

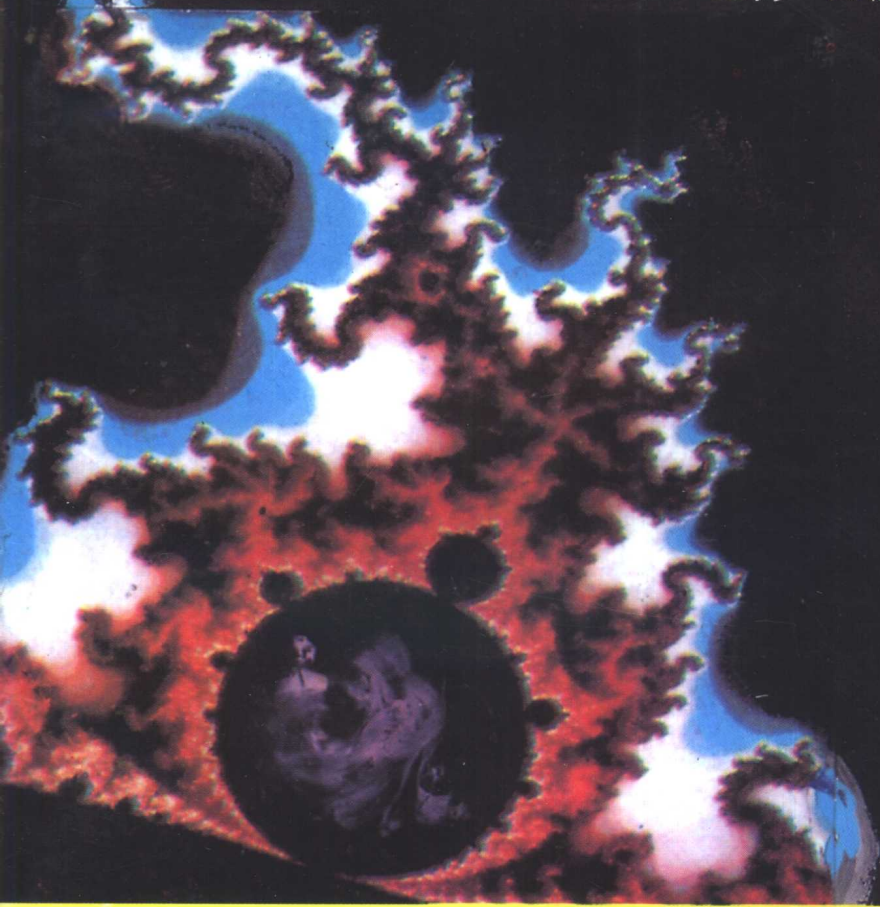
灾变

——世界的昨天和明天

Environmental Catastrophism

王勇 周祖翼 著

中国环境科学出版社



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ABSTRACT

Introduction

As the dawn of the 21st century comes into view, it seems that people have perceived the warm sunshine of the new century and have dreamed of new life brought up by high technology. However, some people get neither surprise nor reverie again as they stand under and glare at the solemn sky, although stars are still flashing at night as before. They have discovered that there are countless bifurcations in the spectrum of new era, which diverges into future. What will be the fate of human beings? Whether is the orbit we have taken a sunny highway or a narrow, zigzag lane?

Dickens once described the chaos in Britain, which was arising from the first industrial revolution in 19th century:

This is the worst era,

This is the best era.

This is a foolish era,

This is a despair era,

This is a hopeful era.

There is a nothing ahead,

There is all ahead.

As human beings are about to come to the end of 20th century, "New Order" historically become the most fashionable pet chase of politicians. East Europe collapsed violently like the dominoes. The Soviet Union vanished legendarily. It is clearly showed to the world that an era is to end and the other is coming. There is no doubt that the old order has disappeared and new frame is going to be established. Although there have been a great number of critical points in the past such as the origin of universe, the evolution of earth, the transition of environment, and development of civilization, the world must have never been more changeable and sensitive than today. The catastrophic symptoms cannot be ignored once more unless man are unable to response to the environmental changes or he turns back on time vector. In short, we human beings must not turn blind eye to the facing bifurcation and catastrophic tendency. We must not lose the chance to select the evolution route and create a sustainable earth.

Nowadays, we live in an economic-social-environmental complex system, which is much more complicated and sensitive than what was described by Dickens. When the mother earth appeared on the "Times", being bound by ropes, and surprisedly becoming the Man of 1988; when the flood wantonly swept East China in 1990; when the volcanoes suddenly erupted in Japan and Philippine in 1991 after they had been dormant for about one thousand years; when Shoemaker Comet struck on Jupiter in the summer of 1994; when the sky and the river are dyeing black and gray by human activities, do we indeed have no power to deal with those kinds of catastrophe but to accept the tragedy? Is it possible to interfere the natural process and select the suitable evolution approach? Who will be responsible for the future of earth? In parti-

cular, what is the role of environmentalists in saving ecosystem and establishing the peace and well-developed world?

Man has been the slave, the general, host, and finally the friend of the nature. The bloody experience and large cost make politicians, scientists, engineers, and businessmen come out of their own ivory towers and take a seat for the common topic: environment and development. Global changes have given rise to more concern about environmental problems such as sea-level rise, green house effect, ozone depletion, and acid rain. Unfortunately, most people don't aware of how risky those problems will imperil their children. On the contrary, what they are interested in are the new and fashionable words. It is likely to happen in future that our children have to buy fresh air by Franc if people don't really understand the nature of environmental catastrophe and prepare for it in advance.

A man can't step into the same stream twice. It is well-known that the world continues changing. But how does the environmental system evolve? What is the rhythm of evolution? What is the theme of evolution, gradual change or catastrophe? What is the mechanism of catastrophe? It often happens that either the small uncertainty or unexpected deviation in the environmental system may result in collapse of a model which is compiled by computer language. Similarly, a comprehensive plan may suddenly become useless only due to the slight variance of policy or an unexpected disaster. How can we copy with those unhappy problems? It is the complexity science that provides us with the possibility to understand the phenomena in far from equilibrium state. New mathematics methods such as fuzzy mathematics, gray sys-

tem, and catastrophe theory have been increasingly used in environmental assessment, prediction, and planning. But, most of them are applied to extrapolate the results obtained in near equilibrium condition to far from equilibrium circumstance. In fact, we are facing the challenge of non-linear phase transition. So the writers audaciously contribute the preliminary ideas about environmental catastrophism to our readers, because we believe that man can understand it, interfere it, select the suitable pathway in chaos, and establish a new order, although catastrophe is unpredictable according to its nature. Chairman Mao once pointed out that not only can we break an old world, but we will establish a new one. With the effort of all people, the peace, justice, and sustainable earth come into the world. from Da Luan (great disorder) to Da Zhi (great order) as Chairman Mao once hoped.

Being involved in geology and environmental science, the writers can trace back to 20 billion years ago when stars were born. It makes the writers look on the world of today with a critical eye and in a large dimension of time and space. We notice that there are a word "catastrophe" which links yesterday and today of earth when we look at the records of both geological history and human civilisation. The ideas in this book are germinated in the research and teaching on environmental science. Firstly, it is "risk" that absorbs the writer like an attractor, then "uncertainty" pull the writer into a new area where "catastrophe" pushes the writer into a deep river. It is many great scientists, such as Prigogine Haken, Laszlo, and Xu, who lead the writer to cross the chaotic river by touching the stones of complexity science. Youngsters are used to being bold and going to extremes. The book also involves some social aspects of

catastrophe, although it mainly deals with the natural system. The aim is to make the readers raise their heads from their own research areas and take a glance at the nearby fields. The readers are expected to enjoy the catastrophe world mixed by joys and sorrows and then get some ideas to deal with disasters and catch the chance provided by catastrophe. People would not resent the Chinese words more than Zai (disaster) and Huo (misfortune), but the twin always accompany people in the whole life. However, catastrophe in this book is defined as the nonlinear transition in the chaotic state and may occur in forms of sudden environmental change or social revolution. It also produces the chance of successful evolution, though its Chinese meaning is similar to Zai (disaster) and it usually bring us the disasters.

It is the discussion with the friends and especially the students of Department of Environmental Science, East China Normal University that encourage the writers to try to figure out the catastrophe phenomena from chaotic environment. Thanks are given to China Environmental Science Press, in particular to editor Mr. Wu Zhenfeng. Without the unconditional help from friends and the love of families, the book would not come into the world. Therefore, the book primarily dedicates to those respectable people, and to the coming 21st century.

Part i Catastrophe—theme of environmental changes

As the 21st century approaches, no one will be against the fact that the world is accumulatively changing. But the rhythm and theme of evolution still remain arguable. Newton created a great paradise where the mechanic equations determine the movement

of everything under heavens. On the other hand, the Newton model led people to the deterministic circle where time and space are reversible, and hence today is designed and decided by yesterday as Lyell said that the present is the key of the past. Although the Newton system were impacted by the achievement of thermodynamics and relativism, it still greatly affects on the thinking mode of people until the complexity science such as irreversible thermodynamics, dissipative structure, synergistic, and catastrophe theory come into the world after 1970's. They together contribute to achieve the understanding the irreversible phenomena.

From a macroscopic point of view, the state of environment is divided into three types: equilibrium; near equilibrium; far from equilibrium. Generally, the former two are classified as equilibrium state.

Actually, the Newton system is grounded on the equilibrium situation, where the movement is deterministic the process is reversible in terms of time and space, the structure is stable and hence the trend of system is predictable. On the contrast, the system is sensitive, irreversible, and unpredictable in far from equilibrium state, where system keep stable mainly due to the exchange of entropy from outside and self-organisation. The environment we live in is undoubtedly a far from equilibrium system, i. e. chaotic system. The change in this kind of system is dependent on the non-linear amplification in critical point rather than on time and position. Catastrophe may derive from two approaches; outside fluctuation is large enough to destroy the structure; either outside or inside small fluctuation firstly leads a system into a unstable state, and then one of the fluctuation becomes the gi-

ant fluctuation. Catastrophe is characterised by the destruction of the original structure and the lose of the function. The overall process of evolution could be described as a step like model which is made up of long term gradual change and short term catastrophe, and the latter is the theme of evolution. It is believed that the evolution quantity is usually determined by few sudden and powerful changes, though the evolution of a system remains in gradual change in majority of time.

Catastrophe can be caused by the bifurcation of natural change, social evolution, and technological revolution. The several examples are given in this Part to show the processes of catastrophe in variety of aspects. It is emphasised that the fluctuations may have either an external or an internal origin and catastrophe may become the source of new order. Catastrophe has dual nature, it does not always stand for disaster, instead, it provides us with the opportunity to create a new order.

Part ii Catastrophic records in earth history

Before the advent of modern geology, the knowledge of the earth's history was based mainly on the religious stories. The discovery of radioactivity has enlightened geology in that it makes the accurate dating of the age of the earth and its evolving events possible. Geologists suggest that the earth has 4600 million years' history, that though much about the earth's history need to be unraveled, they can still feel a sound, clear theme in the evolution history of the earth, that is, catastrophe.

The collision of asteroids and comets with the earth, the inver-

sion of the earth's magnetic field, the eruption of volcano, earthquakes, etc., play an important role in the evolution of life and the planet. Attempts to explain the extinction of the dinosaurs have not been lacking, ranging from the collision with the earth of comets or small planets, high energy radiation caused by the explosion of supergiant stars, to the intensive fire all over the world. The final solution, however, need to include the studies of physiology and heredity of the living, universal events such as the collision of asteroids or comets with the earth and events such as volcanism, reverse of geomagnetic field, climate change, etc. While addressing the dynamic effects of impacts, the flux of earth-crossing asteroids and comets are estimated. A brief description of the story of the Mediterranean being a desert during the exciting years of geoscience revolution are given, and we further suggest that as huge strata of salt of different geological periods are distributed in other parts of the world, desertation may well have its repetitions in earth history. Also addressed in this part is the distribution of glaciation during Ice Age in the world, some indirect effects of the glaciation, as well as other glaciation in the early history of the earth.

Civilization derives sustenance from the geological environment water, soil, mineral and energy resources, yet the abrupt changes in the geological environment could also change the history of civilization. Volcanic activity is generally perceived as a process that produces a picturesque, cone-shaped structure which periodically erupts in a violent manner. Hazard of mudflows, lavaflows, tsunamis are the most important effects of volcanic activity. In the past 200~300 years, there has been a new, but powerful contributions to changes in the earth's environment human being.

Wars, industrialization, exploration of minerals, the burning of fossil fuels, deforestation, population growth and the expansion of cities have all damaged our planet. When it is thought that the great technological skills, as exhibited by landings on the moon and other types of space conquest, should place mankind on a special pedestal, man becomes humbled by the losses resulting from volcanic activity, earthquakes, landslides, floods and hurricanes. Measures should be taken that reduce manmade changes in Earth systems to the barest minimum.

Part iii Development in catastrophe

It is clear that we are facing the challenge of the environmental catastrophe which is more hazardous than ever before. Although the Horror Prophecy about the end of the world in 1999 is not a scientific prediction, man has truly been enveloped in the shadow of environmental risks. First of all, the risk results from the potential strikes of asteroids and comets. The strike from outspace has been proved possible and its consequence is inevitably terrible. Taking the strike of Shoemaker Comet with Jupiter in 1994 as an example, people will undoubtedly believe that if it happened on earth, we would be unable to cope with it but to accept risk. The hazard from outspace makes man to fall in dilemma, because it will cause unimaginable disaster once asteroids visit the earth, although the possibility of strike is so low that man used to neglect it.

Environmental risks have gained much attention, but human response to environmental risks remains in a disorganized state to a great extent. Environmental risk is increasingly threatening human beings and expanding into all aspects of our life. In particu-

lar, the environmental deterioration, such as biodiversity damage and global climate change, is likely to result in catastrophic impacts although it seems not significant in a short time.

What is the landscape of 21st century as a whole? Many well-known politicians and scientists have put forward their predication and view. Unfortunately, no matter how optimistic or pessimistic they are, environmental risk has not been recognised as a prior factor to affect on the development of the world in future. Considering the huge environmental load arising from population explosion, new technology, nuclear power, and so on. The environmental risk will reach its alarm level if we don't deal with it effectively.

Environmental risk assessment mainly involves risk identification, hazard evaluation, and exposure assessment, providing the risk management with a effective route. In a comprehensive risk assessment, the risk quantity is given and compared to acceptable risk level. So that the government can make decision according to risk level which is generally divided into several classes depending on the hazard degree. Risk analysis has been widely and successfully used in environmental assessment of nuclear power station and hazardous chemicals. Taking the land subsidence and a petrochemical plant in Shanghai as the examples, the methodology, procedures, characterization of risk assessment are introduced in this Part. But risk assessment is limited in developing countries due to its high expense and lack of data needed. Moreover, the uncertainty in the risk assessment should be evaluated when the results are applied to risk management and policy making.

The mechanism of catastrophe control is briefly introduced on the basis of catastrophe theory. Although the catastrophe in a chaotic environment is accurately unpredictable, the transition point, probability of catastrophe could be predicted by using risk assessment model. It has been proved that man can interfere and select suitable evolution route in chaos. Mao is thought to be a great man who is good at catching opportunity to succeed in disorder situation.

Re-evaluating the man-made activities in terms of environmental concerns, there have been a number of errors in our mind and behaviour. Some of them are listed in this book with emphasis on the risk transfer of hazardous waste and pollutant. Environmental ethics should be established in modern society and become the standard of human behaviour.

Sustainable development is the best route to establish a peace, justice, and developed earth. To survive and develop in the catastrophic environment, it is strongly recommended that environmental risk should be adequately assessed before the projects are issued on both local and international scales to ensure that any potential adverse impact will be mitigated to an acceptable level. The disaster prevention system, in particular, the first aid, prevention exercise, and prevention consciousness of citizens should be strengthened in developing countries. Engineering-based prevention strategy needs to be improved in developed countries. It is pointed out that environment conservation should be the core policy of local development and international relationship.

To sum up, our aim is to leave a better and sustainable earth and

no qualm to our generation. We are waiting for one day when we retire from environmental service, we can proudly tell our children that the youth of their grandparents has been devoted to the protection of a sustainable earth, the greatest cause of man!

前言

当 21 世纪的曙光渐渐地映入眼帘，人们仿佛已感受到新世纪温暖的太阳，似乎已触摸到了高技术带来的新生活梦幻；可有那么一群人却伫立在仍繁星闪烁的夜空下，仰望那庄严的穹窿，不再有往日的惊奇和遐想，因为他们发现新时代的光谱上布满了叉道，依稀可见的是无数伸向遥远未来的轨道。人类乘坐的唯一的飞船驶往何处？该选择哪一条轨道？飞行速度正常吗？前面是阳光大道还是羊肠小路？

狄更斯曾这样描写 19 世纪的英国由第一次工业革命带来的混乱：

这是一个最坏的时代，
这是一个最好的时代；
这是一个愚蠢的年代，
这是一个令人绝望的冬天，
这是一个充满希望的春天；
我们面前什么也没有，
我们面前什么都有。

当人类伴随旋转的地球即将走完 20 世纪，当“新秩序”历史性地成为政治家最时髦的口头禅，当东欧象多诺米骨牌似地剧变……人们已经清醒地认识到：一个时代行将结束，一个新的格局即将到来；旧秩序即将消失，新时代的曙光已经出现。除非是背着时间之矢或失去了对事物的感受能力的人，才会对面临的这一切无动于衷。

虽然宇宙的起源、地球的演化、环境的变迁、生物的进化及人类的发展已经经历过无数次这样的时刻，但世界从来没有像今天这样动荡多变，如此千姿百态。无论如何，人类再也不能对周围环

境乃至世界的种种分叉和灾变趋势充耳不闻甚至熟视无睹，再也不能对即将来临的时代束手无策或坐失宝贵的选择机会！

我们生活在社会—经济—生态复合系统之中，这一系统较之狄更斯所描绘的19世纪要复杂得多，敏感得多，进化得快得多。作为以维护人类的生存和发展为己任的环保工作者，又在这历史的紧要时分担负着什么责任？扮演着怎样的角色？当缠满绳索的地球赫然出现在1988年美国时代周刊的封面上，破天荒地被评为“新闻人物”；当1991年日本的云仙岳、菲律宾的皮纳图博火山在近千年的沉睡后突然相伴冲天长啸；当夏天的滚滚洪流肆虐中国华东的富饶大地；当修梅克—列维9号慧星于1994年7月与木星发生举世瞩目的“太空之吻”；当越来越多的蔚蓝色天空和清彻河流被染成灰色和黑色，我们的脸上呈现的不仅有遗憾和内疚，更有无可奈何。面对苍茫的大地，许多人会说，我们尚不可能、或许不应该过多干涉自然进化的历程。

从自然的奴隶到主人，又从主人到朋友，人和自然经历了漫长的风风雨雨。血的教训和沉重的代价使政治家、科学家、企业家不得不从各自的象牙塔中走出，坐在一起，谈论共同的话题：环境与发展。海平面上升、温室效应、臭氧层破坏、酸雨等业已成为家喻户晓的名词，但颇具讽刺意味的是，或许大多数人提起这些名词仅仅感到有趣和新鲜，更多的是为了迎合时尚，而并没有也不愿静下心来想一想，这些对他们的儿女、孙辈将意味着多大的危险！不久的将来，用法郎买清新的空气将不再是天方夜谭，人们或许会有这样一天：与其为子女留下成千上万的财产，还不如留下一方清新的空气，一汪清彻的池水，一寸干净的乐土！在某种程度上讲，自然环境的灾变及其后果更甚于社会的灾变，因为人们对此还缺乏更深的了解和足够的准备。

赫拉克利特曾用“人不能两次踏进同一条河流”的形象语言说明世界的变化。确实，世界在不断变化，对此已无人疑义，但环境系统如何进化？进化的方式是什么？是循环往复、螺旋式上升，还是非线性放大？进化的节奏怎样？是渐变还是灾变？进化的动力是