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Study on north boundary of subtropical zone in Funiu Mountain according to soil geochemistry

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The boundary between subtropical zone and temperate zone is not only important in physical geography, but also attractive in agricultural production. Seven soil profiles studied in this paper are placed along the southern slope of Funiu Mountain at different heights above sea level. Many compositions and properties of these soils have been determined in laboratory. In this paper, the laws of migration and accumulation of soil materials on the southern slope of Funiu Mountain are discussed first, then the division of the boundary between subtropical zone and temperate zone in this area according to soil geochemistry is discussed with qualitative methods and mathematical classification method in which twelve selected indexes such as Km, Saf, Ba, β, Feo/Fet, Mno/Mnt and so on are used. The result indicates that the boundary between subtropical zone and temperate zone on the southern slope of Funiu Mountain is about 950 m above sea level.

Study on north boundary of subtropical zone in Funiu Mountain according to soil geochemistry MA Jianhua, XU Shuming, HAN Jinxian, ZHU Lianqi, ZHAO Qingliang (College of Environment and Planning, Henan University, Kaifeng 475001, China) 1 Introduction The boundary between subtropical zone and temperate zone, north boundary of subtropical zone, is not only important in physical geography, but also attractive in agricultural production. So scientific division about the boundary has important theoretical and practical significance. Although some researches on the north boundary of subtropical zone have been done at home and abroad according to the views of climate, vegetation, etc., and some valuable papers about it have been published as well, the agreement has not been reached yet, and the achievement with the view of soil geochemistry in this field has not been seen. Soils are the physical bodies formed under conditions of climate, organism, parent material, landform and time, and so on. They can reflect the regional geophysical properties where they are located synthetically. In different geophysical regions, the migration and accumulation of soil materials must be different too. On the other hand, the situations of soils are more stable than other physical factors. For this reason, we can study the boundary between subtropical zone and temperate zone according to soil geochemistry. In this paper, we make a case study on Funiu Mountain that is located in western Henan province for discussing the division between subtropical zone and temperate zone on the basis of the field and laboratory works of soils, which will supply more scientific and theoretical basis for the division. 2 Collection of soil samples and the experimental results We selected the section from Duiwa gully (550 m above sea level) to Jijiaojian peak (2,212 m above sea level, one of the main peaks of Funiu Mountain). Both spots are located on the southern slope of Funiu Mountain. In order to research the exact location of the boundary, 7 typical soil profiles along the section were placed and drilled according to the difference of altitude and physical conditions (Table 1 and Figure 1). The soil total chemical composition and active Fe and Mn were determined in laboratory (Table 2). 3 The laws of the migration and accumulation of soil materials From the views of soil geochemistry, all soil SiO_2/R_2O_3 (Saf), Km, Ba and β are good indexes that can reflect the degree of soil migration and ferrallitization well (Yu et al., 1987; Zhu et al., 1992). Saf value of all soil layers, β value and Km value of every oxide, Ba value, proportions of active Fe to total Fe (Feo/Fet), active Mn to total Mn (Mno/Mnt) are calculated (Tables 2 and 3). According to all Km values listed in Table 3, the average migration coefficients of soil oxides in the 7 profiles are calculated respectively. The average migration coefficient of each soil oxide is calculated via the following formula: K = where K is the average migration coefficient of profile i and oxide x; Hij is the thickness of soil layer j and profile i; K is the average migration coefficient of profil e i, soil layer j and oxide x; n = 3 when i is S1, S2, S3, S5 or S7, and n = 2 when i is S4 or S6. The migration coefficients of most oxides in all layers and average migration coefficients of soil bodies in S1, S2, and S3 which are under 900 m above sea level are smaller than 1 (Table 3 and Figure 2). This indicates that the heat and water in low mountainous and hilly areas on the southern slope of Funiu Mountain below 900 m above sea level have the advantages of decomposition and eluvia-tion and make the soils have the features of that in subtropical zone. The mi-gration coefficients of Ca and Mg are higher in S1 because of its parent mate-rials belonging to deposit-ed loess, enriching in Ca, Mg and some other alka-line-metals, but the desili-cication and ferrallitization is very evident. The aver-age migration coefficient of SiO_2 and Al_2O_3 on S1 are 0.8 and 1.16 respec-tively, and the proportion of the two coefficients is 1.37, which is the highest of all soil profiles. With the increasing of altitude higher than 900 m above sea level, most mi-gration coefficients of oxides are bigger than 1, which indicates that soils higher than 900 m above sea level have the formation features of temperate soils. Migration coefficients of soil oxides are affected by many factors, e.g. rainfall, heat, vegetation and some others. According to Yan Yuhua, the maximum precipitation occurs at about 1,300 m above sea level on the southern slope of Funiu Mountain (Yan, 1987). Precipitation increases with the increase of altitude from foot to middle, but the low mountainous and hilly areas below 900 m are blessed with abundant heat, human activity here is stronger and the vegetation cover is lower than that of the uphill of the mountain, which has advantage of decomposition, desilicication and ferrallitization. In spite of the rainfall, the soil eluviates here much stronger than that in the middle section of the mountain, and most migration coefficients of soil oxides are smaller than 1. Despite rainfall increases continuously from 900 m to middle mountain, the heat is inferior to those at foothill, which has limited the decomposition of soil minerals, furthermore, the weak human activities and high vegetation coverage have made biomes-enrichment distinctly. Therefore, the migration coefficients of most oxides are bigger than 1, e.g. the average migration coefficient of K_2O can reach 1.18 and 1.32, and those of CaO reach 2.38 and 2.25 respectively in S4 and S5. From 1,500 m upward to the top of the mountain, the temperature decreases and so does the precipitation, the forest vegetation gradually changes to shrubby meadow. Soil eluviation becomes more and more weak here, and the moving of soil oxides changes from a part of soil oxides eluviating to all oxides depositing. It is a tendency that Saf increases with the increase of the altitude. The value of Saf in S1 is the smallest one, in all layers except the layer of parent material. Saf values are smaller than 5.00. The values of Saf in S2 are smaller than 5.50, which are very close to that of Fer-Udic Lvisoils (4.73-5.40) in the eastern part of Funiu Mountain (Ma, 1996). But the values of Saf in S3 are much higher, most of them are higher than 6.00 except illuvial horizon, perhaps it has relations with types of parent material, soil composition and some other local factors, which need to be further studied. But the value of Saf in illuvial horizon of S3 is 5.06. It is within the range of the value of Saf in Fer-Udic Lvisoi (Ma, 1996). Above 900 m, most values of Saf in S5, S6 and S7 are from 5.50 to 6.50 except a few soil layers, which are close to that of Hap-Udic Lvisoils in the eastern part of Funiu Mountain (Ma, 1996). The values of Ba in all profiles have no distinct difference(Table 3), but those of β vary evidently. The β values of all soils located lower than 900 m are smaller than 1, which indicates that alkaline metals and alkaline-earth metals have evident deposit. In contrary, the β values of all soils located higher than 900 m, except S6 profile, are bigger than 1, which indicates that the eluviation is comparatively weak, alkaline metals and alkaline-earth metals enrich obviously. The β values of soils can represent migration and accumulation of soil material better than Ba does, because β is the specific value between Ba in eluviation horizon and that in illuvial horizon. The content of active Fe (Feo) in soils is affected by organic matter content, water content, pH and some other factors. The content of Feo in soils decreases with the decrease of organic matter and water, and with the increase of pH (Guo, 1992). It can be seen that the content of Feo and Feo/Fet in soils have increasing tendency when the altitude increases. The content of Feo in S1, S2 and S3 located lower than 900 m are 2.88-5.5 g/kg (Tables 2 and 3), and the average content of those is 3.9 g/kg. The content of Feo/Fet in soils ranges from 0.033 to 0.118, and the average value is 0.074. But the content of Feo above 900 m is higher, varies from 4.9 g/kg to 8.0 g/kg, and the average is 6.8 g/kg. The value of Feo/Fet above 900 m ranges from 0.29 to 0.75, and the average is 0.55. The content of Mno in soils above 900 m sea level is much lower, varies from 0.05-0.56 g/kg, and the average is 0.33 g/kg. The values of Mno/Mnt have close relations with heat and water conditions. When the heat and water conditions are favorable for soil mineral decomposition and evaluation, the contents of Mno and Mno/Mnt are high, otherwise, they are low. The content variation of Mno demonstrates that the soil minerals under 900 m have been highly decomposed and eluviated, which have formed an obvious different soil geochemistry landscape compared with that below 900 m. 4 The boundary between subtropical zone and temperate zone With regard to the boundary between subtropical zone and temperate zone, the north boundary of subtropical zone, in west Henan mountainous areas, there are several different viewpoints. Liu Shene (1959) and Shi Huamin et al. (1963) advocated that

the boundary is along the main ridge of Funiu Mountain; Hou Xueyu et al. (1959), Qiu Baojian (1962) and Kuang Shengshun et al. (1961), the northern slope of it; Xiao Tingkui et al. (1962), Zhang Guangye et al. (1965), Zhang Jinquan (1981), Li Kehuang (1983), Quan Shilin et al. (1984) and Ma et al. (2002), the southern slope of it. However, different scholars, holding the southern slope, adopt different heights and specific locations where the boundary passes. In order to discuss the north boundary of subtropical zone on the slope of Funiu Mountain further, we have used Cluster Analysis method to analyze the theme according to migration and accumulation of soil materials. During the analysis process, we selected 12 indexes in each soil profile, those are the average migration coefficients of SiO_2, Fe_2O_3, TiO_2, MnO, CaO, MgO, K_2O, Na_2O, the average value of Feo/Fet and Mno/Mnt, the value of Saf and β in illuvial horizon. We got the chart tree of soil classification with Cluster Analysis through five steps (Figure 3). We can see that S4, S5, S6 and S7 located above 900 m can be categorized in the same class at the distance of 3.86, they have similar features of soil migration and accumulation and all of them belong to temperate soils (Figure 3). The soil profiles, S1, S2 and S3, located below 900 m can be categorized in the same class at the distance of 5.11, they have similar features of soil migration and accumulation and all of them belong to subtropical soils. Summarizing the above analysis, we can draw the conclusion that the north boundary of subtropics zone is between S3 and S4. The height of boundary is between 900 m and 1,000 m on the southern slope of Funiu Mountain, and the average height is at 950 m above sea level (Figure 1). Compared with the author´s study in 2002 (Ma et al., 2002), both are the same about the north boundary of subtropical zone on the southern slope of Funiu Mountain. From some viewpoints put forward by different scholars about the north boundary between subtropical zone and temperate zone on the southern slope of Funiu Mountain, we can find that the conclusion in this paper is the same or similar to that of others (Table 4).

关键词： Funiu Mountain; subtropical zone; migration and accumulation of soil materials