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Some Insights into the Genesis and Evolution of Dunefields Along the Lower Ganjiang River and Surrounding the Poyang Lake

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Abstract

Based on a body of relevant literature and field investigations, this paper presents some insights into the genesis and evolution of dunefields along the lower Ganjiang River and surrounding the Poyang Lake, Jiangxi Province, central China. After analyses and comparisons, it concluded that: 1) the dunefields in the Poyang Lake valley occurred at lest during late Quaternary, not Holocene, and there could be theoretically mid-Quaternary dunefields; 2) the essentials of genesis and evolution of dunefields exist during both Quaternary glaciations and dry seasons and periods in the Holocene, especially in specific sites such as Shaling of Xingzi County and Laoyemiao of Duchang County; 3) considering the distinct location and spatial characters of the Poyang Lake valley, as the existence of "Easten Asian Cold Trough" is possible and reasonable, glacial and aeolian processes as a coupled complex should be concurrent and synergic in a much larger spatial extent, the widespread dunefields of late Quaternary suggest more possibly the existence of corresponding glacial products in the region; 4) the future explorations in such vulnerable and distinct environments entail more original ideas and approaches as well as research and analysis techniques in order to obtain more valuable results.

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Keywords: the lower Ganjiang River, Poyang Lake, dunefield, source-bordering dunes, subtropical monsoon climate

Introduction

The region including the lower Ganjiang River and the Poyang Lake are quite distinct and puzzled about the Pleistocene glaciation, aeolian landforms, the dynamics of Poyang Lake, interesting a number of

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scholars in earth sciences[1-9], e.g. Li Siguang, Shi Yafeng, Li Jijun, Huang Peihua, Jing Cairui, Ren Mei'e, Yang Huairen, Yang Dayuan, etc. Recently, more and more researches are concentrated on the issues such as genesis and evolution of dunefields, their dynamics, and relationships between aeolian and fluvial/lacustrine processes in the region [10-17], and some significant progresses have made since 1990s.

Based on a body of relevant literature and field investigations, the paper attempts to present some insights into the genesis and evolution of dunefields along the lower Ganjiang River and surrounding the Poyang Lake, Jiangxi Province, central China, and then makes some remarks.

Distribution and Features of the dunefields in question

Distribution. It is well known that extensive drylands worldwide are, to a great extent, characteristic of active dunefields, while subtropical monsoon zones at most of paleao- or fossil dunefields. Surprisingly, there are many active dunefields scatered in the region, mainly along the lower Gangjiang River and Fujiang River, and surrounding the Poyang Lake, some of which are advancing downwind.

In accordance with existing literautre and analyses from sattelite imageries, there are 6 large-scale dunefields, i.e. those in Shaling of Xingzi County, in the vicinity of Laoyemiao and Zhangjiatang of Duchang County and Houtian Town of Xinjian County, and on the islands of Jishan and Songmenshan. Besides, some local small-scale dunefields can be recognized at Huoyanshan and Beibanding of Xingzi County on the shores of the Lake, and around Tongtian Village and Liangjiafang Village by the Gangjiang River and Fujiang River, respectively (Fig. 1).

Here, it needs to be pointed out that the dunefields in the paper don't include those along the Yanggtz River valley, e.g. south banks of Hukou County and Pengze County.

Primary features. To begin with, due to a number of rivers, lakes, wetlands and hills, the dunefields in the region are separate and dispersed, and with respect to their spatial scale each is limited, insomuch as the largest situated near to Laoyemiao is at most 20 km^2. It can be largely attributed to the insufficient sand materials.

Secondly. the dunefields are in vicinity of rivers or lakes, so that they are referred as source-bordering dunefields[18, 19]. Thus, it can be inferred that rivers or lakes prepare the material and aerodynamic conditions for dune genesis and development. Still, the dunefields are the products of fluvial-lacustrine-aeolian interactions, in some cases plus anthropological actions.

Thirdly. the dunefields are characterized by ridge-like dune complex, which extend NNE-SSW, approximately 15-20° independently of their localities, implying that the dunefields are governed mainly by stable large-scale wind regime. Nevertheless, the discrepancy of angles between extension of ridges and modern shifting sand advance can be perceived on Songmenshan Island (Fig. 2). It might be induced that ridge-like dunefields are, to a great degree, paleao-dunefields formed in the remote past.

The genesis age of the dunefields

During Holocene?

According to the research by Zhou Xueyong, the dunefields in Nanchang areas came into being during the Holocene inasmuch as the Liantang Formation, a series of loose sand sediments and the principal sand

source for dunes, occurred in Holocene [14]. However, more relevant dating data reveal that the age of the Liantang Formation is late Pleistocene (Q_3) [20-22].

Generally, it is accepted the very fact that modern dunes occur in the late Holocene, and their sand materials come from fluvial or lacustrine sediments with respect to the region. Some new data manifest the existence of paleao-dunes in the region, most of which were engendered in late Q_3 [11, 22-24]. So, there is a necessity to separately analyze and discuss the issues on the genesis ages of paleao- and modern dunefields, and further improve the relevant dating techniques.

During late Q^3?

By means of recent analyses on the sandy hills and ridge-like dunefields, it is known that they are formed in late Pleistocene [22-24], i.e. in the Last Glacial Maximum (LGM). According to Yang Huairen [11], aeolian activities were widespread, companying the glaciation and periglacial processes in the very period, mainly due to the existence and development of "Eastern Asian Cold Trough". Accordingly, under the circumstances of strong winds, weak fluvial processes, and bald loose sediments, aeolian landforms came into being, including sandy hills, linear dunes or sifs, and crescent dunes possibly. It is, therefore, plausible to infer that it is during the period that the spatial pattern of dunefields in the region were coined.

Considering the fact that most dunefields are composed by ridge-like dunes and dispersed evenly in the region, it can be certainly concluded that existing dunefields occurred mainly in LGM.

During mid-Pleistocene (Q^2)?

As mentioned above, available data support the viewpoint of late Q_3, and still, the extreme of human's knowledge allow solely to deduce the insights. Against the backdrop of long history of local environments and limited research techniques, little evidence is sustained up to now because of modification by ensuing complicated fluvial and lacustrine processes, put diverse experiences and skills of researchers aside.

In fact, there were generally at lest three major glaciations in the whole Pleistocene throughout the world. As for the central-northern Jiangxi, there were, specifically, three glaciation epochs, i.e. Poyang, Dagu and Lushan, each of which should had its distinct sediments, even in the great plain by the Poyang Lake and lower Ganjiang River. It is well known that intensive glaciation occurred in the epoch in China, aeolian depositions in the region have, therefore, been found and some ideal sites have been determined, especially the widespread Xiashu Loess and the reticulate red layers, the latter might supply valuable information for the subject in discussion [25-31]. The work is eventually a much more arduous task, but is of significant geographical values, and it needs not only hard and patient field investigations, but also new ideas and dating techniques.

Drivers to the genesis and evolution of the dunefields

Wind regimes

Up to now, it can be sure that violent winds necessary to entrain sand grains could be guaranteed completely during Quaternary glaciations, in which prevailing robust highs controlled the vast Eurasia and surrounding sea-lines receded markedly. This fact is largely indisputable. While as to the situations in inter-glaciation, there are no sufficient data to draw a clear picture and supply solid historic data.

With particular reference to the Holocene, the wind regime for aeolian activities varies with specific locations. Through field investigations, two modes of aeolian processes are recognized, i.e. activation of paleao-dune and modification of fluvial / lacustrine sediments by wind. Due to the effects of narrow and speedup over open water, the northern parts of the Poyang Lake often blow high winds (gales) larger than 17m/s and cumulate to more than 20 days in Winter, which can easily entrain sands, especially in Xingzi County (35 days) and some places in lakes [32]. Meanwhile, the lower Ganjiang River and Fujiang River have gales of larger than 20 days [13].

Prevailing wind comes from N and NNE during September to May, and S and SSW in June to August, respectively [13, 32, 33], while the latter determines less the blown-sand winds. Except the specific locations with some deflection of wind directions, these stable wind regime are mainly governed by large-scale atmospheric circulation patterns, just as manifested by the ridge-like dunes (Fig. 3).

Sand sources

On the one hand, modern active dunes get their sources successively from widespread Liantang Formation of late Q_3, paleao-dunes, modern sandy beaches or bars along/around rivers and lakes, especially in dry seasons. By analyzing satellite imageries, many loose sediments can be observed in or by the lower channels of Gabjiang River and Fujiang River, and by viewing those busy vessels for collecting sand from waters across the research region, it proves that the sand sources are abundant under water.

On the other hand, the sand grains can be further provided by decomposition of rocks under modern humid warm climate, considering extensive distribution of rocks bearing sands in the Poyang Lake valley such as sandstones, granites, gneiss, and so forth [20, 21, 34, 35]. Moreover, frequent and extensive human activities in the whole Poyang Lake valley can indirectly promote provisions of sand by destructing vegetation and various constructions such as urban developments, road construction and mining.

Environmental changes

Tectonic movements. It is well known that the tectonic movements in the whole valley are very active as part of the Neocathaysian Tectonic System [8, 9, 36]. The majority of tectonic lines hold the identical direction NNE (cf. Fig. 3) around the Lake, whereas the regions of lower Ganjiang River and Fujiang River become more complicated. These tectonic lines control, to a very large extent, the position, extent and size of dunefields.

Climate Changes. With respect to climate changes, there have been a number of thematic researches [8, 9, 37-39]. In brief, alternative changes between glaciation and inter-glaciation during the whole Quaternary undoubtedly influence the pattern and dynamics of water system, and in turn define the local wind regimes and sand sources. During glaciation, aeolian landforms can be made, and conversely may be destroyed by fluvial processes during inter-glaciation. In the Poyang Lake valley, current evidence only indicates the relic dunefields of late Q_3.

Implications for the environmental changes

Glacial activities coupled with aeolian activities

From the viewpoint of geographies of the high mountains (e.g. the High Asia, the Alps, the Rockies, the Andes, etc.), the Arctic and the Antarctic, glacial and aeolian processes are generally coupled and synergic during glaciation, the differences only consist in the spatial position and the features of land

surface processes. Although the glaciations in Lushan are still being disputed, some periglacial features have been discovered in the region [39, 40], suggesting that aeolian activities should exist in that time. It should be noticed the fact that modern active dunefields are only located in the Poyang Lake valley in the whole middle and lower Yangtze River valley. It is not undoubtedly casual, and there is a specific internal relationship between them.

The dynamics of the Poyang Lake

The morphology and extent of the Poyang Lake are dynamic during the Quaternary and historic period, based on existing data. The lake basin took form in the Cretaceous by tectonic subsidences, and the lake came into being only in the Holocene [40-43].

On the one hand, the lake has a temporal pattern of interchange between expansion and shrinkage with time, along with sea level and climate changes. Then, aeolian activities and cessations might occured concomitantly in some ideal locations. On the other hand, under cunrrent subtropical mon- soon climate, the heights of the lake change dramatically with a range of 9-16m [44] so that there are significant aeolian activities in Winter. Therefore, since the very current climate can produce some dunes, then what will occur when glaciation?

The vulnerability and distintiveness of subtropical humid environments

Just as pointed out by Yang Huairen and Yang Dayuan [8, 9], the position and characters of the eastern parts of China are quite distinct and exceptive because of the massive Qinghai-Tibetan Plateau. Thus, the East Asian Cold Trough is reasonable and possible during glaciation, and the East Asian Warm Trough, if any, is steadily substantive during inter-glaciation. In other words, the extensive zone is high sensitive or vulnerable to the environmental changes, which little input or disturbance will result in large oscilations or fluctuations. It is unsurprising for the unique region to appear some amazing phenomena.

Some remarks

First of all, entities on the Earth have sharp and distinct individual characters varying with localities. Specifically, East Asia has unique humid monsoon climates and corresponding physical geographic processes and phenomena. Therefore, when making comparisons and inferences between different areas, much more attention ought to be paid in order not to commit some avoidable disputes. As to the Poyang Lake valley, there are the well-known Lushan, initiating the glacial studies and disputes, and active dunefields. As one counterpart, the Doting Lake valley in Hunan Province cannot match with it although the two large valleys bear a great deal of geographic attributes.

Secondly, defined by current knowledge and research techniques, data can prove that dunefields in discussion occurred at lest during late Quaternary, not Holocene. There could be theoretically mid-Quaternary dunefields, but unfortunately they are not discovered up to date. In fact, the conditions engendering dunes exist during the Quaternary glaciation, i.e. sand materials and wind regime. It may be attribute to the destruction and modification by ensuing fluvial/lacustrine processes.

Thirdly, the research region is situated between the largest continent, the Eurasia, and the largest ocean, the Pacific, and to the east of the Qinghai-Tibetan Plateau, which determine jointly its distinct and vulnerable attributes to the environmental changes so that many phenomena can not be explained easily

with relevant facts and processes in other regions. It seems to be asserted that a novel originative theory should be put forwards.

Fourthly, it can be concluded that there exists a similar temporal pattern of lake evolution between different stages of the Quaternary, where the lake expansion and shrinkage occured, and different seasons in a year under current climate, where the heights of the lake fluctuate significantly. Furthermore, the wind regime and aeolian activities in Winter allow to deduce the existence of dunefields during Quaternary glaciations.

Last but not least, the dunefields in the region are controlled not only by local physical geographic agents such as climate, geology, geomorphology, hydrology, vegetation and soils, but by surrounding areas as well, e.g. the Dabie Mountains, Lushan Mountain, the Yangtze River, the Tancheng-Lujiang Fault, Nanling Mountains, etc. In addition, modern physical geographic processes intertwine with history and geologic ones, simultaneously governing today's situations of the Poyang Lake valley. Any separate evidence cannot give reasonable solutions.

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