Chemical weathering history of the southern Tajikistan loess and paleoclimate implications

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Abstract  Major chemical elements and Rb, Sr, Ba abundances were measured for loess samples from Chashmanigar loess-soil sequence in southern Tajikistan. And the degree of element loss and intensity of weathering of the samples were calculated. From these calculations we found that the paleosol horizons of the Chashmanigar section were chemically weathered to some extent and the weathering intensity of the soils is stronger than that of loess horizons, indicating that paleosols in southern Tajikistan were deposited in relatively warm and humid interglacial ages. In addition, the southern Tajikistan loess deposited before 0.9Ma BP was more intensely weathered than that deposited after 0.9Ma BP, which may imply the intensification of aridity in this area since 0.9Ma BP.

Keywords: Tajikistan loess, element ratios, chemical weathering, Quaternary paleoclimate.

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In recent years, the loess deposits in Central Asia have attracted increasing attention of Quaternary paleoclimate researchers[1−8]. The centre of the loess deposits in this area is located in southern Tajikistan, where thick and continuous loess sections containing tens of paleosol horizons have basal age of 1.8—2.6Ma[1,4]. Recently, systematical paleomagnetism, magnetic susceptibility, grain size and color reflectance analyses were conducted by Ding et al. for the Chashmanigar section[8]. Their results suggest that the stratigraphy and climate records of the Chashmanigar loess sequence can be well correlated to those of Chinese loess. Therefore, a comparative study of the Chinese and Tajikistan loess deposits may provide new understanding of the Quaternary climate history and its driving forces over the Asian continent.

The transportation and deposition of the Tajikistan loess is quite different from the Chinese loess, as manifested in the following aspects. Firstly, the dust material of Chinese loess was mainly transported from deserts to the north and west of Chinese Loess Plateau by winter monsoon, while the material of Tajikistan loess was mainly transported from deserts to its west, by westerly winds. Secondly, Chinese Loess Plateau is climatically characterized by the hot wet summers and cold dry winters whereas southern Tajikistan by Mediterranean climate with hot dry summers and mild wet winters. So the loess-soil sequences of the two places were formed under different climate conditions and derived from different sources. The comparison of these two sets of loess deposits will be helpful for deepening our knowledge of different responses to globe cli-
climate changes by different regional climate systems. Tajikistan loess research could also provide further clues to understand the climate change pattern in northwestern China. In Chinese Quaternary research circles there are debates about the northwestern China climate pattern in glacial and interglacial periods. Some researchers believe western China differs from eastern China in that it has several cold wet glacial ages and hot dry interglacial ages, meanwhile another group of researchers think cold dry glacial ages and hot wet interglacial ages also dominate in western China as they do in eastern China[9,10]. The solution of this problem is hindered by the lack of continuous deposits in western China and by difficulties to date the deposits there, thus manifesting the importance of loess researches in the west and east of this region.

There are two different views about the formation of southern Tajikistan loess. One believes that paleosol horizons in Tajikistan were formed during interglacial periods[1], while the other regards paleosol as glacial deposits[4,5]. These debates also manifest that it is important for Tajikistan loess research to use paleoclimate proxies. In our study, we measured major chemical elements and Rb, Sr, Ba abundances of loess samples from the Chashmanigar sequence in southern Tajikistan, trying to discuss the character and history of precipitation and temperature variation in this area during Quaternary glacial and interglacial fluctuations.

1 General nature and setting

The Chashmanigar section is located in southern Tajikistan (Latitude38°23’32”N, Longitude 69°49’57”E(fig. 1). Pamirs Plateau and Tianshan cordillera are situated east to this region, while Hindu Kush Mountains to the south and deserts to the west and northwest. The loess there is deposited on river terraces and piedmonts. Although the broad flat “Loess Yuan” does not exist in this area, there are very high loess hills and some sections have thicknesses of up to 200 m, with horizontal loess strata.

The annual mean temperature in this area is 11°C, and the annual mean precipitation is 842mm. Westerly wind pervades this area in winter, which brings forward great deal of humid air, so precipitation concentrates in this season. In dry summer season, southwestern air streams carry eolian dust from Karakum desert, etc. The dust settles down when air currents are stopped by the Pamirs Plateau.

The Chashmanigar section has a thickness of 205m, underlain by a set of Cenozoic gravel sediments. Unfortunately, the lower part of this section is covered by slumps, so we have only sampled the upper part of the loess-soil sequence, with a thickness of 195m.

![Fig. 1. Schematic map of loess distribution in Central Asia.](image-url)