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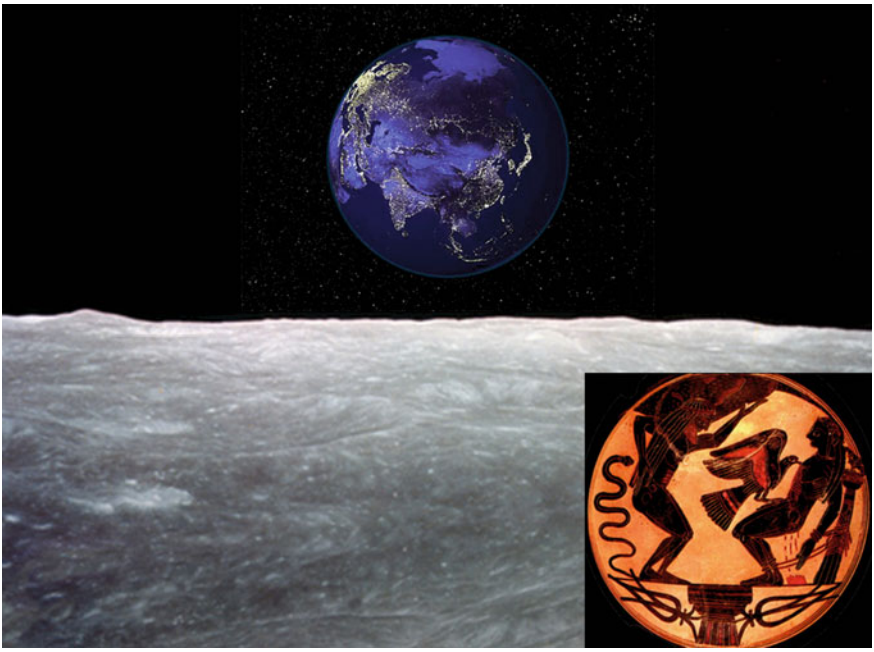

Andrew Y. Glikson

# Evolution of the Atmosphere, Fire and the Anthropocene Climate Event Horizon

With a forward by Professor
H. J. Schellnhuber
Director, Potsdam Institute of Climate
Impact Research (PIK)

Springer

Andrew Y. Glikson
School of Archaeology and Anthropology
Australian National University
Canberra, ACT
Australia

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*In honor of James Hansen and David Attenborough*

# Foreword

When I read Andrew Glikson's new book the famous Russell–Einstein Manifesto, published in 1955 in the midst of the Cold War, came to my mind. In this manifesto, Bertrand Russell, Albert Einstein and the other distinguished signatories point to the massive dangers of nuclear weapons and call for peaceful solutions, while stating: "Many warnings have been uttered by eminent men of science … We have not yet found that the views of experts on this question depend in any degree upon their politics or prejudices. They depend only … upon the extent of the particular expert's knowledge. We have found that the men who know most are the most gloomy". Indeed, Andrew Glikson shares an enormous wealth of knowledge with us, putting anthropogenic climate change in the context of the Earth's and mankind's (common) history. This book is full of facts derived from the recent scientific literature, which are woven into the fabric of a gripping narrative. A narrative—given the weight of evidence—that may turn out to have a dark end. As a reader we sit in a space craft watching the planet revolve around the sun. We look 3.5 billion years into the past to follow the evolution of the atmosphere, the origin of life, its rise and decline, and, finally, the most recent appearance of man. Ultimately, Andrew Glikson asks us to ponder the destiny of our own species, which has the intelligence and the ingenuity to put us into space, and also the power to destroy ourselves.

Hans Joachim Schellnhuber
Director of the Potsdam Institute for
Climate Impact Research (PIK)

# Preface

This monograph traces milestones in the evolution of the atmosphere, oceans and biosphere from about 3.5 billion years-ago [Ga], through natural cataclysms and all the way to the Anthropocene—a geological era triggered by a species which has uniquely mastered ignition. Of all the factors which have allowed life on Earth one stands out—the presence of liquid water, permitted by the planet's unique orbital position around the sun, its active tectonic and volcanic nature and its evolving atmospheric composition, regulating surface temperatures in the range of $\sim -90$ to $+58$°C. The atmosphere, mediating the carbon, oxygen and nitrogen cycles, acts as lungs of the biosphere, allowing the existence of an aqueous medium where metabolic microbiological processes occur—from chemo-bacteria around volcanic fumaroles, to nanobes in deep crustal fractures, to near-surface phototrophs. The histories of the atmosphere and of life are thus interdependent. From an initial Venus-like atmosphere dominated by $CO_2$, CO, $SO_2$, $N_2O$, $CH_4$, $H_2$ and likely $H_2S$, the sequestration of $CO_2$ and the build-up of nitrogen—a stable non-reactive gas—have led to intermittent ice ages from at least as early as $\sim$3.0 Ga. This was followed by multi-stage fluctuations in the level of the atmosphere's photosynthetic oxygen produced by phytoplankton and, from $\sim$ 420 Ma, by land plants, ensuing in a flammable carbon-rich biosphere interfaced with an oxygen-rich atmosphere. Superposed on gradual evolutionary trends were abrupt changes triggered by volcanism, asteroid impacts, possible supernovae and episodic release of methane and hydrogen sulphide. Changes in atmospheric chemistry affected variations in alkalinity, acidity [pH] and oxidation/reduction state [Eh] of the hydrosphere and thereby of marine biological processes. Born on a flammable Earth surface, under increasingly unstable climates descending from the warmer Pliocene into the deepest ice ages of the Pleistocene, human survival depended on both—biological adaptations and cultural evolution, mastering fire as a necessity, allowing the species to increase entropy in nature by orders of magnitude. Gathered around camp fires during long nights for hundreds of thousandth of years, captivated by the flickering life-like dance of the flames, humans developed imagination, insights, cravings, fears, premonitions of death and thereby aspiration for immortality, omniscience, omnipotence and the concept of god. Inherent in pantheism was the reverence of the Earth, its rocks and its living creatures, contrasted by the subsequent rise of monotheistic sky-god creeds which regard Earth as but a corridor to heaven. Once the climate stabilized in the early Holocene,

since about $\sim$7000 years-ago production of excess food by Neolithic civilization along the Great River Valleys has allowed human imagination and dreams to express themselves through the construction of monuments to immortality. Further to burning large part of the forests, the discovery of combustion and exhumation of carbon from the Earth's $\sim$420 million years-old fossil biospheres set the stage for an anthropogenic oxidation event, affecting an abrupt shift in state of the atmosphere-ocean-cryosphere system. The consequent ongoing extinction equals the past five great mass extinctions of species—constituting a geological event horizon in the history of planet Earth.

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