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RESEARCH ARTICLE

Discussion on the previous proposal of the addition of a chronostratigraphic unit over the Holocene

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Abstract A stratigraphical unit was proposed before as the "anthropocene" over the Holocene to characterize the anthropogenic activities. We argue here for the great significance of that proposal. The human-induced geological processes, including anthropogenic weathering, denudation, transportation, and accumulation, are getting more and more important in modern environments. These processes are intensive, rapid, and extensive and, at some cases, even exceed the natural geological process in intensity. The anthropogenic geological processes, which are definitely distinctive from the natural processes that occurred before in the geological history, have both positive and negative effects on the Earth surface system. Adding a chronostratigraphical unit favors the investigation of anthropogenic activities, which concerns both natural and social science. A flooding sediment profile with some anthropogenic fingerprints is clearly identifiable at the top of the Holocene sediments, enabling the three subdivisions of the whole Quaternary sediments in the middle reaches of Yellow River. It is thus necessary to add the chronostratigraphic unit of the "anthropocene" over the Holocene.

Keywords chronostratigraphic unit, human activities, "anthropocene", anthropogenic geological process, positive and negative impact

1 Introduction

The term "anthropocene" is used by some scientists to describe the current period under the control of the human activity. As a major geological force, the impact of human activity on the earth system will exist in the long time that might be ten thousands of years.

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It is Paul J. Crutzen, Nobel laureate, who first proposed the term of "anthropocene" as the sign of modern human activity in the early 21st century (Crutzen and Stoermer, 2000; Crutzen, 2002). This proposal is widely received by the scientists all over the world (Liu, 2004; Deng, 2005; Chen, 2004, 2006).

Therefore, anthropocene is widely used to indicate the current geological period, which is a specific era marked by the human activity. As an informal unit, anthropocene has no restrict and scientific description on its researching content and age limitation. Fortunately, the Committee of the Geological Society of London in 2008 has decided to establish a specific workshop on anthropocene, which is belonging to the Committee of Quaternary Strata. The addition of anthropocene to the geological time scale will be accelerated in the coming days (Deng, 2005).

People, who have worked on the survey of regional geology, especially since 2000, will find that the topographical features shown by the previous map (1982 edition) in China greatly differ from the current status. The mountainous and rural areas have changed a lot in both the natural environment and the society due to reformation policy of China over the past 30 years. The large and medium cities have experienced an abrupt change in both natural and social environments. Similar situation could be found elsewhere in the world. All these reveal that human activities have played a great role on the global change and the society development along with the accelerated modernization and the rapid development in technology. Enhanced risk is found to be substantially subject to environmental pollution and anthropogenic disasters. This particular time duration is thus necessary to be separated from the Holocene, which is helpful to distinguish the anthropogenic impact from natural geological processes. This is an urgent issue in modern geosciences.

In order to present the importance and urgency for establishing anthropocene on the geological time scale, this paper is mainly focused on the features and scopes of

contemporary geological processes. A typical example on the modern flood sediments related with human activity is also demonstrated in detail.

2 Characteristics of geological processes in modern time

The natural geological processes are greatly influenced by anthropogenic activities in modern time. The natural geological processes still exist but work slowly and are still strong in some regions. For example, the tsunami of Indian Ocean in 2004 caused 300 thousand people to die. This natural catastrophe caused a great impact on the adjacent countries and left profound material records. However, the anthropogenic geological processes are widely common and very intensive in modern time, and in particular, they occur frequently within a minute, an hour, a day, a month, or a year instead of millions of years as most of the geological processes did.

The anthropogenic geological processes refer to all kinds of geological processes driven by human activities, either directly or indirectly. They could be listed as the special geological processes and now become the third force beyond the internal and external forces of the Earth itself (Kang et al., 2000). The anthropogenic geological processes have great influence on the Earth surface system via the physical, chemical, and biologic processes, concerning the atmosphere, hydrosphere, and biosphere, as well as the subsurface and the polar regions. These anthropogenic processes also include procedures of weathering, denudation, transportation, and accumulation.

The atmosphere temperature has risen up since 1980s. Global warming is, partly if not wholly, caused by the enhanced burning of the fossil fuel owing to the fast development of world industries, which make great contribution to high concentration of CO_2 and other 30 rare gases with regard to the greenhouse effect. It is shown that doubling the concentration of CO_2 will raise the Earth temperature by 1.5°C–4.5°C. The global warming will generate some natural disasters, such as sea level rising, storms, tsunami, coastal collapse, and landslide, which are threats to the Earth ecology and human beings. According to the reports of the United Nations Environment Programme (UNEP), when the sea level raises 1m, more than one-third of the cities in the coastal regions and some islands in the oceans will be submerged, leaving one billion population homeless (Mo, 2004).

Aside from global warming, the coastal environmental quality has declined, and the polluted area has been kept to expand year by year. Statistically, 80% of waste and polluted water and poisonous materials are documented to originate from the land. For example, along the coast of the Bohai sea in North-east China, over 200 drain outlets discharge into the sea with an flux of more than 3 billion tons of industrial waste water, sewage, and 700–800 thousand tons of pollutants per year, which accounts for 35% of the emission waste and pollutants in China. The area containing one or more pollutants with the content over the standard content of the first-class quality water is over 56% in the whole Bohai sea. The heavy metal in the sediments in the seafloor near the outlets is 100–200 times greater in the content than the national standard. The Bohai sea has become the worst of the polluted sea. The mining of the mineral resource in the seacoast also directly affects the balance of the coast materials as well as the change of hydrodynamic conditions, which resulted in coastal beach erosion and sediments migration. The activities of digging the coastal sand, cutting the corals and mangrove, and building holiday villages will all do harm to the ecological environment of the coast.

The anthropogenic geological processes are enhanced due to the increasing constructions and fast urbanization. The highlands become flat, the underground is excavated, and the river system has changed. Consequently, great changes have occurred in the stress field, underground water, and geochemistry behavior. Especially in some big cities occupied by highly condensed buildings and less-covered vegetation, the accumulation of anthropogenic heat energy would lead to the rise of heat value and intensify the change of the geological conditions and the ecological environment.

The anothropogenic geological processes induced by mining industry cannot be ignored. The development of the mining is fast in China, estimated to be the third exploitation in the world. However, some illegal exploitation, such as the scattered mining on a medium or even minor scales, have polluted the environment and led to frequent geological hazards. The exploitation will directly lead to the loss of the land resources. For example, the surface mining will destroy the surface soil and the vegetation coverage and the local ecology. The waste from mining processes is acidic, alkaline, radioactive, or full of heavy metal, causing the severe contamination of the soil, water, and atmosphere through the flow of the surface water and inputting the dust into the air.

There are many large rivers in the mainland, such as the Yellow River, which has lush forest, vegetation, and grass with the coverage of 53% (Yu, 1992). However, with the growth of the population, the loss of the forest, the palace building in different dynasties, the fires in the wars and the changed climate, water loss and soil erosion, flood and drought, and plague of locust occurred in the catchment. Some areas in the catchment become barren mountains and "high slope of loess." More than 1.6–2.0 billion tons of silt filled up the riverbed in the middle and lower reaches, leaving the occurrence of "suspended river," broken flows, and changed channels.

In general, the anthropogenic geological processes not only have shortened or changed the natural geological processes, but also have intensified the nature processes and have become a significant geological agent.

3 Effect of anthropogenic processes

Anthropogenic processes keep the characteristic of the natural geological processes as well as their own characteristic. The population is the key factor to determine the intensity of anthropogenic processes. In the early history of the human beings, the anthropogenic effect on the alteration of the nature was not obvious because of the slow increase of the population and the low productivity. However, with the growth of industrialization and modernization, anthropogenic processes have produced more negative effects on the natural world (Liu, 2006).

The anthropogenic geological processes mainly occur on the surface of the Earth, which is different from the natural geological processes exerting an effect on the whole Earth, including both the interior and the surface. The anthropogenic geological processes are usually marked by strong, fast, wide, and sharp impacts, which even exceed the natural geological processes in some cases. Nowadays, people change the nature sights, and the compositions and the energy of the lithosphere, the hydrosphere, and the atmosphere with a high efficiency and an amazingly quick speed. All these lead to the destruction of the balance of the geological processes occurring in the ecological environments formed in the geological history.

The anthropogenic geological processes are of high intensity. Take transportation as an example. The rivers in the world are believed to be the No.1 transporter in natural processes. However, the mining of the human beings is found to be three times of that process. The anthropogenic geological processes occur in an increase speed. Natural erosion of a mountain will take hundreds or thousands of million years, but anthropogenic activities will make a mountain disappear in a very short time, see, hundreds (tens) of years/months. The anthropogenic geological processes are of wide effect on the Earth surface system. Human activities not only affect the surface of the Earth but also the lithosphere, the hydrosphere, and the atmosphere and even the space. The anthropogenic geological processes also have a stronger influence on the Earth than before. The explosion of nuclear, the earthquake of the reservoirs and mines, the sandstorm, and so on, are the signs of the strong impact caused by the human activities.

4 Example of study

In the hydrosphere, the flood water featured by high hydrodynamics and high erosion rate is the major force to transport terrestrial materials and to form the natural landscape. The flood water also shows a very close relationship with climate, topography, and provenance of sediments. The diluvium is thus able to record the anthropogenic geological processes. Three types of drift deposit and diluvium in Quaternary could be identified in north-eastern Baotou in Inner Mongolia where anthropogenic collapse of forests occurred: they include Pleistocene, Holocene, and modern sediments. If we classify the Holocene and modern deposit as one unit, it will be hard to recognize the differences between the ancient and modern materials (Fig. 1).

Fig. 1 Profile of modern alluvial deposit in Nian Fang

The evidence to characterize the youngest drift deposit and diluvium in the section is the insole found in the medium sabulous clay (Fig. 2). The insole has been rotten, but it must be the thread product made by sartorius after the foundation of the People's Republic of China. In 1958, the large flood happened in the local and the drift deposit and diluvium that contain the insole could be the record of this flooding event.

In the studied section, the youngest drift deposit and diluvium are featured by sand-gravel layer and sabulous clay. The coarse and medium sabulous clay has parallel bedding with a total thickness of 0.18 m.

The drift deposit and diluvium with the insole can be divided into three parts. The lower part is composed of sand and gravels with the grains of about 0.2–1 cm in size. The composition of the grains is diorite, quartz, and siltstone with a subangular grade in psephicity. The middle part is composed of sabulous clay, with the content of the gravel 1%–2% and the grain sizes of 0.2–1 cm. The composition of the grains is slate and quartz, with a subangular grade in psephicity. The upper part is featured by the coarse and medium quartz sandy clay with the parallel bedding. The psephicity is subround and subangular.

Diluvium sediments in the lower part mainly consist of gravels of various sizes. These sandy gravels are poorly sorted and transported for a short distance. The shingly

Fig. 2 Profile of modern alluvial deposit in Qian Gongzhong

fine-medium-sized sabulous clay overlying the sandy gravels is the record for the decrease in flooding effect (Li, 1983; Qiu et al, 2010). Although few gravels were found in the fine-medium-sized sabulous clay, the poor sorting of the grains and the occurrence of parallel bedding that is widely distributed in river channels represent a high-flow regime. The upper part is coarse- and medium-grained sabulous clay, which increases in size as compared with the sediments in middle part containing 30% coarse sand and parallel bedding. The presence of the coarse sediments suggests that the flood energy is still strong and even stronger than that of the middle part composed of shingly fine- and medium-sized sabulous clay. The shingly sabulous clay was covered by a large area of crops overlying the coarse- and medium-grained sabulous clay. The gravels in the sabulous clay are low in content, 0.2–0.4cm in size, inferring the rapid decrease of flood energy. Consequently, this sediment sequence of the three parts is a record of the whole flooding process; the lower part was formed during flooding, the middle was formed when the flooding became weak, and the upper part deposited at the end of the flooding. It is notable that there is a wide occurrence of the modern drift deposit and diluvium in the local area related to the flooding induced by anthropogenic processes.

The diluvium sediments show that highlands and adjacent lowlands exist interdependently in the space and both contribute to the sediments. Diluvium sediment is the linkage between lowland and highland and can be used to reconstruct composition and paleocurrent in the denudation area and to trace the process of material exchange within the modern mountain-basin system. The diluvium sediments mainly come from local highlands. Coarse clasts in the sediments consist of igneous and epimetamorphic rocks composed of metasandstones and slates. The Mesoproterozoic epimetamorphic rocks (such as in the Zenglongchang Formation) and Permian diorite in the local highlands could also contribute to the sediments. For the decrease in the flow energy, fragments from the highlands will decline in content.

5 Onset of anthropocene and significance of the geological unit over the Holocene

On the basis of the above analysis, sediments linked with anthropogenic activities could be distinguished from the Holocene natural sediments. The former is marked by the impact of human activity. This subdivision might indicate the development of geosciences from natural science to the integrated science of both natural and social science. The onset of the geological unit “anthropocene” over the Holocene should be marked by the middle 18th century industrial revolution, which led to a series of technological reforming that signified the power of people’s reconstructing nature became stronger than before.

In the evolutionary history of the Earth, different classes of geological era have their own biotic events and biostratigraphical record featured by the occurrence of new species. According to a previous study (Walliser, 1996), three periods of biotic events could be identified in the Earth history; they include the extinction, the recovery, and the blank time period. As a result, these biotic events were used to divide and correlate Phanerozoic rocks. However, in the Holocene, no new species appeared to be of strata significance, and the Holocene biostratigraphy did not form. It is notable, however, that the speed of the biotic extinction became faster after the industrial revolution. For example, the extinction speed of the species in rain forest is 10 thousand times faster due to the human activities (Crutzen and Stoermer, 2000). Consequently, the geological unit over the Holocene could have its own biotic characteristics.

The anthropogenic geological processes are becoming stronger than the natural ones in the modern time. It is necessary to add a new chronostratigraphic unit over the Holocene because it is suitable for the reality of the Earth evolution. If the stratigraphic units of the Quaternary focuses on the activities of ape man and early-metaphase human beings, the stratigraphic unit over the Holocene will focus on the activities of modern people. The conventional geology only emphasizes those we get from the earth and

the research and exploitation of the different resources but gives little attention to the damage of the ecological environment related with negative effects driven by human activity (Zhao and Jie, 2008).

It is a trend to add a chronostratigraphic unit over the Holocene. We should strengthen the study on the anthropogenic geological processes to utilize the positive effects but decrease the negative effects. The whole study on the anthropogenic geological processes can sum up the characteristic and the cause of formation, time distribution, and the law of evolution. In addition, it can also help us find new earth sources and hold back the degradation of natural environment. Adding a stratigraphic unit over the Holocene favors the both the theoretical and practical studies of our planet.

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