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Cave Research

A new perspective on the cave research from Geography under the background of climate change

Feng Kong[1,2], Fan Liu[1,2], Xu Yang[1,2], Zhu Wang[1,2], Yongchang Meng, Jian Fang[1,2], Lili Lu[1,2], Jiayi Fang[1,2], Mengjie Li[1,2], Gangfeng Zhang[1,2], Zhuorong Ying[1,2],

[1] State Key Laboratory of Earth Surface Processes and Resource Ecology, Beijing Normal University, Beijing 100875, China

[2] Academy of Disaster Reduction and Emergency Management, Ministry of Civil Affairs & Ministry of Education, Beijing 100875, China

* Correspondence: kongfeng0824@qq.com

Abstract: Through cave environment change to study the ancient climate change, ancient environmental change and climate change has become a hotspot issue in the international cave research field. This research reviewed the characteristics of the cave research field from the perspective of geography. The results show that the cave is not only an irreplaceable alternative to global climate change, but also has a long time series of alternative materials in the environment change. At the same time, the frequent occurrence of extreme weather and climate events makes different kinds of caves to play a very important role in disaster reduction and risk governance. In addition, the cave can be used as a kind of resource, which plays an important role in tourism and archaeology.

Keywords: cave research; geography; sustainable development; extreme precipitation; disaster and risk; resource development

Introduction:

Cave as a comprehensive study object, became a discipline to the International Union of Speleology was officially established as a sign (Poulson et al, 1969) and has become a comprehensive interdisciplinary (Krawczyk, 1996). From the cave evolution mechanism and cave classification, cave development simulation experiment research, cave exploration and international cooperation, cave resources and database construction, cave sediment classification and genetic research, cave stalagmites pale environment records research, cave biological research, cave landscape tourism development, cave environment system observation, cave medical experimental research, cave protection and management have a further development (Nunes et al, 2008). From the angle of geography，cave research has developed comparatively perfect system, including cave formation and evolution, cave hydrologic geology, cave secondary chemical sediment, cave climate and environment change, cave archaeology, cave biology, cave sustainable development and resource protection, and the cave detection and mapping (Leigh et al, 1999).

Since the middle of the 18th century industrial revolution, global climate change is undergoing a warming as the main characteristics of the significant changes. In the 21st century, the global climate warming trending is still in (Bulkeley et al, 2015). Global climate warming profoundly affect the natural environment to the survival of humans and the sustainable development of economy and society, and is a major challenge facing the international community today. Especially in recent 10 years, the global frequent heat waves have caused wide public concern. At the same time, more and more cities attacks by heavy rainfall, causing multiple city urban area flooding, casualties and property damage, ecological system damage seriously.

Since 1950, many new changes has been observed in the climate system, such as the atmosphere and oceans have been warming, the scope and volume of snow and ice has shrunk, a rise in sea level, concentrations of greenhouse gases increase, and so on. These series of changes in the past few decades and even thousands of years of time scale are unprecedented (Edenhofer et al, 2014; Pachauri et al, 2014).

Climate change will also change the large scale circulation pattern, and affect the extreme weather events occurred in different areas. In addition, the increasing of ground temperature increases the surface evaporation, which increase water content of the atmosphere. Ground evaporation ability enhancement, drought occurred more, at the same time, in order to balance the evaporation, precipitation will increase, causing floods (Seneviratne et al., 2012; Jourdain et al, 2013). Climate change will also by influencing the water content of the atmosphere, which in turn affect the properties of the atmosphere, impact on small and medium scale of extreme weather events (Murray et al., 2012; Dufresne et al., 2013; Knutti et al, 2013).

The existing high spatial and temporal resolution of climate dataset is less, and a lot of poor continuity of these climate dataset, lack of measured flaw phenomenon is serious. Thus gives the further deeply study of climate change certain obstacles (Meehl et al, 2007). On hundred time scale of the observed changes in extreme precipitation is whether due to natural climate variability or other factors, because the time is shorter, a long time series dataset sequence is needed to good diagnosis by comparison with the shorter one. A lot of research object in the study of cave recorded the climate change information for a long time, which can reflect the climate change information in the different degree. Therefore, cave recorded information can become a good proxy dataset in climate change research, which also have a more in-depth research on extreme weather events, planning for disaster prevention and mitigation, and resource planning.

Therefore, how to deeply study cave from the perspective of geography in climate change, natural disaster reduction and risk governance and resource sustainable development, has the very vital significance.

Cave in the application of climate change, disaster risk and resource development:

Definition and connotation of cave in geography

According to the definition given by the International Federation of the Cave, cave refers to the natural underground space that people can pass in and out. It can be partially or fully filled by sediment, water or ice. A cave system is the cave that is combined together by two or more channels (British Cave Research Association, 1995). And the study of the morphological characteristics, geological, hydrogeological, chemistry and biology, and the detection and exploitation technology of caves is so called Speleology (Lowe, et al., 1995; Waltham, et al., 1997). However there all many people believe that the rock with smaller and narrower space and fracture should also be considered as cave. In petroleum geology, space larger than 20 cm is referred to as the cave, while narrower than this standard is referred as the pore. The famous Canadian karstical and hydrologist D. Ford thinks that cave system is several corrosion pipelines which connect successively and stretch continuously from the input point to the outpoint point, its minimum diameters is greater than 5~15 mm (Ford, 1988).

Complexity of climate change risk

Current research on the climate mean state has been studied systematically and understood deeply (Goodess et al, 2013). Generally speaking, we now have a certain understanding of the extreme weather and the disasters caused by climate events, but we are lack of understanding in global change, especially in the risk caused by climate change.

The results of existing research show that the changing climate can lead to the change of extreme weather and climate events in frequency, intensity and spatial scope, duration and time of occurrence, and can also lead to extreme weather and climate events than never before (Comfort et al, 2010). With high reliability, economic loss related to the weather and climate disasters has already increased (Field et al, 2012; Smith, 2013). Therefore, we need to fully consider the effects of climate change on heavy rain in different regions when carrying out research on heavy rain. At present, there are many climatic regionalization researches, but all of them are focus on the state of climate, rather than the change of climate. The existing climate zoning can't reflect the regional differences of climate change in today's accelerating climate change rate. The paper *Climate Change Regionalization in China (1961-2010)* develops a method of classification that can diagnose the change of climate and its influence in different regions, according to the nature of the climate change. And climate change has been divided into nine mode based on the change trend of climate change (increase/decrease/no obvious change trend) and wave characteristics (increase/decrease/no obvious fluctuation characteristics). Take those nine modes as the foundation of the zoning of climate changes, China can be divided into five primary tendency and 14 secondary wave characteristics area (Shi et al, 2014).

Application in climate change of scientific cave measurement

Stalagmite is a peculiar physiognomy in karst cave (Baker et al, 1993). Stalagmite is formed by cave dripping water. Since the dripping water is basically from the atmospheric precipitate which usually dissolving the soil and the bedrock during the cave seepage process, the stalagmite chemical components retained the atmospheric precipitation and the chemical composition information of the soil in the cave (Bard et al, 2002). These changes in chemical composition are closely related to the environmental climate changes. Hence, we can gain the information of climate and environment changes in the historical period by testing the age of stalagmite and analyzing the chemical composition of the stalagmite such as the isotopes of carbon and oxygen and microelement.

Because of the long-time record and continuity, stalagmite is one of the alternative materials to study the effects of climate change (Fleitmann et al, 2003). In the context of climate warming, climate change including three aspects: trends, fluctuation and extreme weather/climate events. According to this, there are three question need to be further study. The first question is how much the intensity of these 3 kinds of climate change? The second question is how does these 3 kinds of climate change performance in different periods, especially for the trend change, fluctuation changes and extreme precipitation events? The third question is whether precipitation has a significant trend, fluctuation and extreme events like the temperature in the coming hundred years?

Advantage of cave sediments in the environmental change

Global change has become the focus in the geography, taking all kinds of geological and phenological records reflect paleoenvironment change process. Currently widely used on international deep-sea sediment, ice cores, lake sediment, loess, tree wheel, coral, as a carrier of the reconstruction of paleoclimate and paleoenvironment (Kaufmann et al, 2004). Various kinds of information carriers, cave stalagmites because of its wide distribution, can record the time range is wide, high resolution and sensitive recorded from the area until the global environment. Because it provides the time resolution reached ten years even the interannual high precision environmental information, and thus in global change research has played a more and more important role (Baldini et al, 2006). Cave carbonate sedimentary compared with other natural materials, with wide distribution, coast to inland, tropical to arctic can find; Time span - from modern date back to thousands of tens of thousands of years, or even hundreds of thousands of years ago. Under small disturbance, is located in the earth's surface, from external denudation, erosion environmental information intact, and marine sediments, ice cores, tree round match (Xie et al, 2003). Cave carbonate deposition (mainly refers to drop stone) formed in the atmosphere, water circulation and its growth rate and composition can reflect the changes of the upper cave. As terrestrial sediment, it has the sedimentology, chronology and geochemical characteristics (Kaufmann et al, 2003). Using the stalagmite carbon isotopic variation and the difference between grassland and forest ecosystem photosynthesis characteristics, restore the evolution between the forest and the grassland, shows its in the important position and role in the study of the global environment (Borsato et al, 2007). With the deepening of the research, more and more alternative indicators are extracted for the ancient climate research, and cave for continental climate provides a kind of alternative indicators.

Role of cave in disaster prevention and reduction

Under the background of climate change, the increasing extreme precipitation events and extreme heat events induce landslide or debris

flowing in mountainous regions, which cause serious consequence. Especially for the Railways and roads in these areas, the geological disasters can break the transportation and lifeline (Knapp et al, 2008). Tunnelling becoming considerable important in this condition. By May in 2014, there are 108 caves which the length are surpass 3000 meters in China. The biggest cave system in China is subterranean river cave system in Bailang, Leye, a place where in Guangxi Province. The total length of is cave is 75 kilometres. The second one is Tenglong cave in Lichuan, locate in Hubei Province, and the length is 58.2 kilometres. Moreover, the cave which the length exceed 20 kilometres including Bailong cave in Xiuwen, Longzi river cave in Zhenyuan, Shuanghe cave in Suiyang and Duobin cave in Suiyang (Shang et al, 2007). Compare to outdoor transportline, cave becomes significant refuge when the disaster is happenning. In addition, it is also a vital transportation system or lifeline system. It can be further research for the cave distribution and application prospect in China.

Scientific value of cave in tourism and archaeology

There are millions of caves located within the vast territory of China. They scatter from Yichun in the northmost province of Heilongjiang, to Sanya in the southmost island of Hainan; and from Shiquan River of Tibet Plateau in the west，to Hangzhou and Tonghua in the east. Besides, there is rather long history of scientific observation and recordation (Boaretto et al, 2009). Several caves had been visited and explored before the Sui and Tang Dynasty, leaving massive carved stones, inscriptions and other relics. The great geographer and traveler Xiake Xu (1587—1641) in the Ming Dynasty explored over 300 karst caves in southern China, making him the pioneer of cave exploration in the world. In modern times, cave archeology and cave cultural study in China were remarkable in the world, represented by the discovery of Peking Man Cave (Fu et al, 2013). A number of new achievements have been made and several complex giant cave systems have been detected, with the development of national economy and collaboration of China-foreign joint cave exploration. More and more caves have been found, detected and developed. According to preliminary statistics, there are about 300 caves having been developed for tourism in China, and the number of caves with great archaeological significance reaches nearly a hundred. Many caves in China are characterized with huge halls. There are 24 cave halls with planar area over 3000 m2 in the world and seven of them are in China. The hall of Gebi River cave system in Guizhou Province has an area of 116 thousand m2, ranking the second in the world (Zhou et al, 2007). The southern humid areas with tropical and subtropical climate are the most places for long and large caves distribution. In China they are mainly distributed in Guizhou, Guangxi, Yunnan and Sichuan Province, the western part of Hunan and Huibei Province, and the northern part of Guangdong. In the southeast region of China, like Anhui, Jiangxi, Jiangsu, Zhejiang, Fujian, Hainan and Taiwan Province, carbonate rocks scatter sporadically like islands or strips, and caves are also developed with the advantageous climate condition. But their size and density of fractures are much lower than that in the southwest region. In the northern region of China, which was once believed not suitable for the development of caves, caves have also been found in recent years. Most of them are ground water caves and several are more than 1 kilometer in length, such as the water cave in Benxi, Liaoning Province (3134 m), the Shihua cave in Fangshan, Beijing (2500 m) (Jin et al, 2009). Therefore, cave is very valuable in both tourism development and geographical archaeology, and further research in this field is still in need.

Conclusions and Discussions:

The mainly cave research applications in geographical study

In conclusion, cave research applications in the study of geography are widely expanded with global warming and global economy development. It is mainly observed in the following three aspects.

The first aspect is, the complexity of the risks of climate change makes the cave sediments good proxy data in the global climate change research, and further reveal the fact of climate change from a longer time scale. In addition to that, the sediments with a longer deposition time are outstanding materials in the study of environmental evolution, and have the very vital significance.

The second aspect is, under the background of climate change, extreme weather/climate events become more frequent, and caves as a shelter, play an important role in disaster prevention and mitigation in the mountainous area.

The third aspect is, as human continuously explore the nature, caves have become a kind of tourism resources, which play a very important role in the resource development and tourism planning. Apart from that, caves also need the attention and in-depth study of archaeology.

The suggestions about better protect cave resources

The practical and effective protective measures must be established for the karst caves distribute in China. There are several aspects that we should pay attention first as below.

This first aspect is the accuracy of cave sedimentary data. It's very important to make sure the research data accurate enough and which should be collected by different researchers in different places for bias caused by equipment and experimental methods. For example, the standards of standard solutions used in the determination of metal elements will highly affect the results of the experiment; the lack of standard processes in the sampling and field measurement will also lead to the experimental data deviation.

The second aspect is the impaction caused by climate change on cave. Caves are inevitable impacted by the global climate change. Hence, it's very necessary to pay enough attention to make thorough research on how the caves' scale, size, structure and etc. are impacted in different regions with the changes of years under the background of the global climate change.

The third aspect is the settings of cave refuges. It's meaningful to make deep researches on how to fully use the cave refuges without making these shelters as flashy sites because that cave refuges are generally in mountain areas with lower population density.

The fourth aspect is the rational plan of cave tourism resources. It's necessary to take some in-depth studies whether a cave are suitable as a tourism location in the long term and make adjust measures according to local conditions. It is important to take researches on how to rationally explore the cave tourism resources in different regions, and it is necessary to carry out a lot of researches.

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