Foreword

Anthropocene: natural and man-made alterations of the Earth's fragile equilibrium

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The present issue of *Rendiconti Lincei* is dedicated to an international conference held in Rome, at the Accademia Nazionale dei Lincei on November 26 and 27, 2012. It discussed with a multidisciplinary approach a theme of great importance for the future of mankind. Indeed, scientists have the heavy responsibility to provide decision-makers with well documented, clear and unambiguous data and with projections for climate change, population growth, energy, water and food supply. The proposal of the conference was presented at the Commission of the Academy on Environment and Natural Disasters in 2011, and carefully planned by the organizing Committee that included members of both the Class of Physical, Mathematical and Natural Sciences and the Class of Moral, Historical and Philological Sciences. The plan was to have two full days of meeting, a variety of contributions to present all the facets of the problem, to have only invited lectures, with a few, but first-class foreign guests, to alternate presentations arising both from natural and human sciences. The Anthropocene Conference was a success, all the lectures were followed with increasing intellectual tension, and the meeting terminated with a round table entitled “The Earth, what future?”, moderated by the Conference conveners Maria Bianca Cita Sironi and Antonio Golini.

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Extended abstracts (for the scientific papers) or full, extended papers (for those originated from the human sciences) were published in the *ATTI DEI CONVEGNI LINCEI* (vol. 278, pp. 1–238, 2013), along with the interventions to the round table. The authors of scientific papers were invited to submit manuscripts, to be peer-reviewed, for the publication on the *Rendiconti Lincei*, edited by Springer. Almost all submitted a manuscript, and we thank them all for the prompt response. Because of the widely interdisciplinary character of the conference, many papers are to be considered to be aimed at a general audience.

The opening lecture was given by Jan Zalasiewicz, a British stratigrapher, who supports the proposal to formalize the Anthropocene as a chronostratigraphic unit, with a Global Stratigraphic Section and Point (GSSP) defined at the base of the oldest deposit originated by the extraction of coal near Cardiff. In this paper, he compares and confronts the Anthropocene as proposed above, with the Ordovician/Silurian boundary, some 444 million years ago, when a rapid climate change occurred, with a warming event starting from a global icehouse state.

Next scientific presentation was given by Enrico Flamini, chief scientist of the Italian Space Agency (ISA), who compares the Earth, Venus and Mars, the so-called “terrestrial” planets of the solar system. They have the same origin and the same age (some 4.5 billion years) and initially shared the same history, but had a different evolution. The new data obtained are such that we know better the surface of Mars than the surface of our planet, and can understand why the cold planet has no magnetic field and when it became too cold to bear liquid water. A high temperature was measured directly on Venus with the space missions and the planetary extension of greenhouse effect (Venus atmosphere consists of 96 % carbon dioxide) was documented.

Enrico Bonatti gave an inspiring philosophical and scientific lecture, predicting the far reaching consequences of an uncontrolled population growth, conflicting with the natural evolution of the Earth. Since the early days of mankind, two opposite traditions existed. The first, strongly rooted in the West, conceived the Earth as the center of the Universe, and Man as the final product of the Genesis, created in the image of God. Time for a man-centered Earth was limited, and ended with either Apotheosis or Apocalypse. It took a long time for geologists to collect enough data to persuade the nonscientists that the Earth existed since 4.5 billion years, whereas *Homo sapiens* appeared only some 200,000 years ago. The alternative tradition of limitless or cyclical time in a world where man was not the center of the universe was in existence in the Hindu and Chinese civilizations, but had supporters also in the Greek (Heraclitus, Herodotus) and Roman (Epicurus, Lucretius) culture. The paper terminates recalling the experiments run by J.B. Calhoun in 1973 that proved the growth and decline of a mice population, although raised in an environment with limitless space and food.

Remarkable for the richness of documentation synthesized is the paper by William W. Hay, a paleoceanographer who dedicated most of his professional life to develop the scientific scenarios and the development of the Ocean Drilling Program. The four major greenhouse gases that are present in the Earth atmosphere are discussed. Water vapor is the most abundant, but it is controlled by temperature so that its distribution is mainly restricted to lower atmosphere of the tropical and subtropical areas. Methane and nitrous oxide have short residence times in the atmosphere, of one or two decades. CO₂ introduced in the atmosphere has a much longer lifetime. The study of this gas trapped in air bubbles from the ice cores investigated from Antarctica showed that the increase of CO₂ produced by the burning of fossil fuels starting from the industrial revolution now exceeds 40 %. The greenhouse effect is augmented by a series of feedbacks, mostly positive. Among the strongest positive feedbacks is melting of Arctic sea ice, where the modern decline began in the 1970s with strong peaks in 2007 and 2012. Results of various numerical models predicting sea ice extent for the interval from 1,900 to 2,100 show that in 2012 the melting was so rapid that the ice extent was 70 years ahead of schedule. The final conclusion reached by the author is that the increasingly chaotic weather is an indication that the Earth's climate system is becoming unstable in response to the ongoing, man-induced perturbation.

The paper by the climate modeler Antonello Provenzale from CNR Institute of Atmospheric Sciences and Climate, Turin, witnessed the first attempts of climate modelers that originally took into account only atmospheric circulations,

then considered also the oceanic circulation, but soon realized that the Earth is a complex system, where atmosphere, hydrosphere, cryosphere, geosphere and biosphere interact. The paper briefly describes the increasing complexity of the climate models, mentioning their problems for downscaling, parameterization, and the exponential growth of the amount of data. The concepts of climate scenarios and climate predictability are highlighted as well as the need of a deeper understanding of the fundamentals of climate dynamics.

Two contributions concerning the cryosphere are presented by protagonists of the Italian Research Program on Antarctica (PNRA). Massimo Frezzotti (ENEA, Rome) and Giuseppe Orombelli (University of Milano-Bicocca) synthesized from a lot of new data the status and present trends of glaciers and ice sheets: 10 % of the continents are covered by glacier ice, of which 99 % in volume is locked in the polar ice sheets. The Greenland ice sheet is losing ice at an increasing rate that reached -263 Gt/year in the 2005–2010 interval, much faster than the Antarctic ice sheet (-81 Gt/year). Other synthetic data are presented on the trends of mountain glaciers that are losing ice at a high rate. On the Alps, for instance, a loss of 70 % of their present glacier volume is expected by the end of the twenty-first century. The paper by Carlo Barbante and Jacopo Gabrieli, of CNR Institute for the Dynamics of the Environmental Processes in Venice, describes the impact of human activities on the atmosphere, as documented in the ice cores obtained from drilling in the Colle Gnifetti glacier (Monte Rosa, Central Alps), at an elevation of 4,400–4,550 m. The new results obtained on polycyclic aromatic hydrocarbons, lead, uranium, plutonium and other radioisotopes deposition in the last several centuries are presented and discussed. This is the most detailed historic record obtained so far of anthropogenic air pollution as documented in a mountain area at the heart of Europe.

Telmo Pievani, who teaches Philosophy of Sciences at the University of Padua, speculates on the Anthropocene and the sixth mass-extinction, the first one eventually attributable to the direct influence of *Homo sapiens*. After a thorough, well-written introduction on the removal of catastrophism in evolutionary theory, the reality of mass-extinctions, the essence of Neo-catastrophism, the Sixth mass-extinction are discussed in comparison with the other five recognized during the Phanerozoic (the last 540 million years): end Ordovician at 444 My, end Devonian at 360 My, end Triassic at 200 My, end Jurassic at 145 My, end Cretaceous at 65 My. Two models are considered: the HIPPO model (Habitat fragmentation, Invasive species, Population growth, Overexploitation of biological resources) and the PERFECT STORM model, when different critical parameters converge. For the Anthropocene, the experts pointed out three major parameters: accelerated

climate changes, alterations of atmospheric composition, and ecological stresses with abnormal intensity, plus positive feedbacks.

The paper by the biologist Giovanni Amori from the CNR Institute of Ecosystem studies, Rome, and co-authors, treats biodiversity from the standpoint of a researcher that—based on experimental observational data—tries to extrapolate to the future the trends recorded during the Anthropocene, when over 250 animal species became extinct, mostly on islands. As a case study, they review the existing literature and test whether or not all the mammalian orders react to the risk of extinction. The conclusion is that species belonging to the orders Rodentia, Primates and Arctodactyla were more prone to become extinct whereas those belonging to the orders Chiroptera and Carnivora were less. According to the authors, the leading conservation organizations (IUCN) did not select the most fragile groups as those requiring the main preservation attention.

An example of geoarcheology is presented by Mauro Cremaschi, from the University of Milan. A well-documented case study on the influence of man on climate in the old world, dating back to the early Holocene, agrees fairly well with the Ruddiman's hypothesis on the increase of greenhouse gases derived from the spread of agriculture and pastoralism. But the evidence provided by the terrestrial records (landscapes, sediments, soils) and the archeological sites suggests that the trend is not linear. In the Po plain of northern Italy the anthropogenic control underwent a series of successes and failures. Adaptation to climate changes is unsuccessful when over-exploitation of natural resources exceeds the limits of environmental sustainability.

Two papers are devoted to energy resources. The paper by Adriano Zecchina, professor of Physical Chemistry at the University of Turin, has a tutorial character and briefly summarizes the state-of-the art on energy, energy consumption and population growth, as well as the relation between the consumption of energy from hydrocarbons and the accumulation of carbon dioxide waste. The existing literature is increasing exponentially in response to the Intergovernmental Panel on Climate Change and its

various assessment reports. The paper by Nuclear Physicist Ettore Fiorini, from Milano-Bicocca University, is devoted to Nuclear energy, the success of the first generation power plants, the panic situation generated by the few but impressive disasters, the failure of the prospect to change from nuclear fission to nuclear fusion, the present decline related—at least in part—to the so far unresolved problems originated by the nuclear waste disposal.

The concluding paper by Sandro Pignatti is a critical review of the book “Assault on the planet” that the author (a plant ecologist) published with the economist Bruno Trezza in 2000. The book was conceived as an original contribution to the discussion on the conflicting relationships between the economic system, requiring a continuous growth, and the ecosystems tending towards a steady state. Although written before the term Anthropocene was introduced, the book was an analysis of the new conditions and problems created by the exponential increase of human activities on the global environment. After 13 years, in which globalization, the web and a long economic crisis deeply modified our society, the main ideas developed in the book are considered still valid and the raised problems still asking for an alternative, new way of thinking.

When writing this editorial 1 year after the conference, we ask ourselves: what has changed in responding to the basic question THE EARTH, WHAT FUTURE? It seems that the energy crisis is still a major concern but the general situation is improving, at least in the United States (see Time Magazine, October 28, 2013 POWER SURGE) where a power revolution affecting natural gas, wind plants, solar energy, nuclear, petroleum and biogas is recorded. What remains out of control is the climate that persistently documents a chaotic regime, unstable variability, strong anomalies, and disasters that are beyond the possibility of mitigation by humans.

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