Earth."

A wind farm in Germany

Going forward

There are differing opinions as to what these changes might bring and how humans might be able to overcome them. James Lovelock (1919 —), an English independent scientist, believes that humans have passed the point at which they can control change. Non-human processes are now in control and will bring the planet back into some kind of equilibrium, which may not support much human life. The best we can do, he feels, is to try to adapt to the changes.

Others believe that humans have been in tight fixes before and have always been able to figure a way out, using their unique abilities of collective learning to generate new ideas, new technologies, and new solutions. If only a few thousands or millions of humans could do this at previous crises, why can't seven billion do it now?

Geologists continue to debate other questions: Do we date the Anthropocene from 8,000 years ago, or from 2,000 or 200 or 100? How do we know when we have reached the critical point of human influence on the Earth? Whatever geologists decide about the name of this epoch, the mere consideration has been a productive way for scientists to try to get a handle on the scale of contemporary change.

Meanwhile, people have to align themselves with this decisive period in planetary history. Human decisions made in the near past and those made in the near future will determine the direction of life on our planet. Many leading scientists and journalists believe that we have at most 10 years in which both to rally ourselves to change our destructive behavior and to implement new technologies. Otherwise, humans could face a looming breakdown in our planet's current life-support systems. Many people trust that human ingenuity will be able to get us through this decisive period, but it will take the commitment, innovation, and cooperation of a large portion of all humans on the planet to accomplish this.

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