地理学报(英文版) 2002年第12卷第2期

The paleogeographic implications of loess mounds: Laizhou Bay plain

作者: ZHANG Zu-lu LIU En-feng

The loess mounds are a newly discovered type of landforms on the Laizhou Bay plain south of the Bohai Sea. Research shows that they were formed in the late period of the late Pleistocene when the Bohai Sea was exposed in the period of late W?mu glacial age and changed into plain. As the exposed area is not protected by vegetation, the sediments at the sea bottom are blown and transported southward by strong north winds, and deposit on the coastal plains. As thick loess is accumulated, the loess mound landforms are formed in the direction of down wind.?

The paleogeographic implications of loess mounds: Laizhou Bay plain ZHANG Zu-lu, LIU En-feng, NIE Xiao-hong, WANG Lin (Department of Geography, Shandong Normal University, Jinan 250014, China) Loess mounds are made of gray-yellow loess materials and the number is over 200 in the area of over 1000 km2 on the alluvial or marine-built plains south of Laizhou Bay (Figure 1). 1 The formal and distributional characteristics of loess mounds 1.1 Formal characteristics The plane forms of loess mounds are irregular oval or round. Their major axes are in north-south trending, most of them are 300 to 500 m long, with smaller ones tens m long, and individual larger ones more than 1,000 m long. The minor axes of the loess mounds are usually 200 to 300 m long, with linear ones more than 20 m, and the wider ones near 600-800 m. Usually the loess mounds are 3-10 m higher than the surrounding flatland, and the highest can be over 30 m. Their distribution characteristics are long-welt brecks, which are lost scattered. The few larger-scale ones formed gentle rolling brecks of over 1 km2 in southeastern part of the area, appearing like little "loess Yuan" on the Loess Plateau. The loess mounds have been cut and used for agricultural development. Figure 1 Distribution of loess mounds on the plain south 1.2 The distributional characteristics of loess mounds The loess mounds lie in the southeast of west-east belted littoral-plain in the north of Luzhong Mountains of Shandong, that is, between Changyi-Shouguang City south of Weifang City, 36o40´-36o55´N, 118o59´-119o29´E. The area is about 50 km long in the west-east direction and 15-20 km wide in the north-south direction. The close packed area of loess mounds is in the southwest of Changyi City and east of Hanting City. From the southwest to the north or west, its density becomes sporadic from closed 1.3 yokes/km2, and size from larger to dwarf. The south edge of loess mounds area is connected with piedmont denuded-constructional plain of Taishan, Lushan and Yishan mountains, and the north edge is marine-built plain, 20-30 km apart from the Laizhou Bay, with the gradient ratio decreasing from the southern 5.5? to the northern 6?. The east of the distributing area vanishes completely on the west bank of Weihe River because of the holding-up of low hills formed of fracture and fault-folds on the edge of the NNE Yishu fracture belt. To the west, loess mounds disappear on the east of Raohe River, coinciding with the west margin of perdic Yishu fracture belt. To the west of Raohe River, the flat country is lifted up by the basal block folding. Thus, the configuration of the west, south and east in the "distributing area" outside is high, and is moderately pitching only toward northern Laizhou Bay. So, the loess mounds lie in a half graben-like basin, opening toward north, controlled by the fault basin. 2 The sedimentary structure and material component characteristics of loess mounds 2.1 The sedimentary structure characteristics of loess mounds The accumulated soil horizons composing of loess mounds cover up the river alluvium and lacustrine formation in the form of nonconformity, and the sedimentary structure is very simple, the texture of sediments is relatively homogeneous. There are no obvious bedded planes or ride horses, and no sediment bedded plane or bedding on the plane sections. And no up-growth of palaeosol is found on all loess plane sections. Only minority plane sections have lime carbonate concentrating layers. Though the loess in this area has obvious features of loess in macroscopic aspects, the characteristics such as big grain size and unconsolidated texture make other signals as pores and vertical joints not typical as in-land l

oess. 2.2 The characteristics of sediments The result of grading analysis shows that the loess grains are mainly made of open-grained fine-sand and bulldust. The content of fine-sand, 0.25-0.05 mm in diameter, is between 51.5-77%, usually 68%. The bulldust mean content, 0.05-0.005 mm in diameter, is 21%, the minimum is 12.9% and the maximum 38.4%. The clay whose diameter is bellow 0.005 mm takes up only 12% of all, the minimum is 8.3% and the maximum is 15.7%. But the medium sand whose diameter is above 0.25 mm is very sparse. (Table 1). As Table 1 shows, the main grain size of this area is within fine-sand range, and the second is bulldust. It is different from the loess in Shanxi Province, Shandong Province and Miaodao Islands (Cao et al., 1987; Liu, 1985; Zhang et al., 1989). The difference with Luochuan loess in Shaanxi Province is also apparently shown on the probability curve (Figure 2). The truncation point of the loess in the Laizhou Bay is more close to that of sand-loess and sand of storm, which is between 3.5-5Φ contrasting with 6-7Φ of loess truncation point. In addition, the slope under the truncation point of loess is very similar to that of sand-loess or sand of storm, which shows that the percentage of near-earth space jumping grains is comparatively large. All these fully show that the loess of this area is sand-loess and majority of it is proximal facies materials. Figure 2 Probability curves of loess grain size in different areas The detrital minerals in the loess exceed 30 species, of which the light minerals content is the highest, whose main species are feldspar and quartz; the heavy minerals content is between 1.5 % and 26 %, most of them are common hornblende, epidote, sphene and opaque minerals. This assemblage is very similar to that of the loess of Luochuan of Shaanxi Province and near-by area of Shandong Province (Cao et al., 1987; Liu, 1985). But the content of the stable epidote in this area is higher and the content of stable sphene is also very high, which shows that the loess materials had undergone deep dote-dissociation. Furthermore, the X diffraction pattern of loess shows that the clay mineral assemblage is similar to that of the loess in other areas, but its obvious feature is that the content of montmorillonite is higher, accounting for 13.9 %, and the content of Kaolin is relatively low (Figure 3). These indicate that the material provenance and formation of loess are different from other loess and it has relation with the groundwater actions that is quick magnesium (Zhao et al., 1991). Table 1 Grain composition of the loess in different areas Table 2 Statistics of microfossils in loess mounds According to investigation, no findings of large spinal animal fossils exist in the loess mounds. But there are many fossils of marine-built facies foraminifera, ostracodo and gastropod and their fractions, over 30 species or genus, in the 16 specimens collected. The most frequently seen in the fossils are Elphidium crispum, Protelphdium sp., Ammonia sp., Campylocythereis tomokoae, Valvata parviumbilicata, Odostomia sp., Nomion sp., Ammonia sp. etc. But many sheaths and ornamentations of sorted fossils are abraded or failed. Besides, the detectable quantity of fossil specimens on the plane sections decreases from north to south and the reduction factor and percentage of which has an increasing tendency (Table 2). All these fully show that the loess materials composing of loess mounds come from north, that is, from the marine sediments in the Bohai Bay. 3 Formation modes of loess mounds All the characteristics of loess mounds, such as their macroscopic features and regularities in distribution, the sediment structure and material composition characteristics of accretion bodies, show typical aeolian sediment character. And masses of the marine-built fossil organisms in the loess fully show that loess provenance and marine sediments have close relation. Furthermore, the scanning result of quartz sand grains in the loess, through electron microscope, shows that sand grains have better psephicity, and 2/3 of which is above Grade 3. The scanning image also clearly shows the "V-shaped" feature of subaquatic impact craters and conchoidal fractures on the surface structure of quartz sand grains, and the vestige pavements corroded or abraded on the edges or edge angles. It also shows the oriented corroded vestiges and SiO2 sediments on many big surface piezoglypts. All these are vestiges of obvious subaquatic motion force and typical structures of marine shelf sand surface. The sand grain surface usually has closely packed pockmarked impact crater vestiges, which are usually on the corroded or sub-aquatic abraded vestige pavements. It shows that wind action comes after the marine motion force action. All the microscopic proofs further prove that the fine-sand is the product of seawater action on Bohai Sea shelf, and then is transported and accreted by wind. This makes it have the double characteristics of marine-build and aeolation. Figure 3 X-ray spectra of clays in the loess, of which the mound is composed The littoral of the Laizhou Bay is a monsoon-affected region, and is one of the coastal areas witnessing strong wind in our country. According to 20 years´ meteorological data of the area, from 1959 to 1980, such as Changyi City, Hanting City, Shouguang City and the sea approach meteorological data in the littoral region (SCTC, 1989), a conclusion can be drawn that the prevailing wind is deflective north wind, deferior by north-east and north winds (Figure 4). Especially in winter, the average wind speed comes to 10 m/s, and the highest can reach 20 m/s owing to the strong wind force and high wind speed. All these are the characteristics of wind action prevailing areas. The area 20 km south of Laizhou Bay is the accretion area of loess, lying in the north wind prevailed southern depression. This makes the sediments can subside and accumulate easily. So the loess in the region is the sediment of proximal marine-built loess sands carrie

d by local winds. Figure 4 Direction rose of the winter wind maximum speed in Changyin County in 1970-1980 According to the grain composition of loess, massive clastic fragments carried by local wind from near-earth space below 100 m occupy a dominate place, and the secondary are midland grains of Asia levitated by upper air planetary wind from north-west. The grains under fine-sand grade can form a lower air clast layer near the ground or at a higher attitude, when they are blown and carried by near-earth wind, and can be horizontally carried directly in down-wind direction, that is, SSE direction. As the ground sands or dust stroms meet plant associations, local ground salients or other barricades during the course of being carried, they can quickly fall around them. By repeated accumulation, they can form elliptic accumulators stretching north-south in plane, whose apical coincided with wind direction. Adopting the name of "pier" called by the local people, we named the mounds morphology "loess mounds" combining their forms and composition of loess. 4 The age of loess mounds The loess mounds accumulated on the plain in the forms of isolation and dissemination, whose ages can be deduced by the age of loess. 4.1 The bed successions of loess in the loess mounds The loess composed of the loess mounds accumulated on the alluvium and lacustrine formation in the form of discordance. Above the geostrome is sandy clay and silty clay taking on light yellow, brown yellow and local black brown. Among them there are many horses such as sandy gravel or siltage whose thickness is between 5 m and 20 m. According to the present study, they belong to mid-Epipleistocene or late Epipleistocene (Zhao et al., 1991). In many places of the layers, many macro-zooliths are found, such as Palaeoloxodom namadicus, Coelodonta antiuitatis, Bos primigenius, Bison sp. and Struthiolithus anderssoni. So the loess in the loess mounds is on the top of late Pleseries geostrome. 4.2 The 14C ages of loess mounds As the lime carbonate illuviation of the loess materials in the loess mounds is lighter, the author only finds three places having lime carbonate ghibli and does the 14C age-dating with nuclear center and envelope separately. The data show the nuclear is the early sedimentation representing the initial forming dates, and the envelope is lime carbonate sedimentation having many disturbing elements with great variations, representing the late dates. The time interval of carbonate core between nuclear center and envelope can represent the date when carbonate core formed. The data of 14C age-dating are shown in Table 3. Table 3 14C dates of calcareous concretions in loess mounds Figure 5 Schematic illustration of aeolian transport action and deposition in the loess mound area We can see from Sheet Three that accretion formed between 16000 a BP and 6000 a BP, and the nuclear center between 16000 a BP and 8000 a BP The date of loess accumulation is earlier than that of carbonate core forming, that is, before 16000 a BP This is accordant with the loess layers in the loess mounds. It is more accurate that the main accumulation date of loess is between 24000 a BP and 16000 a BP, and the date of loess mounds landform forming through loess scission is later than that of the loess accumulation. The date is matched with the late W?mu glacial of late Epipleistocene or later. Of course, the accumulating of loess could last to the early of Holocene post-glacial period. 5 The palaeogographic environment for the formation of the loess mound landforms When the last glacial, that was W?mu glacial, of late Epipleistocene came into mature period, global temperature dropped by 8-13oC and the eastern sea level of China descended by 130 m. During the glacial, with sea level declining, shelf cropping out and groundwater level lowering, the aridness on the ground surface became serious. Furthermore, Mongo high-pressure strengthened, and the prevailing northwest wind, northeast wind and north wind became more powerful. The cold and arid climate made the wind have strong blowing up and carrying capacity. With the decline of global temperature, sea level dropped by a big margin. By the prevailing period of the last glacial, the Bohai shelf turned into plain because of seawater retreat. The unconsolidated clastic fragments deposited on the floor were fully calvous, which made the Bohai shelf harsh desert. Under the strong blowing of northwest, north and northeast winds, marine deposits were blown up. Through transporting and grading, open-grained debris were transported in near distance or stayed in places where dunes formed. Thus Bohai shelf plain became deserted depositional environment (Xia et al., 1991; Zhao, 1992). This environment became the main source of loess near littoral area. These prove that loess deposit is actually the derivation deposit of Bohai shelf desert (Zhao, 1992). Many fine materials are blown up and transported to distant area, thus the south coastal plain in down wind direction became the main accumulation place. In many favorable configuration areas, the deposits were especially concentrated. Through the transport and deposition by near-earth wind as stated above, the depositions became loess deposition layers. In post-glacial of Holocene, with global climate becoming warmer, seawater coming into Bohai Bay again, and precipitation increasing, a series of hydrographicnets fluting northward gradually flourish, which originated from southern Taishan, Lushan and Yishan mountains. Continual oscillation of the rivers, such as Weihe, Mihe and Bailanghe rivers, the loess sedimentary provinces were corroded and scissord strongly. Furthermore, there are many other exokinetics, such as precipitation and aeolian erosion. Under their common action, the virgin loess sedimentary layers and loess mounds changed gradually and has become loess mounds morphological landscapes as we see now in southern area of Laizhou Bay. References

关键词： loess landform; Laizhou Bay plain; south Bohai Sea; late Pleistocene paleogeography; desertificatoin of continental shelf?