Comparative research on soil magnetic susceptibility and Chroma and grain of grassland soil and farmland soil in alpine region

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Abstract. This thesis aims at researching unchanged perennial farmland and grassland soil on the northern of Qinghai Lake basin and differences between soil magnetic susceptibility, chroma and soil particle size composition of grassland and farmland in lengthways profile(0-60cm). The result shows that the distinction of X_{lf} between grassland and farmland is smaller above 15cm, and farmland X_{lf} is finer than grassland below 15cm. The X_{fd} of grassland is finer than farmland above 30cm, which has a little difference below 30cm. Farmland chroma value is finer than the grassland generally. The lightness of grassland has increased trend and farmland has the decrease trend above 30cm, the lightness of grassland and farmland has no other changes below 30cm, the change of redness and yellowness in lengthways profile has a decrease trend from 0 to 60cm; the clay and silt content of grassland are finer than farmland except sand content; the sand maximum content of farmland in 0-10cm segment; 20 to 35 cm segment sand content decrease and began to increase from 35-60cm segment; the soil particle size composition has a big difference, in particular, when it is above 30cm, it has a little difference below 30cm.

1. Introduction

Qinghai Lake is regarded as an important part of the Qinghai-Tibet Plateau, and it's responsible for the ecological safety of the northeastern Qinghai-Tibet Plateau and even the inland, is to control the eastward spread of desertification in west natural barrier [1, 2]. The historical land-use patterns period of the lake mainly is animal husbandry. After the founding of our country, land-use pattern began to change significantly, and large areas from grassland to farmland is reclaimed [3]. Due to the artificial grassland reclamation into farmland, the area of desertification was increased rapidly. Although natural grassland vegetation was to some extent improved by the way of returning farmland back to grassland in some parts of lake region farmland later[3], the entire area around the lake still remains a serious deterioration of ecological environment in recent years. Then the soil quality and the evolution of traits in the lake surrounding area where it is filled with frequent human activities and natural ecosystem's fragile will become particularly important.

The magnetic susceptibility, chroma and particle size of soil were the most intuitive, obvious and important natural properties [4, 5]. The magnetic properties of the soil, chroma and particle size were closely related to the soil physical, chemical and biological properties [6, 7], which was the basis for the study of soil environment and entire ecosystem characteristics. At the same time, because of the simple, rapid and targeted measurement methods, they can be widely used in various sedimentary environment analysis [8, 9]. The current studies show that the soil magnetic susceptibility and chroma are shipped in two main aspects: one was that the soil magnetic susceptibility and chroma can be quantified as climate proxies because of sensitive to climate change, which also can be applied into the study of loess-paleosol to reflect the changes in the strength of warm, cold and dry soil of historical periods of climate and development [10]. On the other hand, the heavy metals of environmental pollutants produced by the industrial activity, chemical burns and automobile exhaust affect the magnetism and chroma characteristic of soil, so the combining of the soil magnetic susceptibility, chroma and elements of heavy metal could be regarded as an evaluation of soil pollution indicators to assess the degree of soil heavy metal contamination [11,12].Similar to the magnetic susceptibility and chroma of soil, the particle size indicators of soil, on the one hand, are currently used into aeolian deposits, lake sediments and river sedimentary environment [13,14,15], which can also indicate sediment provenance, condition wind power, water power environment, transport routes and etc.. On the other hand, the particle size indicators of soil can directly reflect the soil particles and the soil structure component to assess the degree of soil development. However, as for the progress in research stage, there are fewer studies of the magnetic susceptibility, chroma and particle size of soil under different land-use patterns in the same region. Furthermore, the magnetic characteristics, chroma, particle size of the soil profile distribution are closely related to the changes of the land use patterns made by human activities.

To sum up, this study was based on the five remote sensing interpretations from 1987 to 2010 in such area, and the grassland and farmland around Gangcha County in the northern part of Qinghai Lake, which have been unchanged for nearly 30 years, are selected as the research object, in order that a good research of natural grassland and farmland soil profile could be made to examine the influence of different land use patterns on soil magnetism, chroma and particle size. Furthermore, the soil succession laws under different human activities could be estimated correctly, and some references for sustainable use of area soil resources could be provided.

2. Study area

Gangcha County was located throughout the western Haibei state and belongs to Haibei Tibetan Autonomous Prefecture. The county is connected with the north shore of Qinghai Lake, and boasts a total area of nearly 8138km^2. It lies between 36°58'06 "~38°04'04" N, 90°20'44 "~100°37'24" E, at an altitude of 3200m~3800m between [16]. It is a typical plateau continental climate with long hours of sunlight, where large temperature differences between day and night, the seasons of this area are not clear and drought climate and some other characteristics are clear. In this area, the number of annual rainfalls is 370.5mm, which are mainly concentrated in the June-September. And the annual evaporation is 1500.6-1847.8mm, which forms a climate of cold winter and cool summer. The average temperature of January is -17.5 ℃, while the average temperature of July is 11 ℃. However, the annual average temperature is 0.2-5.7 ℃. The dominant wind direction in winter and spring is from the west, while in summer and autumn the dominant wind direction is from the southeast. And the annual average wind speed is 3.7m/s; besides, the maximum wind speed is 30m/s [17]. Vegetation distribution shows the significant vertical zones, which can be divided into several typical types including alpine meadows, alpine grasslands, mountain pastures, meadows and plains [18]. Soil in this area mainly includes chestnut soil, chernozem, gray brown soil, alpine meadow soil, alpine cold desert soil, sand soil and etc.. The main type of soils around the lake is plain dark chestnut soil, which boasts a quality of higher soil organic matter content and soil fertile. The main types of grassland are rooted with alpine mountain temperate steppe class-based, and the native vegetation mainly conclude *splendens*, *stipa* and *poa crymophila*[18].

3. Experimental Methods

3.1 Soil plot choice

It is based on the five remote sensing image interpretation of the early Lake District from1987 to 2010, and five remote sensing images were superimposed. The grassland and farmland layers were intersected and interpreted in the GIS software, select the unchanged farmland and grassland nearly 30 years ministry of Qinghai lake north as study plots (Figure 1), and the unchanged grassland coordinate point is 37°16'43.29 "N, 100°17'37.12" E, the unchanged farmland coordinate point is 37°16'42.79 "N, 100°17'28.62 "E.

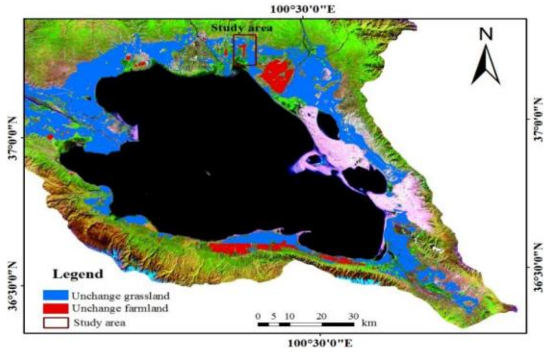

Fig.1 Diagram of study area

3.2 Soil Sampling Methods

Soil samples were collected in October, 2014. The sampling interval is 30m × 30m, five sampling points were respectively selected under two different land-use modes; each sample point includes 12 soil samples with a drill of 0-60cm depth (sampling interval of 5cm) with a diameter of 5cm of soil augers. 10 sampling points and 120 soil samples were selected under such two types of land use patterns. All soil samples were brought into laboratory and dried naturally and cleaned. After it was under grind through a 200 mesh sieve, it would be arranged, collected and set aside.

3.3 Determination of soil magnetic susceptibility

Magnetic susceptibility was measured with MS-2B type magnetic susceptibility instruments made by the British company. Measurement process mainly includes: the dried sample was poured into 10ml volume plastic cylindrical cartridge and weighed sample mass; the magnetic susceptibility meter background value was measured for a time, and the continuous measurements for three times was made after the samples were put. Meanwhile, the measurement sample is removed from its background value for one time. The change of both of the background measurement value should be under 0.3. The low frequency is 470hz, the high frequency is 4700hz, the unit gear of measuring for the SI is 0.1 tear [19]. Finally, the frequency and high-frequency magnetic susceptibility were calculated through magnetic susceptibility test results, samples low (high) frequency magnetic susceptibility value = (average of 3 measurements of the sample-around twice the average background value) × 10/sample mass, units $10^{-8}m^3kg^{-1}$. Frequency magnetic susceptibility (X_{fd} %) = (low frequency magnetic susceptibility X_{lf} - high-frequency magnetic susceptibility X_{hf}) / low-frequency magnetic susceptibility X_{lf} × 100. (Note: According to the measured low-frequency and high-frequency magnetic susceptibility magnetic susceptibility, the overall trend is consistent. However, the overall value of the low-frequency magnetic susceptibility values are higher than the high-frequency magnetic susceptibility. So, just low frequency magnetic susceptibility and the frequency magnetic susceptibility compared analysis were selected here .)

3.4 Determination of soil Chroma

Chroma was taken from Minolta spectrophotometric colorimeter measurement produced by Japan. When the sample was dried naturally in the laboratory, and then it was through 200 mesh sieve. Then, the sample was placed on the test board, flatten. Three areas of smooth surface were randomly selected to be measured for three times, and the instrument automatically determined three measurements of L *, a *, b * mean, and it was ensured that the error was less than 0.1. (L * value: psychometric lightness; a *value: psychometric red-green chromaticness; b * value：psychometric yellow-blue chromaticness)

3.5 Determination of Soil particle size

After all samples were dried naturally and through 2mm sieve, 0.4g soil samples were accurately weighed and placed in a beaker of 50mL. And then, the samples was processed as follows: 1) 10mL10% hydrogen peroxide was added and heated when it was to boil so that it could react calmly in order to remove soil organic matter ease of oxidation salts; 2) after the beaker was cool, 10mL10% hydrochloric acid (Hcl) was added and shaken sufficiently when it was to boil so that it could be reacted freely and carbonates could be removed; 3) the distilled water was put into the samples, and it would be kept for 12 hours; 4) 10mL of 10% sodium hexametaphosphate was added and it was placed in an ultrasonic shaker test. Among this, the particle size analysis instruments was Mastersizer2000 Malvern laser particle size analyzer produced by a British production company. In process of measurement, the degree of shading existed between 17% and 20%, and then, the same measurement would be done for three times, and the final result was accorded to the averaged value.

3.6 Soil data processing

In order to contrast and analyze the change features and otherness of magnetic susceptibility, chroma and particle size of soil between grassland and farmland intuitively, the measure numerical value of the soil magnetic susceptibility, chroma and particle size on five sampling sites of grassland and farmland were on the average from the surface layer 0-60cm to the deeper. And the standard deviation of the average value was accessed, which reflected the dispersion degree of the correspondent numerical value to the average value.

4. Results and analysis

4.1 Analysis of soil magnetic susceptibility difference sectional of grasslands and farmlands

The low frequency magnetic susceptibility (X_{lf}) and frequency dependent susceptibility (X_{fd}) of grassland and farmland were shown in Table 1: the X_{lf} of grassland between (38.83-54.73)$\times10^{-8}m^3kg^{-1}$, the average value was 46.11 $\times$ $10^{-8}m^3kg^{-1}$, farmland X_{lf} between (45.6-64.2)$\times10^{-8}m^3kg^{-1}$, the average value was 54.33$\times10^{-8}m^3kg^{-1}$, we can see that the low-frequency magnetic susceptibility of grassland is less than farmland; X_{fd} of grassland between 5%-8.73%, the average value was 7.22%, farmland of X_{fd} between 4.64%-8.61%, the average value was 6.96%, it was obvious that the frequency of the magnetic susceptibility of grassland was less than farmland.

Fig.2 showed the trends of change on low-frequency and frequency magnetic susceptibility of the grassland and farmland in the profile. The low-frequency susceptibility of grassland was slighter than that of the farmland in the whole profile and had a small amplitude, while the low frequency magnetic susceptibility of farmland was larger in the profile. The difference between grassland and farmland's low frequency magnetic susceptibility in 0-15cm segment were not that significant, and 15-60cm segment of the low-frequency magnetic susceptibility of farmland was significantly greater than that of the grassland. The X_{fd} of grassland was greater than that of the farmland above 30cm, which also had a little differences below 30cm.

Table 1 The X_{lf} and X_{fd} content of grassland and farmland

Sampling point		X_{lf}(×10-8m3kg-1)	X_{fd}(%)
Grassland	Max value	54.73	8.73
	Min value	38.83	5.00
	Average value	46.11	7.22
Farmland	Max value	64.20	8.61
	Min value	45.60	4.64
	Average value	54.33	6.96

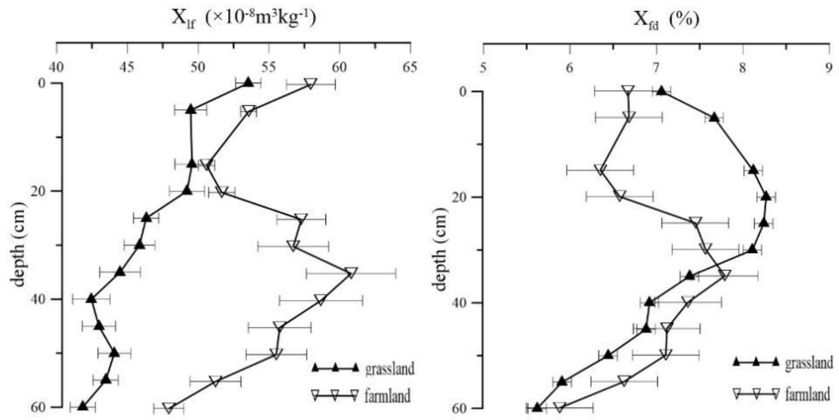

Fig.2 The X_{lf} and X_{fd} variation of grassland and farmland profile

4.2 Aanalysis of soil Chroma difference sectional of grasslands and farmlands

As Table 2 showed, the value of the lightness of the grassland was between 43.79 and 50.01, with an average value of 47.35. The value of farmland lightness was between 50.02 and 55.34, with an average of 52.37. The value of grassland redness was between 4.79and 6.03, with an average of 5.25. The value of redness of farmland was between 5.32and 6.10, with an average of 5.63. The value of yellowness of grassland was between 13.26 and 15.53, with an average of 14.02. According to these above, it was obvious that the lightness, redness, yellowness of farmland were greater than these of the grassland.

The chroma change trend of grassland and farmland in lengthways profile consistently showed that (Figure 3): the fluctuations extent of lightness and redness between grassland and farmland were greater than these of the yellowness. In addition, it was noticed that the lightness had the opposite trend with redness and yellowness. The lightness of grassland had increased trend and the lightness of farmland has decreased trend above 30cm. The lightness of grassland and farmland had no other changes below 30cm. The change of redness and yellowness in lengthways profile had decreased trend from 0 to 60cm. The redness of the grassland and farmland at 15cm kept unchanged basically, which below 15cm was of the less slowly decreasing trend. However, decreasing trend of grassland was significantly obvious compared with farmland. The yellowness of grassland and farmland over the entire lengthways profile was of the slowly decreasing range trend.

Table 2 The chroma content of grassland and farmland

Sampling point		L*	a*	b*
Grassland	Max value	50.01	6.03	15.53
	Min value	43.79	4.79	13.26
	Average value	47.35	5.25	14.02
Farmland	Max value	55.34	6.10	16.42
	Min value	50.02	5.32	14.46
	Average value	52.37	5.63	15.42

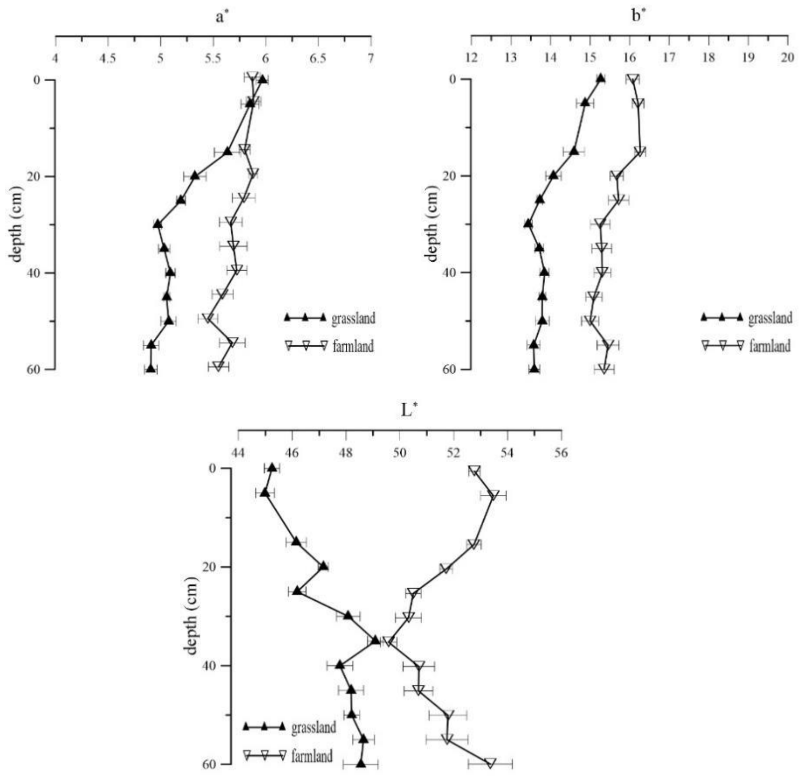

Fig.3 The chroma variation of grassland and farmland profile

4.3 Analysis of soil particle size sectional of grasslands and farmlands

According to analyzing particle size distribution of grassland and farmland(Table 3), it was obvious that grassland sand content was 5.62%~12.64%, with an average value of 8.98%, while the farmland of sand content was 9.81%~21.64%, with an average value of 15.25%. It was obvious that the sand content of farmland was 6.27% more than that of grassland, namely, it was nearly as twice as that of grassland; grassland silt content was 66.42%~73.18%, with an average value of 70.8%, while the farmland silt content was 60.45%~71.48%, with an average value of 66.65%, the different value between the silt contents was 4.15%; grassland clay content ranged from 17.92% to 21.99%, with an average value of 20.22%, while the farmland between clay content was 16.2%~19.82%, with an average value of 18.1%, the different value between the clay contents was 2.12%.

According to the soil particle size lengthways profile of grassland and farmland, it was obvious that the sand, silt and clay content of grassland and farmland changed with its depth(Fig. 4). The overall sand content of the farmland in the entire lengthways profile of the depth's degree was greater than that of the grassland. At 0~20cm segment, sand content of the farmland reached the maximum. Sand content at 20~35cm segment decreased, while when it was at 35~60cm or less, it started to increase again. The silt and clay contents of grassland on the entire profile were greater than these of the farmland. The soil particle size composition had a biggest difference when it was above 30cm, and it had an unobvious difference when it was below 30cm.

Table 3 The particle size content of grassland and farmland

Sampling point		Sand（%）	Silt(%)	Clay(%)
Grassland	Max value	12.64	73.81	21.99
	Min value	5.62	66.42	17.92
	Average value	8.98	70.8	20.22
Farmland	Max value	21.64	71.48	19.82
	Min value	9.81	60.45	16.2
	Average value	15.25	66.65	18.1

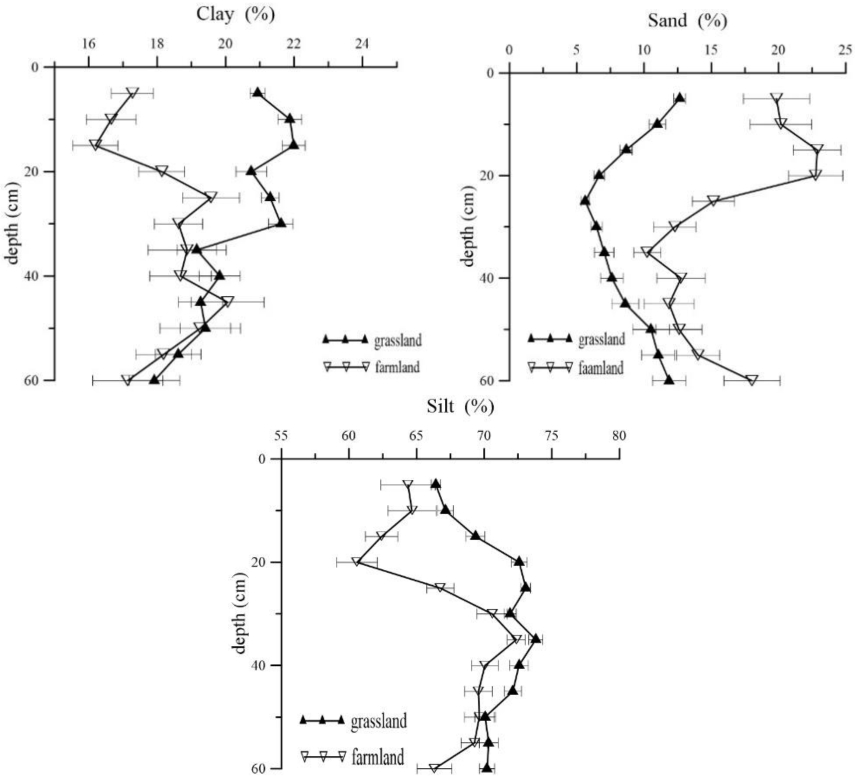

Fig.4 The particle size variation of grassland and farmland profile

5. Discussion

5.1 Effect on human activities of soil magnetic properties and chroma

Soil magnetic susceptibility was a proxy index for the degree of soil development, climate and environmental pollution, because its fast determination and visual had been widely used [20], which also was used to reflect the comprehensive information on global environmental change and human activities [5, 12]. This also could characterized the type and content of soil magnetic substance, so the process of soil formation and human factors were the main factors to affect soil magnetic susceptibility fluctuations in the vertical directions. Generally, the soil low-frequency magnetic susceptibility had been negatively correlated with clay and organic matter content and positively correlated with silt content [21].The low-frequency magnetic susceptibility of farmland in the whole was greater than the grassland, especially at 20cm. The value of low frequency magnetic susceptibility of farmland was obviously higher than that of the grassland, which was closely related to human activities such as the irrigation and long plowing of the farmland. According to the survey, planting rapeseed for many years in this area. After harvesting artificial, its roots still buried in the ground, which required human’s plowing. In this process, on the one hand, because the root carried a portion of soil and leaded to loss of soil fine particles, on the other hand, from plowing to the sowing of next year spring, as abandonment leaded to the fine particle components in the way of wind erosion and it was exhausted. However, the low-frequency magnetic susceptibility were negatively related to the soil clay content, so the low-frequency magnetic susceptibility was greater than that of the grassland. In addition, the farmland would be irrigated when the sowing was finished. This process made the iron and other magnetic substances soil contain from the surface to the deep sides with a continuous migration, accumulation and transformation, which also made low-frequency magnetic susceptibility of farmland heighten. Relative to those farmland affected largely by human activities, grassland was of no frequent tillage and irrigation effect. In soil development process, the influenced frequency and intensity of human activities was much lower than farmland, which was essentially based on soil self-development. So the low frequency magnetic susceptibility trend of grassland along the whole profile was less than that of the farmland. Frequency magnetic susceptibility reflected the relative content of magnetic minerals, which could not only help people understand the transition state particles content in superparamagnetic (SP) to stable single domain (SSD) process[22], but also had a positive correlation with soil clay content and organic matter content in a way. It was not difficult to explain how 30cm above the grassland frequency magnetic susceptibility was greater than that of the farmland. However, 30cm below had no difference (grassland above 30cm was affected slightly by human activity, the mature degree of soil development was higher than farmland, below 30cm the farmland had a fewer and smaller difference with grassland because of less human activities affected).

Soil color was one of the most important characteristics of soil, which was widely used in semi-quantitative or quantitative description of regional climate change and the degree of soil development [23]. Generally speaking, the lightness of the soil color was mainly controlled by organic matter and carbonate content; the higher organic matter content was, the lower the lightness of the soil was, the higher carbonate content was, the higher the lightness was; redness was mainly controlled by the degree of hematite mineral content, the higher the hematite content was, the higher the soil redness was; yellowness was mainly controlled by goethite content, the higher the goethite content was, the higher the degree of yellow soil was[24]. Due to 35cm above the grassland, soil development degree was strong, soil fine particle content and the corresponding organic matter were high. Therefore, the brightness value of 0-35cm grassland was smaller than that of farmland and showed an increasing trend. Similarly, due to the effect of tillage in the 0-35 cm section, farmland soil development action was trended to be weak and its soil fine grained loss, so the corresponding organic matter was less, and the corresponding lightness values within this range was high; the human disturbance of farmland below 35cm was less, but the content of organic matter was still lower than that of grassland. Therefore, the lightness value was greater than the grassland and there was an increasing trend. The redness and yellowness indexes of farmland were bigger than these of grassland in the whole section, while the redness and yellowness were mainly related to hematite and goethite. Before the experimental analysis of hematite and goethite were performed, the conclusions could not be made optionally. So, the further research and analysis of this study would be made in the future.

5.2 Impact of human activities on soil texture

Soil particle size was the basic study of soil environment and the entire ecosystem characteristics, the particle size was closely related to the physical, chemical and biological properties of the soil [25]. The intensity of human activities would cause the changes in soil particle component. The study showed that there were differences in grain size between grassland and farmland. The sand particles, silt particles and clay particles had an obvious change as the bound of 30 cm. In order to explain this difference more intuitively， a definition of 30cm was made as the boundary, above which it was disturbance layer, below which it was non-disturbance layer. Moreover, the specific analysis of the particle size frequency curves was made: above the bound (Fig. 5-a), the grassland frequency curves were bimodal and the kurtosis was basically similar, and the main peak was between 10μm and 100μm which belonged to silty-sand loam; the minor peak was between 1μm and 10μm, which belonged to clay loam. Those indicated that the grassland was due to the less human interference, the vegetation was covered perennially and soil development was stronger, the soil particles were finer; the frequency curve of the disturbed layer of farmland was multimodal, the main peak was between 10μm and 100μm, the minor peak was between 100μm and 200μm, these indicated there was a considerable part of coarse particle joining in besides soil own development in the process of soil formation, because only less than 75μm dust usually existed in a suspended state [26], dust which was larger than 75μm was difficult to suspend in the air for a long time, and it could only saltation move. The third peak was between 2μm~10μm, which belonged to clay loam, but the volume percentage was small. Maybe, this was the results of the arable land under human short-term perennial crops and perennial tilling, and most fine particle was in erosion by the wind, so the soil particles became generally coarser; below bound (Fig. 5-b), the frequency curve shape of the grassland and farmland was substantially similar, it was almost close to normal distribution and had only one peak and lay between 4μm and 10μm. The peak of grassland was slightly higher than that of the farmland, which showed a relatively homogeneous and stable depositional environment and the sediment was very pure. The frequency curve shape of the grassland was the main components of the clay, which was not in much fluctuate. This indicated that human activities mainly occurred in the soil layer above 30cm which was under the impact of human activities. Grassland was regarded as a "natural land", the soil evolution would tend to be homogeneous without human disturbance or low intensity of human activity; the farmland was regarded as a "disturbance of land" in case of human's high intensive activity, and the particle size would be further coarsening, and the desertification process would be aggravated.

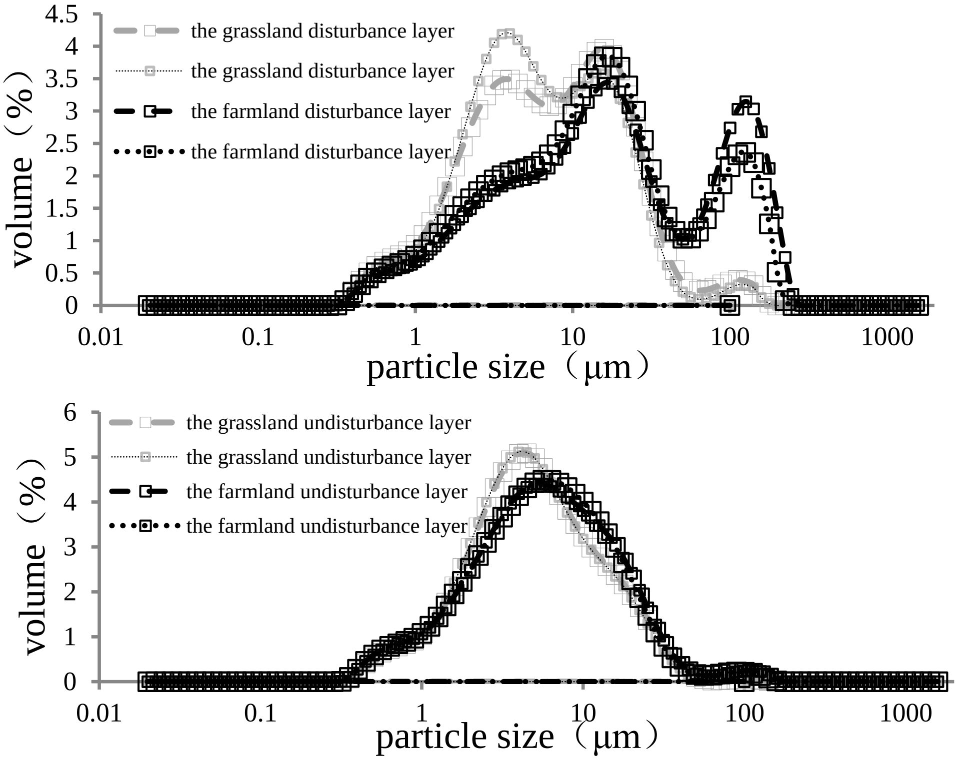

Fig.5 The particle size frequency curve of grassland and farmland
a. Disturbed layer, b. Undisturbed layer

6. Conclusion

(1) The magnetic and chromatic characteristics of soil would be obviously different under the disturbance of human activities, the low-frequency magnetic susceptibility of farmland along the entire profile was larger than grassland, especially in the 20cm-45cm segment; the X_{fd} of grassland was greater than that of the farmland above 30cm, and it had a little differences below 30cm. The lightness, redness, yellowness values of the farmland were greater than these of the grassland; the

lightness of grassland had a increasing trend and the lightness of farmland had a decreasing trend above 30cm; the lightness of grassland and farmland had no other changes below 30cm, and the redness and yellowness of soil had no fierce fluctuation in the entire profile.

(2) For the perspective of the composition, the particle size of grassland and farmland soil belonged to all sand-clay loam, grassland silt and clay contents were larger than farmland, and the sand content was less than that of the farmland; The components of the particle size of grassland and farmland along the entire profile had an obvious difference, and the soil particle size composition had a big differences especially above 30cm, but it had slight differences below 30cm, indicating that human activities mainly occurred in the soil layer above 30cm the impact of human activities, grassland as a "natural land" , without human disturbance or low intensity of human activity, the soil evolution will tend to be homogeneous, farmland as a "disturbance of land", in the case of human high intensity activity , particle size will be further coarsening, aggravate desertification process. This indicated that grassland was regarded as a "natural land", the soil evolution would tend to be homogeneous without human disturbance or low intensity of human activity; the farmland was regarded as a "disturbance of land" in case of human's high intensive activity, and the particle size would be further coarsening, and the desertification process would be aggravated.

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