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Editorial

Thinking on improvement of natural resources management

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Over the past thousands of years, human society has experienced evolution from the primitive civilization, the agricultural civilization, the industrial civilization and to the ecological civilization, which is a history from low-level to advanced development. The core of the ecological civilization is "respecting nature, complying with nature and protecting nature", which is essential to harmonious co-existence between man and nature. This harmonious co-existence requires constantly improving system and mechanism for the development of national space, natural resource conservation and utilization, and ecological environment protection, to realize the win-win of resource development and environmental protection. It is a thousand-year plan to achieve ecological civilization based on unified management of natural resources. Establishment of the Ministry of Natural Resources in April 2018 is a milestone to take forwards the natural resources management systems in China, which is also an important step to promote the construction of ecological civilization in terms of fully representing the idea of "Big Resources" and "Big Science". In order to comprehensively improve the unified management system and scientific restoration ability of natural resources, we must establish a strong technology support system, build a highly qualified and professional geologic survey team, along with the guidance of Earth System Science.

1. Earth System Science is the core theoretical foundation of the unified management and systemic restoration of natural resources

The earth is a complex giant system, which is composed of processes with multiple spatial-temporal scales and is represented as a multi-layered system in space. Earth system science regards atmosphere, biosphere, lithosphere, and mantle/core as one integrated system. By means of long-span interdisciplinary, it aims to build the evolutionary framework of the earth, understand the ongoing earth processes and mechanisms, and predict any changes that may occur in the future. The research object of the Earth System Science involves from molecular structure to the global scale in spatial scale, and from the hundred million years evolutionary process to transient rupture and deformation in time scale.

Earth System Science has constantly developed and improved since 1980s. It can be argued that if the greatest development of the earth science in the 19th century is the evolution theory, in the 20th century is the theory of plate tectonics, then the breakthrough in the 21st century is the theory of the Earth System Science. In 2008, senior officials of U.S. federal government strongly advocated to create an independent agency for Earth System Science by merging the National Oceanic and Atmospheric Administration (NOAA) and United States Geological Survey (USGS) to meet the unprecedented environmental and economic challenges, indicating that the Earth System Science is severely influencing the reformation and improvement of natural science institutions. At the other level, China is currently promoting unified management and systemic restoration of natural resources including mountains, lakes, waters, forests, fields and grass, which also provides an unprecedented practical platform for the development of Earth System Science.

In the future, for Earth System Science, it should pay specially attention to the three key issues: the shallow crust ("root"), the critical zone ("branch") and the human-earth coupling system ("leaf").

1.1. How to conduct the exploration of detailed fine structures in the shallow crust (0−10 km) and scientific utilization of resources, environments and spaces

Urban underground utilizable spaces, deep oil and gas resources, mineral resources and geothermal resources, most of these exists in the shallow crust about 0−10 km underground,

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whereas the reservoir formation, mineralization and thermal accumulation are controlled by the processes in deeper Earth. Understanding how the deeper earth operates and evolves in different processes at different space-time scales is essential in tackling significant issues of resources and environments. Acquiring both resources and spaces in deep earth is an inevitable choice. It is necessary focused on exploring fine structures and distribution of resources and energy in the earth crust ranging from 0 to 10 km, and figuring out how to use urban underground spaces to provide an essential support for national resources and energy security and development of economy and society.

1.2. How to understand the processes, mechanisms and functions of the Earth Critical Zone

The Earth Critical Zone is not only a complex system in the epigeosphere where the atmosphere, the biosphere, the hydrosphere and the lithosphere mutually interacting, but also an important bridge in coupled the material and energy circulation between the climate systems, surface processes and deep earth processes. In the critical zone where the soil is core and water is the main driving force for substance circulation and conversion. On the basis of pedosphere, the interface processes such as soil-water, soil-air, soil-organisms and soil-rock interactions are driving the natural environments on earth surface, and sustaining resources for sustainable development of creatures. The systematic science will be applied to explore the critical zone with respect to structure, formation and evolution mechanisms, material transformation processes and its interactions, investigate the service functions and sustainable development of the critical zone, model the processes and systems, and provide rationally solutions to develop and exploit natural resources.

1.3. The human-earth coupling system: coupling of the regional human activities and the resources environments

Interaction between human activities and natural environment has gradually become the main driving force for the evolution of earth surface system. The interacting relation between humans and the earth has become a key scientific subject in understanding and responding to environmental changes and fostering sustainable development of various spatial scales. Studying the human-earth coupling relation allows us to understand more about the changing trend of the earth surface and its related mechanisms, record and interpret the characteristics of the changing earth, propose the effective coping strategies. Future Earth, which is jointly initiated by International Council for Science (ICSU) and International Social Science Council (ISSC), brings the research topics "Dynamic Planet, Global Development and Transition to Sustainability" inferring that the human-earth coupling relation has become a main direction in the international community of earth science and a key issue for the academic community to engage in the governance of resources and global environment.

2. Unified management and systemic restoration of natural resources require a strong technical system establishment covering all processes of investigation and evaluation, probing and monitoring, and simulation and prediction

Unified management and systemic restoration of natural resources requires standardized, consistent and authoritative basic data but more importantly to establish a strong technical system covering all processes of investigation and evaluation, probing and monitoring, and simulation and prediction to provide comprehensive data services and technical solutions for integrated management of natural resources.

2.1. Investigation and evaluation system

Investigation and evaluation are critical methods to understand the formation process, material composition, space-time distribution and structural evolution of natural resources, which is also fundamental for integrated management of natural resources. Under the integrated management system for natural resources, the integrated ground-air-space survey methodologies and techniques is needed to acquire the characteristic data of natural resources with respect to elements including quantity, attitude and distribution. New technologies such as Big Data and Cloud Computing, taking attributive features of different resources categories into account, are applied to comprehensively evaluate resources in respect of quality, ecological value and benefits in order to provide an accurate and credible foundation to support homeland spaces planning and applications controlling.

2.2. Probing and monitoring system

Probing is an important technology to discover energy, resources and spaces within the Earth, and monitoring is essential in understanding how various elements of natural resources of different categories change over time. At the global level, the Global Environment Monitoring System (GEMS), the Global Terrestrial Observing System (GTOS), the Global Climate Observing System (GCOS), the International Long-term Ecological Research Network (ILTER), the Flux Observation Network (FLUXNET) and the Integrated Global Observing Strategy (IGOS) have been established, which form the basis of energy resources, environment comprehensive utilization and management in the global scale and regional scale. To meet the requirements for unified management of natural resources and the control usage of national space, it is necessary to enhance probing of resources, ecosystems, environments and spaces of the earth, and to create an observation and monitoring system covering land, mineral resources, water, marine space, forest/grass/intertidal zones etc., so as to understand the natural resources of various categories change in terms of quantity, quality, structure and distribution, and finally to provide technical support with development, exploitation and protection of natural resources.

2.3. Simulation and prediction system

Simulation and prediction are essential to rational utiliza-

tion, quantitative evaluation and risk anticipation of natural resources. The hydrological, biogeochemical and ecological processes that may occur in the process of development and exploitation of natural resources will be simulated to predict and warn against any possible changes of the natural resource ecosystems at national, regional and local levels as early as possible, therefore to provide a scientific support for administrators and decision-makers to develop contingency plans and establish response mechanism for the purpose of risk alleviation or elimination.

Investigation and evaluation, probing and monitoring, and simulation and prediction, constitute an integral technical system. In the past, we had carried out effective efforts in the area of investigation and evaluation, and obtained massive information and data related to natural resources of various categories. In recent years, probing and monitoring has been successively enhanced, but simulation and prediction just started and needs to be immediately strengthened.

3. Unified management and systemic restoration of natural resources require us to build a high quality, comprehensive, professional and strong integrated geological survey team system

To achieve the integrated management of natural resources, we must establish an integrated geological system consisting of highly qualified and professional teams. USGS, affiliated to the U.S. Interior Department which is responsible for comprehensively administering natural resources, has become a federal institution with functions of investigation and evaluation of natural resources ever since it was reformed in 1996. In 2001, Geoscience Australia was founded by emerging the Australian Surveying and Land Information Group (AUSLIG) and the Australian Geological Survey Organization (AGSO), is also a good example for comprehensive natural resource survey. Whether based on international experiences or the development of Earth System Science, integrated management of natural resources urgently requires establishing a research institution for Earth System Science. The research institution would have the functions to thoroughly investigate and evaluate varieties of natural resources including land, mineral resources, marine resources, water, forests and grass. It is expected that this institution can play a unique role in production, integration and release of authoritative data on natural resources, evaluation of environmental resource carrying capacity, homeland space suitability, and systematic simulation along with the prediction of natural resources development and exploitation.