Chapter 10
Geology of Mankind

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The Anthropocene could be said to have started in the late eighteenth century, when analyses of air trapped in polar ice showed the beginning of growing global concentrations of carbon dioxide and methane.

For the past three centuries, the effects of humans on the global environment have escalated. Because of these anthro-pogenic emissions of carbon dioxide, global climate may depart significantly from natural behaviour for many millennia to come. It seems appropriate to assign the term 'Anthropocene' to the present, in many ways human-dominated, geological epoch, supplementing the Holocene—the warm period of the past 10–12 millennia. The Anthropocene could be said to have started in the latter part of the eighteenth century, when analyses of air trapped in polar ice showed the beginning of growing global concentrations of carbon dioxide and methane. This date also happens to coincide with James Watt's design of the steam engine in 1784.

Mankind's growing influence on the environment was recognized as long ago as 1873, when the Italian geologist Antonio Stoppani spoke about a "new telluric force which in power and universality may be compared to the greater forces of earth," referring to the "anthropozoic era". And in 1926, V.I. Vernadsky acknowledged the increasing impact of mankind: "The direction in which the processes of evolution must proceed, namely towards increasing consciousness and thought, and forms having greater and greater influence on their surroundings." Teilhard de Chardin and Vernadsky used the term 'noösphere'—the 'world of thought'—to mark the growing role of human brain-power in shaping its own future and environment.

The rapid expansion of mankind in numbers and per capita exploitation of Earth's resources has continued apace. During the past three centuries, the human population has increased tenfold to more than 6 billion and is expected to reach 10 billion in this century. The methane-produc-ing cattle population has risen to 1.4 billion. About 30–50 % of the planet's land surface is exploited by humans. Tropical rainforests disappear at a fast pace, releasing carbon dioxide and strongly

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increasing species extinction. Dam building and river diver-sion have become commonplace. More than half of all accessible fresh water is used by mankind. Fisheries remove more than 25 % of the primary production in upwelling ocean regions and 35 % in the temperate continental shelf. Energy use has grown 16-fold during the twentieth century, causing 160 million tonnes of atmospheric sulphur dioxide emissions per year, more than twice the sum of its natural emissions. More nitrogen fertilizer is applied in agriculture than is fixed naturally in all terrestrial ecosystems; nitric oxide prod-uction by the burning of fossil fuel and biomass also overrides natural emissions. Fossil-fuel burning and agriculture have caused sub-stantial increases in the concen-trations of 'greenhouse' gases—carbon dioxide by 30 % and methane by more than 100 %—reaching their highest levels over the past 400 millennia, with more to follow.

So far, these effects have largely been caused by only 25 % of the world population. The consequences are, among others, acid precipitation, photochemical 'smog' and climate warming. Hence, according to the latest estimates by the Intergovernmen-tal Panel on Climate Change (IPCC), the Earth will warm by 1.4–5.8 °C during this century.

Many toxic substances are released into the environment, even some that are not toxic at all but nevertheless have severely damaging effects, for example the chloro-fluorocarbons that caused the Antarctic 'ozone hole' (and which are now regulated). Things could have become much worse: the ozone-destroying properties of the halo-gens have been studied since the mid-1970s. If it had turned out that chlorine behaved chemically like bromine, the ozone hole would by then have been a global, year-round phenomenon, not just an event of the Antarctic spring. More by luck than by wisdom, this catastrophic situation did not develop.

Unless there is a global catastrophe—a meteorite impact, a world war or a pan-demic—mankind will remain a major environmental force for many millennia. A daunting task lies ahead for scientists and engineers to guide society towards environ-mentally sustainable management during the era of the Anthropocene. This will require appropriate human behaviour at all scales, and may well involve internationally accepted, large-scale geo-engineering pro-jects, for instance to 'optimize' climate. At this stage, however, we are still largely treading on *terra incognita.*

Box 10.1: Texts by Paul J. Crutzen and Colleagues on the Anthropocene: Setting the Scientific and Policy Agenda and Initiating a Global Debate on a New Era of Earth and Human History

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Texts from the Anthropocene Symposium: Honouring Paul J. Crutzen on his 80th Birthday (2013)[1]

1. Hartmut Graßl: Shaping Germany's Role in Ozone and Climate Policy. The Push by Paul Crutzen
2. Ralph J. Cicerone: Stratospheric Ozone and Climate Change: different Human Causes and Responses
3. Mario J. Molina: Climate Change Science and Policy
4. Susan Solomon: Ozone Depletion: An Enduring Challenge

[1]These presentations can be listened to on the website of the Max-Planck Institute on Chemistry (MPIC) at: http://www.mpic.de/aktuelles/pressemeldungen/news/konferenz-zu-ehren-von-atmosphaerenchemiker-paul-crutzen.html. The English programme is at: http://www.mpic.de/fileadmin/user_upload/images_presse/Images_PIs/Crutzen_Symposium/Program_Anthropocene_Symposium_SB11_small.pdf. The presentations can also be approached on YouTube at: https://www.youtube.com/watch?v=g0HuKpbMREU.

5. Veerabhadran Ramanathan: The Two worlds in the Anthropocene: A new Approach for Climate Change Mitigation
6. Henning Rodhe: The Anthropocene Sulfur Cycle
7. Jack Fishman: Tropospheric Ozone in the Anthropocene: Are We Creating a Toxic Atmosphere?
8. John P. Burrows: Living in and Observing the Anthropocene from Space
9. Klaus Töpfer: The Anthropocene—Sustainability in a World of 9 Billion People
10. Meinrat O. Andreae: 400,000.036 years of Biomass Burning

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